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Indigenous Food Crop Production and Extent Decisions among Farm Households in Northern Ghana

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Abstract

This study identifies the socio-economic factors influencing the adoption and the extent of production of indigenous food crops among farm households in northern Ghana. Based on a multi-stage sampling procedure, data on 405 households were obtained using a structured questionnaire. The study employed descriptive statistics and a double hurdle econometric model to identify factors affecting households' adoption and extent of indigenous food crop production decisions. Descriptive results show a high rate of adoption (66.9%) with significant differences between producer households and non-producer households in respect to farm size, market distance, household size, number of children and number of women. Econometric results show that significant factors influencing farm households' decisions on adoption are crop income use by women, farm size, awareness of the nutritional importance of indigenous crops, participation in food security projects, access to credit and distance to a market. The factors that affect indigenous crop production diversity positively include income use by women, farm size, number of land parcels, household size and bicycle ownership. Household head education, number of children and women tend to limit the extent of diversity of indigenous crops produced. The study recommends, for promoting the production of indigenous crops, strategies including provision of credit, empowerment of women, targeting distant communities relative to market centres and raising awareness about the nutritional relevance of indigenous food crops.

1. Introduction

Food crop cultivation is the primary source of livelihood for over 72% of households in the northern parts of Ghana, yet the area is the most challenged in the country in terms of the number of people who suffer from malnutrition(GSS, 2012, 2015).Poor nutritional status amongst the poor is partly attributed to lack of access to diversified foods(Islam et al., 2018; Jones et al., 2014).Current choices of food crops produced have focused on a few energy-rich but micronutrient-deficient foods as crop diversity in agricultural systems today have declined as a consequence of changes in climatic conditions and the adoption of modern food production methods(Ebert, 2014). According to Pingali (2012), modern methods of food production in particular have promoted the cultivation of high-yielding cereal crops and achieved tremendous increases in output per unit input. However, these methods have led to a decline in the cultivation of useful food crops, especially indigenous and often underutilized crops which contribute to agro biodiversity with huge potential to improve dietary diversity and nutrition security of subsistence farmers (Ebert, 2014; Mabhaudhi et al., 2019; Sibhatu et al., 2015). Indeed, Pingali (2015) notes a growing disconnect between agricultural policy and contemporary nutritional challenges in which agricultural policy continues to be heavily biased towards productivity improvement of staple crops (especially wheat, rice and maize) with little attention to dietary diversity needs of the middle class.

For increased and better access to diverse foods among peasant farm families, agricultural production diversity offers a huge opportunity (Carletto et al., 2015; Chivenge et al., 2015; Dillon et al., 2015; Ecker, 2018; Jones, 2017; Jones et al., 2014; Kumar et al., 2015; Shively and Sununtnasuk, 2015; Sibhatu and Qaim, 2018).According to Carletto et al. (2015)a strong link exists between household agricultural production and dietary patterns and nutrition as well. In the context of Ghana, Ecker (2018)reports that farm production diversification and household income growth are the main factors strongly associated with increased household dietary diversity. On their part, Kumar et al. (2015)suggest a positive association between production diversity and household nutrition outcomes including dietary diversity and anthropometric indicators for children. The study by Shively and Sununtnasuk (2015) stressed the relevance of specific crop groups and the consumption of own production and the ultimate effect on the nutrition outcomes among children. Diversifying food crop production to include indigenous crops can help improve household nutrition, increase incomes and preserve local cultures. Diversified food crop production through indigenous or underutilized food crops could be effective in tackling malnutrition among subsistence farm families as they are said to have high content of micronutrients (see Chivenge et al., 2015; Ebert, 2014; Mabhaudhi et al., 2019; Mabhaudhi et al., 2016; Padulosi et al., 2013; Tadele, 2009). A wider production of these crops could help governments of sub-Saharan African countries to contain the high incidence of micronutrient deficiency among their people. Alders et al. (2018)observe that, in addition to not being sustainable, current food systems fail to provide nutritious and safe food to support good health for all; hence the need for the protection of specific food systems and dietary preferences of local communities. Others have noted that indigenous food crops have nutritional, agronomic, ecological and economic traits that make them more suitable for improving agricultural systems in developing countries (Ebert, 2014; Padulosi et al., 2013).

In terms of origin, Maundu (1997), as cited in Muthoni and Nyamongo (2010) considers indigenous crops as those crop species native to specific geographical localities or regions. Aboagye et al. (2007) and Heywood et al. (2013) view the crops in terms of their economic and social usefulness. According to Aboagye et al. (2007) the crops are underutilized because they are less important in terms of quantities produced, consumption and utilization. Heywood et al. (2013) contend that indigenous crops have great potential in enhancing livelihoods and food security but are less competitive to other crops in mainstream agriculture. In terms of nutrition and economic importance, these crops, especially vegetables and pulses, are rich sources of vitamins, micronutrients and non-animal proteins and are key contributors to incomes of farm families (Ebert 2014). Indigenous cereals have more nutrient content compared to other cereals such as maize and rice. Millet for instance has a high content of amino acid (methionine) which is lacking in the diets of the poor who largely live on starchy staples; millet could also be used as food among diabetic patients (Tadele, 2009). The crops contribute significantly to agricultural systems' resilience to climate change as their wider use will improve agro biodiversity and inject production diversity into mono-cropping systems and as well help build resilience against both biotic and abiotic stresses (Mabhaudhi et al., 2016). This is particularly important especially as Islam et al. (2018) assert that most economic agents including farm households now face increasing natural and economic risks. Indigenous food crops are also noted for their comparative advantage on marginal lands where they contribute to sustainable agricultural production by withstanding harsh conditions with little or no expensive inputs (Chivenge et al., 2015).

A large body of literature exists with respect to empirical research on African indigenous food crops and vegetables(Ayodele and Shittu, 2013; Ayodele et al., 2011; Cloete and Idsardi, 2013; Krause et al., 2019; Mwangi and Crewett, 2019; Mwaura et al., 2013; Nagarajan et al., 2007).However, much of these studies have largely been centred on the analysis of the perceptions and consumption patterns (Ayodele and Shittu, 2013) and marketability or commercialization (Ayodele and Shittu, 2013; Krause et al., 2019; Mwangi and Crewett, 2019)all of which focusing indigenous leafy vegetables. An understanding of the factors determining farmers' production and extent of production decisions of indigenous and underutilized food crops is essential for food and nutrition policy design in sub-Saharan Africa. The present study differs from previous ones in scope and context as it looks at the generality of indigenous food crops in terms of farm households' decisions regarding their production and extent decisions. This paper therefore contributes to the literature by extending the analysis of the production of indigenous and underutilized crops in general as well as the diversity of their production at the farm household level. The paper identifies the determinants of the decision to produce indigenous/underutilized crops and the extent or level of their production by farm households in northern Ghana. The rest of the paper is organized as sections for a review of literature, materials and methods, results and discussion and concludes with a summary of key findings and policy recommendations.

Theoretical Framework

The paper draws from the agricultural household models which have been adopted extensively to empirically assess households' resource allocation decisions (Benin et al., 2004; Kankwamba et al., 2018; Kumar et al., 2015; Van Dusen and Taylor, 2005). As Ahn et al. (1981) observe, household consumption of leisure and goods and the consumption of farm output and resource use (including family labour) should all be determined simultaneously. In this study, farm households' multi-cropping practices relative to the production of neglected and underutilized crops within the context of a semi-subsistence farm household economy (Benin et al., 2004) are assessed. The model assumes that farm households allocate resources (labour, land, capital and time) to produce commodities so as to maximize household utility subject to an income constraint. Solution to the household production and consumption decision problem involves maximizing this utility function. In respect of indigenous crop output, the optimal farm output q^*, is obtained as a function of input prices P_j, w and a vector of farm characteristics K and this is specified in Equaiton 1:

$q^* = f(P_j, w, K)$ ……………………..……….... 1

With imperfect markets, households' production and consumption decisions are inseparable and optimal production and consumption decisions are determined not by observable market prices of inputs and outputs but by shadow prices which serve as constraints (Sadoulet and De Janvry, 1995; Taylor and Adelman, 2003). Such market imperfections in farming communities represented by a vector of household characteristics, D, is included to capture the effects of household socio-demographic factors affecting decisions on the production and consumption of farm output. Re-stating the optimal indigenous crop output in terms of a vector of farm production characteristics K and a vector of household characteristics D is represented in Equation 2 based on which farm households' indigenous food crop production status were determined for empirical modelling.

$q^* = f(D, K)$ ……………………...………….... 2

2. Materials and methods

2.1 Econometric Model

Households' decisions in respect of production and extent of indigenous food crops are modelled as a two-step process. First is the decision on whether or not to produce indigenous food crops; and second, the decision on the extent of production. The double hurdle model developed by Cragg (1971) was employed in the analysis in preference over both the Tobit and Heckman models which are alternative estimation methods. The Tobit model is restrictive as it assumes that indigenous crop production and extent decisions are influenced by the same factors but these could be different. The Heckman model assumes that zero observations in the response variable are as a result of sample selection bias but this could simply be the case of non-participation in production (Keelan et al., 2009). The double hurdle model assumes that households' decisions to produce indigenous crops are qualitatively different from their decisions on the extent of production.

For the empirical modelling, households were categorized as producers of indigenous food crops if they reported cultivating at least one or more indigenous food crops and non-producers if they did not produce such crops as explained. A latent variable indicating a household's indigenous food crop production status q_i^*, is defined as a linear function of a vector of household and farm characteristics Z_i, assumed to affect households' decisions to produce indigenous food crops and u_i, an error term (Equation 3).

$q_i^* = \delta Z_i + u_i$……………………..…..………. 3

From Equation 3 a household produced indigenous food crops in the year under study given the condition that $Q_i^* > 0$ and the observable dichotomous variable, Q_i, indicates whether or not a household is a producer as specified in Equation 4.

$q_i = \begin{cases} 1 \text{ iff } \delta Z_i + u_i > 0 \\ 0 \text{ iff } \delta Z_i + u_i \leq 0 \end{cases}$……………….……………. 4

where$q_i = 1$indicates that the household is a producer and $q_i = 0$indicates otherwise.

Most studies on households' decisions regarding crop production have usually incorporated the extent of crop production diversity objectives (Islam et al., 2018; Sibhatu and Qaim, 2018). Whilst some studies have used land area as a measure of the extent of production diversification (Benin et al., 2004; Mal et al., 2012), others have used species diversity indices measured based on the Simpson, Shannon-Weiner and the Herfindahl approaches (Rahman, 2008). The extent of indigenous crop production diversification in this study is assessed based on land area that farmers commit to the cultivation of indigenous crops and crop species diversity indices. Crop species diversity indices were measured based on the Shannon-Wiener and Simpson diversity approaches using the classification of households as producers of indigenous cereal crops; pulses and vegetable/oilseed crops.The household's decision on the extent of production is defined in Equation 5:

$y_i = \beta' X_i + \varepsilon_i$ …………………………………..5

where y_i represents the production diversity and measured either as land size in area planted to indigenous crops following Benin et al. (2004) and Mal et al. (2012)or as Shannon-Weiner and Simpson species diversity indices following De and Chattopadhyay (2010).$X_i$is a vector of variables explaining the extent of cultivation; β, a vector of parameters to be estimated in the extent decisions and ε_i is the random error term. $u_i$andε_i are assumed to be randomly and independently distributed as$u_i \sim N(0,1)$ and$\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$.Data relating to the size of land used for indigenous crops production was obtained based on farmers' estimation of the portion of their cultivated fields taken up by all indigenous crops. The Shannon-Wiener diversity index was measured based on the number of crop species present in the data. The index indicates crop species richness whilst the Simpson diversity index measures the number of individual crops per species present which measures the crop species abundance on the farmer's field (Keylock, 2005).The Shannon-Wiener index was calculated using the following formula(Mburu et al., 2016):

$$\text{Shannon} - \text{Weiner Index(H)} = -\sum_{j=1}^{s}(P_i)\ln(P_i) \ldots\ldots\ldots..6$$

where$P_i = \frac{n_i}{N_j}$, with n_i being the number of crops in each crop category which were produced by the household in the season; N_j is the total number of individual crops across all crop group species in the data such as in the cereals, pulses and vegetables/oilseeds in respect of each household. $n_i$varies across households depending on the number of cereals, pulses and vegetables/oilseed crops produced. ln is the natural log,$\sum$ is the sum of the calculations, and s is the number of crop groups. In all, there were 10 different indigenous crop species comprising of 3 different indigenous cereal crops, 4 pulses/legume crops and 3 vegetables/oilseed crops in the data. Indigenous crop diversity indices were calculated for each household in the sample by first estimating p_i and substituting the value in the formula specified in Equation 6.The Simpson diversity index was calculated using the formula:

$$Simpson\ Index(D) = \frac{1}{\sum_{i=1}^{s} P_i^2} \ldots\ldots\ldots\ldots\ldots\ldots.. 7$$

The log-likelihood function for the standard double hurdle model is estimated using the maximum likelihood estimation technique which is stated mathematically as follows (Greene, 2012):

$$L = L(\delta, \beta) = \pi_{y_{i=0}}\left[1 - \Phi(q_i'\delta)\Phi\left(\frac{X_i'\beta}{\sigma}\right)\right]\left[\pi_{y_{i>0}}\left(\phi\left(\frac{q_i'\delta}{\sigma}\right)\phi\left(\frac{y_i - \beta}{\sigma}\right)\right)\right] \ldots. 8$$

Where Φ denotes the standard normal cumulative distribution function, ϕ is the standard normal probability distribution function, and σ is the variance between the error terms. The first part is the log-likelihood for a probit, and the second part is the log-likelihood for a truncated regression, with truncation at zero value of the continuous dependent variable in the second stage.

A likelihood ratio test was carried out to determine the suitability of the double hurdle model against the use of the Tobit model (Greene, 2000, 2012). The results established that farm households' decisions on the production and extent of indigenous crops were made in two different stages and thus, indicating the preference of the double hurdle model over the Tobit model. The potential for the existence of multicollinearity among the independent variables in the models was checked as multicollinearity between any two or more explanatory variables makes it difficult to separate the independent effect of each parameter on the dependent variable. The results of the Variance Inflation Factor (VIF) showed no serious multicollinearity existing between any two or more of the variables.

2.2 Sampling and Data

The sample selection followed a multistage sampling procedure. The first stage involved a purposive selection of three districts identified during the preparatory stages as areas where indigenous crops were being promoted. These include Chereponi, Karaga and West Mamprusi Districts. The sample size for the study was determined based on the population of farm households engaged in crop production(GSS, 2012).With the total number of farm households engaged in crop farming in the three sampled districts and with a 5% margin of error, the sample size was estimated at 390.A total of 450 structured and pretested questionnaires were distributed with 150 to each district. The second stage involved the selection of 16 farming communities through a simple random process resulting in the selection of five communities each from the Karaga and Chereponi Districts and six in the West Mamprusi District. The third and final stage involved a random selection of 25 households from each community giving a total of 130 households in each of Karaga and Chereponi Districts and 145 households in the West Mamprusi District resulting ina total of 405 farm households which were eventually used in the analysis. Primary data collected were related to households' socio-economic and demographic characteristics and households' agricultural production profiles. Qualitative data was also collected through Focus Group Discussions (FGDs) and key informant interviews. Two FGDs were held for each sampled district whilst at least one key informant was interviewed in selected communities. The key informants comprised Agricultural Extension Agents (AEAs), experienced farmers and community leaders. FGDs and key informant interviews were used to aid in the interpretation of results obtained from econometric estimations.

3. Results and discussion

Summary statistics of respondents (Table 1) show that about 67% of households produced indigenous crops whilst the rest, 33% did not. Male headed households were 82% and just about a fifth (22%) of household heads reported having formal education. The average age of household head was 44 years and this is similar to findings of earlier studies such as GSS (2014) and GSS (2015). A typical household is composed of eight members with about two adult women and four young children of less than 15 years. The mean farm land owned of an average household is 7.2 hectares which is likely to be located in at least two different places. Farms are located about 4 km from households' dwellings and the average travel distance to the nearest market centre is 7 km. In terms of ownership of household assets, about 66% of households reported having a radio set, 77% mobile phone, 80% bicycle, 35% motorcycle and only 2.5% have tricycles. Credit, being critical for increased economic productivity is a serious challenge in the area as less than five percent (4.2%) of households reported having received one form of credit or the other in the previous one or two years. Approximately 10% of households are participating in food security projects, usually implemented by NGOs and a little over half (52%) of household heads indicated they were aware of the nutritional relevance of indigenous crops.

Between indigenous crop producer households and non-producer households, significant statistical differences were found with respect to household size, number of young household members and the number of adult women. The findings on household size and adult women is indicative of the availability of more family labour to producers than non-producers and this additional labour helps households to grow a wider range of crops that would likely include indigenous crops. There were also more producer households being aware of the nutritional relevance of indigenous crops compared to non-producer households. Significant differences were also found between the two groups in terms of mean distance to the nearest market centre, the size of farm land owned, number of farm locations and total cultivated land size, all of which are consistent with previous empirical findings (Ibrahim et al., 2009). The level of households' participation in food security project was also statistically different between producers and non-producers and there were more households producing indigenous than non-producing households that took crop choice decisions with the participation of women as well as women's participating in the use of crop sale proceeds compared to non-producer households.

Table 2 presents the results of the maximum likelihood estimation of the double hurdle model. The significant factors affecting the probability of households' decisions to produce and the resulting marginal effects are presented in columns 2 and 3, respectively. The last three columns show the significant determinants of households' extent of production of the crops. Factors that influence households' indigenous crops production decisions are women's participation in the control and utilization of farm income, farm size, households' being aware of the nutritional benefits of indigenous crops, household's participation in food security projects, access to credit and average distance to the nearest market. Household's crop production objective, measured as either crop produced was meant for consumption and sale or for sale only, is also significant but tends to reduce the probability that a household produces indigenous crops.

The marginal effects of the significant independent variables show that where revenue from the sale of farm produce is controlled or used jointly by both the man and a woman or women alone, the chance that a household produces indigenous crop increases by 17%. This reflects the fact that some indigenous crops are produced for sale and women's use or a joint use of proceeds at the household level is a motivation for households to produce the crops since consensus decisions are likely to be reached on what crops to include in the household's cropping mix. Households with crop production objective that considers both subsistence and market motives are 22% less likely to produce indigenous crops. The results suggest households produce indigenous crops for subsistence rather than for both subsistence and commercial motives and thus policy on improved household nutrition can target farmers' crop production diversification into the indigenous crops. Land holding size has a minimal positive effect of 0.2% on the probability of households' decisions to go into indigenous crop production. The finding confirms earlier studies that farmers with access to large land parcels tend to engage in crop diversification (Choa et al., 2016; Makate et al., 2016; Sichoongwe et al., 2014). The results suggest that even though land size matters in terms of indigenous crop cultivation, increasing land size will only result in a marginal increase in the likelihood of household producing indigenous crops.

Households' awareness of the nutritional relevance of indigenous crops increases their likelihood of growing indigenous crops by 12%. This finds support from Ndenga et al. (2011) which observed an increase in the number of farmers going into the cultivation of indigenous vegetables in Kenya after having received sensitization on the nutritional importance on these crops. The result is also consistent with Senyolo et al. (2018) that farmers tend to adopt the production of indigenous food crops if there is a positive thinking among rural farmers that indigenous food crops have essential nutritional content. This finding suggests that policy can target sensitizing households on the nutritional importance of the crops as a strategy to boost production. Also, when households participate in food security projects the likelihood of them opting to produce indigenous crops increases by 13% and having access to financial support such as microfinance as it pertains in the study area, or even from friends and relatives increases the probability of producing indigenous crops by 14%.Distanceto market increases the probability by only 0.7% suggesting that households located far from the nearest market place tend to strategize, in the context of higher transactions costs in getting their food needs, by growing a wider variety of crops including indigenous ones as compared to households located closer to market centres. This finding collaborate an earlier finding by Kankwamba et al. (2012) and Sichoongwe et al. (2014) but contradicts that of Mwaura et al. (2013) whose study found a negative influence of market distance on the likelihood growing indigenous vegetables in Kenya.

The important factors that influence households' extent of cultivation of indigenous crops are presented in the last three columns of Table 2. The results show that when crop sale proceeds are used by women or jointly by both the man and woman, more land is allocated to the production of indigenous crops (40%) and the diversity of indigenous crop varieties also increases by 5% and 12% in terms of Shannon-Wiener and Simpson diversity indices, respectively. A one hectare increase in the farm land owned by the household increases the size of land used for indigenous crop cultivation by 8% and in terms of the Shannon-Wiener and Simpson diversity measures by 0.4% and 0.9% respectively. Related to land size is the number of farm plots which shows the level of fragmentation of a household's farm land distribution in different locations. The amount of land devoted to the production of indigenous crops is increased by 27% if the number of farm locations increases by one. This reflects the intuition that multiple farm plots is indicative of varied soil fertility, and given the different crops, the tendency for increasing production by planting different types of indigenous crops is high.

Education of household head reduces the diversity of indigenous crops in terms of the Simpson diversity index by 12% but larger households tend to allocate more farm land for the cultivation of indigenous crops and so is the variety and diversity of the crops in terms of the Shannon-Wiener and Simpson crop diversity criteria. While an additional person in the membership of a household increases farm land allocated for indigenous crop production by 13%, indigenous crop diversity in terms of the Shannon-Wiener and Simpson measures increase by only 2% and 4% respectively. These findings on household size and land use is consistent with previous finding that a larger household size is indicative of extra labour that enables the household to put more land under cultivation(Senyolo et al., 2018). In terms of indigenous crop diversity, larger households may want to increase the variety of foods to meet the different and varying physiological needs of household members.

The number of young household members affects crop diversity negatively such that an additional young household member to the household decreases indigenous crop diversity by 2% in respect of the Shannon-Wiener measure and 4% in the case of the Simpson diversity criteria. Similar results were found in terms of the number of adult women living in the household with an additional adult woman decreasing indigenous crop diversity by 4% and 7% in terms of the Shannon-Wiener and Simpson criteria respectively. The finding about young household members is not surprising as more young members implies that there is less labour available for households to engage extensively in the production of these crops. However, from the point of nutrition, households with more young members might rather engage in the production of a diversity of these crops so as to meet the nutritional requirement of these young ones. Also, relative to the notion that indigenous crops are much associated with women, one would expect that rather than a decrease in the variety of indigenous crops, the presence of more women in a household should naturally lead to a more diversified portfolio of indigenous crops being cultivated.

The most common means of transport in the study area is the bicycle and wealthy households who can afford motor cycles are not very common. It is not therefore surprising that bicycle ownership increases the amount of farm land committed to the planting of indigenous crops by 45%. Motorbike ownership decreases land allocation, the Shannon-Wiener and Simpson diversity indices by 59%, 8% and 17% respectively.

Table 1. Socio-Economic and Demographic Characteristics of Farm Households

Variables	Pooled	Producers	Non-Producers	P-value
Mean indigenous crop diversity:				
Land area planted to indigenous crop	1.1	1.6		
Shannon-Wiener diversity index	0.54	0.81		
Simpson diversity index	1.48	2.21		
Crop choice decision by women	56.3	60.5	47.8	0.0149**
Use of crop income by women	63.0	74.5	396	0.0000***
Crop produced for consumption and sale	65.9	56.1	85.8	0.0000***
Male household head	82.2	80.4	85.8	0.1827
Household head has formal education	22.2	22.1	22.4	0.9546
Age of household head	43.8	43.8	43.8	0.9799
Household size	7.8	8.1	7.2	0.0106**
Household members less than 15 years	3.6	3.9	3.2	0.0023***
Number of adult women	1.9	1.9	1.7	0.0965*
Total land holding (hectares)	7.3	8.5	4.9	0.000***
Farm land parcels owned	2.2	2.4	1.9	0.000***
Total land cultivated (hectares)	4.4	5.2	2.7	0.000***
Farm distance in km	3.8	3.9	3.5	0.1310
Proximity to market in km	6.8	7.9	4.8	0.0002***
Ownership of a radio set	66.5	66.8	56.7	0.0477**
Ownership of a mobile phone	77.3	77.5	76.9	0.8886
Ownership of a bicycle	80.0	81.2	77.6	0.3981
Ownership of motorcycle	35.8	36.5	34.3	0.6639
Ownership of a tricycle	2.5	1.1	5.0	0.1657
Access to credit	4.2	4.8	2.9	0.3682
Aware of the nutritional relevance	51.6	58.3	38.1	0.0001***
Participation in food security project	9.9	12.2	5.2	0.0272**
Number of Farm Households	405	271	134 (	
	100%	66.9%	33.1%	

***, ** and * indicate significant levels of 1%, 5% and 10% respectively.

Similarly, owning a tricycle has the tendency of reducing land allocation for the cultivation of indigenous crops remarkably and 16% diversity in the crops according to the Shannon-Wiener diversity indices. Households that have tricycles may use them for commercial purposes such as the transportation of passengers and goods, a common practice in the study area and this could be the reason for its negative effect.

Farm distance has a positive effect of 9% on the extent of land used in the production of indigenous crops and this suggests that households may prefer to produce a wider diversity of crops on their farms when farms are located farther away from the reach of domestic animals. Location of the household also has negative implication on how much land is used for the production of indigenous crops. Households located in the Karaga District are less likely to allocate more land for the production of indigenous crops and are less likely to have diversity in these crops as compared to households in the Chereponi District. In contrast, compared to the Chereponi District, farm households in the West Mamprusi District are more likely to allocate more land for the cultivation of indigenous crops and are also more likely to have more diversity in these crops.

Table 2. Determinants of Indigenous Crop Production and Extent of Production Decisions by Farm Households

Variable	Production Decisions		Extent of Production Decisions		
	Coefficient	Marginal Effect	Land Allocation	Shannon-Wiener Index	Simpson Index
Crop choice decision by women	0.288	-	-0.167	-0.0196	-0.0403
Use of crop income by women	0.752***	0.1739	0.401*	0.0469*	0.1175*
Crop produced for consumption and sale	-0.949***	-0.2195	-0.330	0.0142	0.0430
Male household head	0.0649	-	-0.109	-0.0397	-0.0893
Household head has education	-0.00384	-	-0.142	-0.0434	-0.1199*
Age of household head	-0.0117	-	-0.0102	-0.0002	-0.013
Household size	0.00179	-	0.131**	0.0157**	0.0406**
Household members less than 15 years	-0.00111	-	-0.0735	-0.0167*	-0.0414**
Number of adult women	-0.0860	-	-0.171	-0.0286*	-0.0705*
Farm land parcels	0.0984	-	0.274**	0.0212	0.0437
Total land cultivated (Hectares)	0.0711***	0.0165	0.0763***	0.0035***	0.0087***
Farm distance in km	0.0673	-	0.0875*	0.0047	0.0109
Proximity to market	0.0283*	0.0065	-0.00804	0.0009	0.0008
Ownership of a radio set	0.210	-	0.0412	0.01462	0.0588
Ownership of a mobile phone	-0.160	-	0.183	0.0399	0.0996
Ownership of a bicycle	0.215	-	0.445*	0.0219	0.0785
Ownership of a motor cycle	-0.141	-	-0.587***	-0.0787***	-0.1693***
Ownership of a tricycle	-0.346	-	-2.121***	-0.1619*	-0.3865
Access to credit	0.610*	0.1411	0.322	0.0435	0.0785
Aware of the nutritional relevance	0.506**	0.1171	0.149	0.0344	00709
Participation in food security project	0.572*	0.1322	0.145	-0.0298	0.0607
District Dummies					
Karaga	-0.376	-	-0.533*	-0.0334	-0.0929
West Mamprusi	-0.303	-	0.133	00063	0.0091
Constant	-0.811		1.258*	0.6366***	1.7800***
Observations	405		271	271	271
Sigma	-		1.447***	0.1797***	0.309***
Wald $chi^2(24)$	133.53		145.94	50.83	54.05
Prob> chi^2	0.0000		0.000	0.001	0.000
Log pseudo likelihood	-167.18		-484.59	-80.59	-142.78
Pseudo R^2	0.3497				

*** p<0.01, ** p<0.05, * p<0.1 indicates significance levels of 1, 5 and 10% respectively.

4. Conclusion and recommendations

This study identified the key determinants of households' indigenous crop production and factors influencing the extent of their production in the Northern Region of Ghana. Farm households tend to produce indigenous food crops when women take active part in the utilization of farm income, when households have large parcels of farm land and are aware of the nutritional importance of indigenous crops. When households participate in projects of food security and are supported with credit there is a high likelihood that they will cultivate indigenous food crops and distance to the nearest market centre tends to increase the probability of farm households decision to engage in the production of indigenous food crops. Larger portions of farm fields are more likely to be used for cultivating indigenous/neglected food crops by households where women havecontrol over crop income and large farmlands are available and distributed in different locations. Households with larger size, means of transport (bicycle) and located remotely from farm fields tend to commit more of their fields to the production of indigenous crops. Ownership of higher value means of transport such as motorcycles and tricycles tend to discourage farm households in allocating more farm land to planting of indigenous crops. The number and variety of indigenous crops species that farm households produce tend to increase with factors including women taking control of the use of household farm income, farm size and household size but decreases with education of household head, number of adult women, number of young household members and the ownership of motorcycles and tricycles. These findings are useful for designing policies that aim at increasing indigenous crops production by farm households in contexts such as northern Ghana.

Policy to promote increased production of indigenous crops should target households in remote areas and those living in areas with difficult market accessibility and supported with credit. Policy on gender should consider promoting women's participation in decision making at the household level since increased women's participation in household decision making can increase their access to and use of household resources which in turn promotes the production of indigenous crops. Educational campaigns may be useful in creating awareness on the nutritional benefits of indigenous crops to boost production.

Future research could explore the welfare effect of the adoption of indigenous food crops in the rural and farming communities in Ghana. Studies could explore the empirical nexus of household nutritional outcomes and indigenous food crop production to contribute to finding sustainable means of addressing the high rates of malnutrition recorded in rural Ghana.

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References

1. Aboagye, L., Obirih-Opareh, N., Amissah, L.and Adu-Dapaah, H. (2007). Underutilsed species policies and strategies: analysis of existing national policies and legislation that enable or inhibit the wider use of underutilized plant species for food and agriculture in Ghana. Global Facilitation Unit for Underutilized Species (GFU) Via dei Tre Denari, 472.
2. Ahn, C. Y., Singh, I.and Squire, L. (1981). A model of an agricultural household in a multi-crop economy: the case of Korea. The Review of Economics and Statistics, 520-525.
3. Alders, R. G., Ratanawongprasat, N., Schönfeldt, H.and Stellmach, D. (2018). A planetary health approach to secure, safe, sustainable food systems: workshop report.
4. Ayodele, O.and Shittu, O. (2013). Cost-benefit analysis of melon (egusi) seed and seed-oil yield responses to phosphorus fertilizer application. International Research Journal of Agricultural Science and Soil Science, 3(5): 152-155.
5. Ayodele, V., Makaleka, M., Chaminuka, P.and Nchabeleng, L. (2011). Potential role of indigenous vegetable production in household food security: A case study in the Limporo Province of South Africa. Acta horticulturae.
6. Benin, S., Smale, M., Pender, J., Gebremedhin, B.and Ehui, S. (2004). The economic determinants of cereal crop diversity on farms in the Ethiopian highlands. Agricultural Economics, 31(2&3): 197-208.
7. Carletto, C., Ruel, M., Winters, P.and Zezza, A. (2015). Farm-Level Pathways to Improved Nutritional Status: Introduction to the Special Issue. Journal of Development Studies, 51(8), 945-957.
8. Chivenge, P., Mabhaudhi, T., Modi, A. T.and Mafongoya, P. (2015). The potential role of neglected and underutilised crop species as future crops under water scarce conditions in Sub-Saharan Africa. International journal of environmental research and public health, 12(6): 5685-5711.
9. Choa, A., Oob, A. T.and Speelmanc, S. (2016). Assessment of Household Food Security through Crop Diversification in Natmauk Township, Magway Region, Myanmar. Paper presented at the Tropentag 2016: conference on international research on food security, natural resource management and rural development.
10. Cloete, P.and Idsardi, E. (2013). Consumption of indigenous and traditional food crops: Perceptions and realities from South Africa. Agroecology and sustainable food systems, 37(8): 902-914.
11. Cragg, J. G. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods. Econometrica: Journal of the Econometric Society, 829-844.
12. De, U. K.and Chattopadhyay, M. (2010). Crop diversification by poor peasants and role of infrastructure: Evidence from West Bengal. Journal of Development and Agricultural Economics, 2(10), 340-350.
13. Dillon, A., McGee, K.and Oseni, G. (2015). Agricultural production, dietary diversity and climate variability. The journal of development studies, 51(8): 976-995.
14. Ebert, A. W. (2014). Potential of underutilized traditional vegetables and legume crops to contribute to food and nutritional security, income and more sustainable production systems. Sustainability, 6(1): 319-335.
15. Ecker, O. (2018). Agricultural transformation and food and nutrition security in Ghana: Does farm production diversity (still) matter for household dietary diversity? Food Policy, 79: 271-282.
16. Greene, W. H. (2000). Solutions Manual Econometric Analysis.
17. Greene, W. H. (2012). Econometric analysis; Seventh Edition: Pearson Education India.
18. Ghana Statistical Service (GSS). (2012). 2010 Population and Housing Census: Final Results.

19. Ghana Statistical Service (GSS). (2014). Ghana Living Standards Survey Round 6 (GLSS 6): Poverty Profile in Ghana-2005-2013. Accra.

20. Ghana Statistical Service(GSS). (2015). Ghana Demographic and Health Survey 2014. Accra.

21. Heywood, V., Fanzo, J.and Hunter, D. (2013). Overview of agricultural biodiversity and its contribution to nutrition and health. Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health, 35-67.

22. Ibrahim, H., Rahman, S., Envulus, E.and Oyewole, S. (2009). Income and crop diversification among farming households in a rural area of north central Nigeria. Journal of Tropical Agriculture, Food, Environment and Extension, 8(2): 84-89.

23. Islam, A. H. M. S., von Braun, J., Thorne-Lyman, A. L.and Ahmed, A. U. (2018). Farm diversification and food and nutrition security in Bangladesh: empirical evidence from nationally representative household panel data. Food security, 1-20.

24. Jones, A. D. (2017). On-farm crop species richness is associated with household diet diversity and quality in subsistence-and market-oriented farming households in Malawi. The Journal of nutrition, 147(1), 86-96.

25. Jones, A. D., Shrinivas, A.and Bezner-Kerr, R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. Food Policy, 46: 1-12.

26. Kankwamba, H., Kadzamira, M.and Pauw, K. (2018). How diversified is cropping in Malawi? Patterns, determinants and policy implications. Food security, 10(2): 323-338.

27. Kankwamba, H., Mapila, M.and Pauw, K. (2012). Determinants and spatiotemporal dimensions of crop diversification in Malawi. Project Report produced under a co-financed research agreement between Irish Aid, USAID and IFPRI, Paper(3).

28. Keelan, C. D., Henchion, M. M.and Newman, C. F. (2009). A double-hurdle model of Irish Households' food service expenditure patterns. Journal of International Food & Agribusiness Marketing, 21(4): 269-285.

29. Keylock, C. (2005). Simpson diversity and the Shannon–Wiener index as special cases of a generalized entropy. Oikos, 109(1): 203-207.

30. Krause, H., Faße, A.and Grote, U. (2019). Welfare and food security-effects of commercializing African indigenous vegetables in Kenya. Cogent Food & Agriculture(just-accepted), 1700031.

31. Kumar, N., Harris, J.and Rawat, R. (2015). If they grow it, will they eat and grow? Evidence from Zambia on agricultural diversity and child undernutrition. The journal of development studies, 51(8), 1060-1077.

32. Mabhaudhi, T., Chibarabada, T. P., Chimonyo, V. G. P., Murugani, V. G., Pereira, L. M., Sobratee, N., Govender, L., Slotow, R.and Modi, A. T. (2019). Mainstreaming underutilized indigenous and traditional crops into food systems: a South African perspective. Sustainability, 11(1), 172.

33. Mabhaudhi, T., O'Reilly, P., Walker, S.and Mwale, S. (2016). Opportunities for underutilised crops in southern Africa's post–2015 development agenda. Sustainability, 8(4): 302.

34. Makate, C., Wang, R., Makate, M.and Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: adaptive management for environmental change. Springer Plus, 5(1): 1-18.

35. Mal, P., Anik, A. R., Bauer, S.and Schmitz, P. M. (2012). Bt Cotton Adoption: A Double-hurdle Approach for North Indian Farmers. AgBioForum, 15(3): 294-302.

36. Maundu, P. M. (1997). The status of traditional vegetable utilization in Kenya. Promoting the Conservation and Use of Underutilized and Neglected Crops (IPGRI).

37. Mburu, S. W., Koskey, G., Kimiti, J. M., Ombori, O., Maingi, J. M.and Njeru, E. M. (2016). Agrobiodiversity conservation enhances food security in subsistence-based farming systems of Eastern Kenya. Agriculture & Food Security, 5(1): 19.

38. Muthoni, J.and Nyamongo, D. (2010). Traditional food crops and their role in food and nutritional security in Kenya. Journal of Agricultural & Food Information, 11(1):36-50.

39. Mwangi, J. K.and Crewett, W. (2019). The impact of irrigation on small-scale African indigenous vegetable growers' market access in peri-urban Kenya. Agricultural water management, 212, 295-305.

40. Mwaura, S., Muluvi, A.and Mathenge, M. K. (2013). African leafy vegetables and household wellbeing in Kenya: A disaggregation by gender. Retrieved from

41. Nagarajan, L., Smale, M.and Glewwe, P. (2007). Determinants of millet diversity at the household farm and village community levels in the drylands of India: the role of local seed systems. Agricultural Economics, 36(2): 157-167.

42. Ndenga, E., Achigan-Dako, E., Mbugua, G., Maye, D.and Ojanji, W. (2011). Agricultural diversification with indigenous vegetables for cash cropping and nutrition: examples from Rift Valley and Central Provinces in Kenya. Paper presented at the II International Symposium on Underutilized Plant Species: Crops for the Future-Beyond Food Security 979.

43. Padulosi, S., Thompson, J.and Rudebjer, P. (2013). Fighting poverty, hunger and malnutrition with neglected and underutilized species (NUS): needs, challenges and the way forward.

44. Pingali, P. (2015). Agricultural policy and nutrition outcomes–getting beyond the preoccupation with staple grains. Food security, 7(3): 583-591.

45. Pingali, P. L. (2012). Green Revolution: Impacts, limits, and the path ahead. Proceedings of the National Academy of Sciences, 109(31): 12302-12308.

46. Rahman, S. (2008). The economic determinants of crop diversity on farms in rural Bangladesh. Journal of International Agricultural Trade and Development, 5(1), 51-70.

47. Sadoulet, E.and De Janvry, A. (1995). Quantitative development policy analysis (Vol. 5): Johns Hopkins University Press Baltimore.

48. Senyolo, G. M., Wale, E.and Ortmann, G. F. (2018). The determinants of farmers' decision to produce African leafy vegetables in the Limpopo province, South Africa. African Journal of Science, Technology, Innovation and Development, 10(7), 771-778.

49. Shively, G.and Sununtnasuk, C. (2015). Agricultural diversity and child stunting in Nepal. The journal of development studies, 51(8): 1078-1096.

50. Sibhatu, K. T., Krishna, V. V.and Qaim, M. (2015). Production diversity and dietary diversity in smallholder farm households. Proceedings of the National Academy of Sciences, 112(34):10657-10662.

51. 51. Sibhatu, K. T.and Qaim, M. (2018). Farm production diversity and dietary quality: linkages and measurement issues. Food security, 10(1):47-59.

52. Sichoongwe, K., Mapemba, L., Tembo, G.and Ng'ong'ola, D. (2014). The Determinants and Extent of Crop Diversification Among Smallholder Farmers: A Case Study of Southern Province Zambia. Journal of Agricultural Science (1916-9752), 6(11).

53. Tadele, Z. (2009). Role of orphan crops in enhancing and diversifying food production in Africa. Paper presented at the Afr. Techol. Develop. Forum Jour.

54. Taylor, J. E.and Adelman, I. (2003). Agricultural household models: genesis, evolution, and extensions. Review of Economics of the Household, 1(1): 33-58.

55. Van Dusen, M. E.and Taylor, J. E. (2005). Missing markets and crop diversity: evidence from Mexico. Environment and Development Economics, 10(4): 513-531.