Assessing Socioeconomic Factors Influencing Production and Commercialization of Bambara Groundnut as an Indigenous Climate Resilient Crop in Nigeria

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Abstract

Climate change is impacting the cropping system, landscape, livelihoods, and nutrition diversity of farming households and communities in Africa. Climate change adaptability and resilience are emerging as important criteria for setting national priorities for promoting indigenous crops to enhance food and nutrition security, especially of resource-poor smallholders. However, many climate resilient indigenous crops have been lost due to inappropriate policies that fail to prioritize climate resilience and nutritional diversity. Bambara groundnut (*Vigna subterranea*) is an indigenous crop in Africa. It is tolerant to drought, poor soils, and short spells of elevated temperatures. It, therefore, offers several advantages over other legumes as a source of nutrition, food security and improved welfare in the face of climate change. The research investigated farmers' perceptions and socioeconomic factors that influenced the cultivation and commercialization of bambara groundnut and the effect of commercialization on smallholder farmers' welfare in two local government areas (LGAs) of Benue State, Nigeria. In all, 300 smallholder farmers were sampled through a multistage sampling technique. The method of analysis involved the estimation of a fractional regression and treatment effect models. We found that older farmers who perceived that bambara groundnut is a climate-resilient and food security crop allocated more of their total farmland to its production. The perception that bambara groundnut is a climate-resilient crop also impacted positively on the commercialization of bambara groundnut. Formal education coupled with the commercialization of bambara groundnut led to increased farmers' welfare. We recommend that more sensitization and education should be given to farmers on the good characteristics of bambara groundnut as a climate-resilient and food security crop while they are also supported to upscale its production for commercialization purposes.

Keywords

Indigenous crop · Bambara groundnut · Commercialization · Climate resilience · Food security and nutrition · Household welfare

Introduction

Bambara groundnut (BG) is an indigenous drought-tolerant African legume (Chai et al. 2016; Mwale et al. 2007). Nigeria is the biggest producer of BG in Africa (Hillocks et al. 2012). Bambara is mainly cultivated and consumed in the northern parts of Nigeria by smallholders. The crop is important for its climate resilience and nutritive value (Mabhaudhi et al. 2013; Stadler 2009; Brough and Azam-Ali 1992). Its gross energy exceeds that of other common pulses such as cowpea, lentils, and pigeon pea (FAO 1982), and it also contains significant quantities of important dietary nutritional components such as protein, carbohydrate, and fats (Goli 1997). In this respect, it offers several advantages over other legumes as a source of nutrition, including protein content as high as 30% for some landraces (Adebowale et al. 2011). Its protein is a good source of essential amino acids, specifically methionine, cysteine, and lysine (Adebowale et al. 2011; Yao et al. 2015) comparable to other legumes such as cowpea and chickpea, and its carbohydrate has up to 53% starch with high amylose content (Yao et al. 2015; Oyeyinka et al. 2015). BG is also a good source of important dietary fatty acids such as linoleic (18:2, omega-6), linolenic (18:3, omega-3) and oleic acids (18:1, omega-9) (Yao et al. 2015; Minka and Bruneteau 2000; Adeleke et al. 2018; Aremu et al. 2013). In addition to its suitability as a food security crop for subsistence farmers, BG is also capable of fixing nitrogen into the soil, thereby contributing to soil fertility improvement. BG is reported to be tolerant to drought, poor soils, and extreme heat, hence making it a suitable crop to the low-input production systems (Karikari 1996). BG is a significant indigenous legume crop for promoting resilience to climate change, food security, and nutrition (Hillocks et al. 2012; National Research Council 1996).

Bambara groundnut is categorized as a neglected and underutilized crop species (Hillocks et al. 2012; Mkandawire 2007), and it is one of the indigenous legumes that require urgent rescue and inclusion in priority crops for Africa (National Research Council 1996). The search for food system resilience in response to climate change is leading to the re-discovery of the crop. However, the cultivation and scalability of production of BG face some challenges due to the nature of the crop, production potentials, utilization, and market access. In particular, its cropping system appears to be at least partly responsible for BG's underutilization. While, BG is believed to yield well in a mono-cropping system, such systems are not always advantageous to the farmer because local, resource-poor farmers can utilize only a small portion of land for intensive mono-cropping. Another factor limiting the production of BG is attributed to problems with processing and poor knowledge of its utilization for a range of purposes. The utilization of BG, as with other legumes like cowpeas, faces other challenges. It is mainly consumed directly or with little processing but requires a long cooking time to attain a desirable soft texture and palatability (Azam-Ali et al. 2001; Taiwo et al. 1998).

Despite the exclusion of the BG in the priority crop list of most African nations, the significance of BG lies in its potentials for promoting food security and nutrition, climate resilience, ease of production, multiple uses, market potentials, and potential for genetic improvement (Chai et al. 2016; Hillocks et al. 2012; Mwale et al. 2007;

Azam-Ali et al. 2001). Further, there is a dearth of information on the socioeconomic factors that influence BG as an indigenous climate-resilient crop in Nigeria. More importantly, sustainable adoption and scalability of BG depends on how farmers perceive it. Therefore, this chapter assessed the influence of smallholder farmers' perceptions and the socioeconomic characteristics relating to the allocation of land to, and commercialization of BG in Nigeria. It further examined the effect of commercialization of BG on the welfare of farmers who are engaged in growing it.

The rest of the paper is organized as follows. Section "Materials and Methods" discusses the materials and methods, while section "Results and Discussion" presents and discusses the results from the data analysis. In section "Conclusion and Recommendations," the paper concludes with some policy implications.

Materials and Methods

Study Area

The study site is Benue State, Nigeria. Benue State was selected for the study because it is the "Food Basket of the Nation," and lies in the savannah and northern area of Nigeria. In addition, BG is known to be widely cultivated, traded, and consumed in Benue State. Gboko and Kwande local government areas (LGAs) in Benue State correspond with the development domains (Olayide et al. 2009a; Thornton et al. 2002) which were implemented for the study. The development domains involve the combination of population density/market access and agricultural potentials.

Sampling and Spatial Analysis Using GIS Methods

The study utilized a geographic information system (GIS) for spatial analysis (Olayide et al. 2008, 2009a; Omamo et al. 2006; Thornton et al. 2002) to gain a better appreciation of the patterns of agriculture, agricultural development challenges, and opportunities in the study areas. Many types of spatial analysis and mapping are feasible. The current analysis focuses on agricultural development domains representing particular realizations of agricultural potential and population density/access to markets, to visualize differences and similarities in agricultural development priorities and options.

Agricultural Potential and Population Density

Agricultural potential of any location is a strong indicator of agricultural productivity and human welfare. Crop productivity (measured in terms of output per hectare) in BG will hinge on important drivers like length of growing period. Agricultural potential largely influences the absolute advantage (productivity) of a location in production of particular agricultural commodities, while access to markets and infrastructure and population pressure help to determine the comparative advantage (profitability) of particular livelihoods, given the absolute advantages (Pender et al. 1999, 2004). For example, an area with suitable climate and soils may have an absolute advantage in producing high-value perishable vegetables, but little comparative advantage if it is remote from markets and roads.

Improvements in markets or access roads are thus expected to favor production of higher value commodities as well as non-farm activities and should contribute to higher incomes and welfare (Pender et al. 2004). Improved access to markets and infrastructure has more ambiguous theoretical impacts on land use, land management practices, and resource conditions, depending upon the relative impacts on costs of productive factors (Pender et al. 2004) and because of ambiguous effects of output prices on incentives to conserve land. Population density is expected to influence the labor intensity of agricultural production, including the choice of commodities as well as production technologies and land management practices, by affecting the land/labor ratio (Pender 2004).

Population growth may drive expansion of agricultural production into forest or grazing areas, reduce the duration of fallow periods, or induce adoption of land-saving commodities or technologies through crop-livestock intensification, investments in land improvement, and adoption of labor-intensive land management practices through mechanization, among other changes (Olayide et al. 2009a). Without improvements in technologies, markets, or infrastructure, crop-livestock intensification is unlikely to improve welfare, though it may improve resource conditions by inducing land conservation (Olayide et al. 2009b).

Agricultural Potentials

The key factor that endows any location with a comparative advantage to support agriculture-based livelihoods is its biophysical potential to nurture the growth of economically important plants and animals. Location-specific factors strongly influence the types of crops and livestock that will perform well, the risk of exposure to harmful pests, diseases, floods, droughts, and erosion hazards (Omamo et al. 2006). Within Africa (particularly Nigeria), dominated by a smallholder, subsistence-oriented agricultural production base, some of the most binding constraints to improved agricultural production potential have been recognized as the amount and variability of water supply, the biotic pressure of pests and diseases, and soil fertility.

The length of growing period (LGP), defined as the number of days in a year when sufficient water is available in the soil profile to support plant growth, is a shorthand way of capturing agricultural potential in a single layer of attribute. The final number of classes in the development domain surface is the product of the classes in each component layer (agricultural potentials and population density/market access). The length of growing season (LGP) approach (Olayide et al. 2009a) was adopted. Two patterns of LGP were identified for the study area: short (210–239 days) and long (240–269 days). Kwande local government area is classified as long LGP while Gboko local government area has a short LGP (Fig. 1).

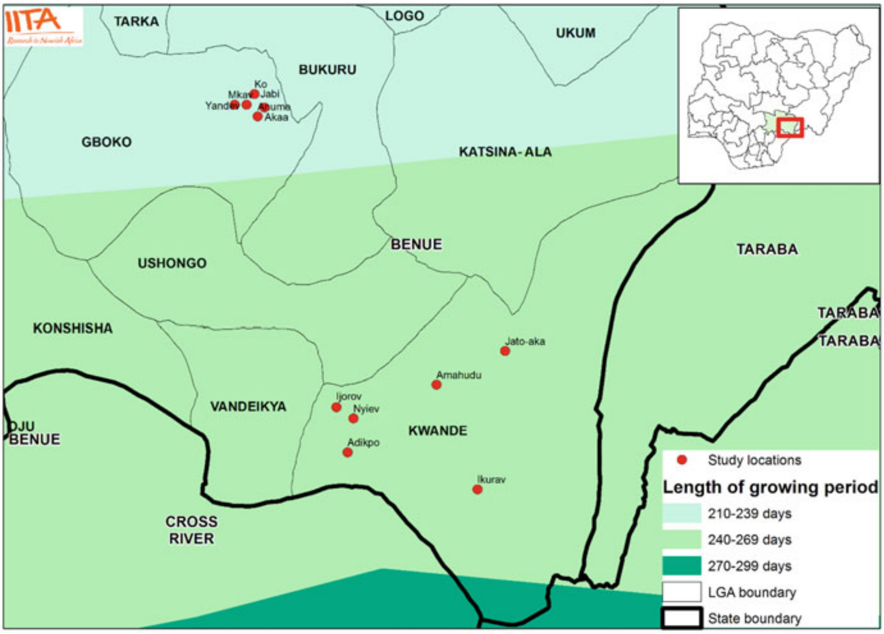

Fig. 1 Agricultural potential map of the study area

Population Density and Market Access

The land-to-labor ratio has been theorized to have consequences for land management and other production technology strategies. This means, holding other factors constant, farmers in areas of high population density are more likely to adopt labor-intensive production strategies than are those in areas of low density. As such, population density is a useful organizing frame for examining land management decisions. Because the development domains will be used to help gauge the potential effects of innovations in rural production and natural resource management strategies, it makes sense to examine the patterns of rural population densities only, to the extent that they can be isolated spatially from urban areas (Omamo et al. 2006).

Another important metric in geospatial analysis of development domains is market access. Market access and population density are often correlated and can be used interchangeably (Olayide et al. 2008). This involves measurement of physical distance or travel time between production locations and predefined market locations. Such market locations are usually determined using settlement population size criteria. The study area delineated by population density was defined as follows: High population density was more than 150 persons per square kilometer while low population density was 75–150 persons per square kilometer. Areas with population density less than 75 persons per square kilometers were not considered (Fig. 2).

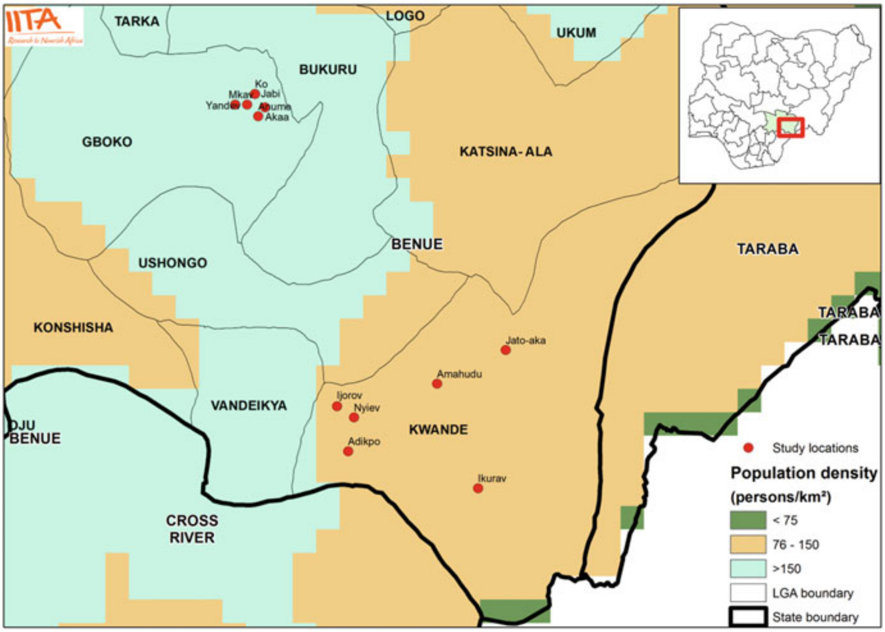

Fig. 2 Population density map of the study area

Data Collection

Farm-household level data were collected using structured questionnaires. Field observations and market surveys were also conducted. A total of 300 farmers were sampled at random from a list of farming households in the study area. The sample comprised 25 farmers from each of the 12 communities in the development domains in Gboko and Kwande local government areas of Benue State, Nigeria. Data were analyzed using descriptive statistics and the estimation of a fractional regression and a treatment effect models. The analytical models are explained in sections "Econometric Model of the Effect of Farmers' Perception of Bambara Groundnut as a Climate Resilient Crop on Land Allocation to Production" and "Modelling the Effect of Commercialization on Welfare of BG Farmers."

Econometric Model of the Effect of Farmers' Perception of Bambara Groundnut as a Climate Resilient Crop on Land Allocation to Production

Consider farmer *i*, who allocates a proportion y, of total arable crop land to BG cultivation. We argue that, the farmer's perception of BG's characteristics as a climate-resilient crop will influence what proportion of land to allocate to its production. Our dependent variable, *y*, therefore assumes a proportional nature, which requires a proportional variable modelling technique (Papke and Wooldridge 1996, 2008). The summary statistics of the proportion of land allocated to BG production indicates that all farmers cultivate at least some area of BG, but others cultivate BG as the sole crop. This means that the proportional dependent variable has no zero, but a one. We therefore use a fractional regression model to analyse the effect of the perception variables on the proportion of land allocated to BG production.

The fractional regression assumes the form

$$g(y) = x_i'b \tag{1}$$

g is a nonlinear distribution or link function that transforms the model such that all predictions from the model fulfil the requirement that $0 \leq \bar{y} \leq 1$. The b coefficients are estimated using the quasi-maximum likelihood function, with the log-likelihood given by

$$\ln L = \sum_{i=1}^{N} w_i y_i \ln\left\{G\left(x_i'b\right)\right\} + w_i(1 - y_i)\ln\left\{1 - G\left(x_i'b\right)\right\} \tag{2}$$

where $N =$ sample size, y is the proportion of land allocated to BG production by farmer i, w is an optional weight, G is the probit or logit link function, and x is the vector of explanatory variables, with specific emphasis on the perception of BG as a climate resilient crop. Empirically, therefore, the land allocation to BG function is expressed as follows:

$$g(y|x) = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + e \tag{3}$$

The definition, measurement, and summary statistics of these variables are presented in Table 1.

Modelling the Effect of Commercialization on Welfare of BG Farmers

We examine how farmers decision to commercialize (produce BG beyond subsistence needs) influence their welfare outcomes in a linear framework as follows:

$$w_i = b_0 + x_i'b + \delta_i c_i + e_i \tag{4}$$

where w_i is the welfare measure for farmer i; b is a coefficient vector associated with control variables x; c is the decision to commercialize (1 if farmer commercializes BG production, 0 otherwise), and e is an unobserved stochastic variable. The effect of commercialization on farmers' welfare, measured by δ, is the primary objective in this model.

Table 1 Definition and measurement of variables

Variable	Definition and measurement	Mean	Std. dev.	Min	Max
y	Proportion of land allocated to BG production	0.72[a]	0.3850	0.0002	1
c	Commercialization dummy; 1 if farmer produces beyond subsistence, 0 otherwise	0.65[a]	0.4778	0	1
w	Welfare (in naira), proxied by natural log of household expenditure	10.521	0.7088	9.190	12.504
x_1	Age, in years	42.00	13.259	19	83
x_2	Primary education dummy; 1 if yes, 0 otherwise	0.18[a]	0.3876	0	1
x_3	Secondary education dummy; 1 if yes, 0 otherwise	0.38[a]	0.4878	0	1
x_4	Tertiary education dummy; 1 if yes, 0 otherwise	0.26[a]	0.4394	0	1
x_5	Vocational education dummy; 1 if yes, 0 otherwise	0.04[a]	0.1963	0	1
x_6	Perception that BG requires little rainfall (drought-tolerant) compared to other legumes, index	2.13	1.8444	1	4
x_7	Perception that BG is a food security crop and that it is readily available; index	2.34	1.8915	1	4
x_8	Perception that BG is a food security crop and that it is accessible; index	2.37	1.8304	1	4
x_9	Perception that BG is a food security crop and that it is affordable; index	2.36	1.8633	1	4
x_{10}	Perception that BG requires little or no manure or fertilizer; index	2.14	1.8999	1	4
x_{11}	Perception that BG is less tedious to cultivate; index	2.51	1.9865	1	4
x_{12}	Community; 1 if Kwande, 0 if Gboko	0.5[a]	0.5008	0	1
x_{14}	Household size, number of persons	6.89	3.0707	1	18
x_{15}	Formal grain market: dummied; 1 if present in community, 0 absent	0.26[a]	0.4394	0	1
x_{16}	Nature of road: dummied; 1 if tarred, 0 otherwise	0.72[a]	0.4505	0	1
x_{17}	Fertilizer: dummied; 1 manual, 0 if otherwise	0.75[a]	0.4356	0	1
x_{18}	Weeding: dummied; 1 if manual, 0 otherwise	0.68[a]	0.4659	0	1
x_{19}	Ploughing: dummied; 1 if manual, 0 otherwise	0.92[a]	0.2665	0	1
x_{20}	Sex: dummied; 1 if male, 0 if female	0.39[a]	0.4893	0	1

[a]indicates that the value is a proportion

But, the decision variable (commercialization) is endogenous in the model because the decision to commercialize or not is nonrandom. Farmers could self-select into being commercial based on inherent unmeasured attributes such as innovativeness, risk-aversion, comparative advantage, among others which could also influence welfare (Cerulli 2014; Maddala 1983). Failure to account for this self-selection and going ahead to estimate the model with ordinary least squares (OLS) regression could lead to biased estimates (Greene 2003; Wooldridge 2009).

Therefore, to address this self-selection bias we estimate the welfare model augmented with an endogenous treatment effect commercialization variable. This process generates the latent continuous commercialization function:

$$c_i^* = z_i' \gamma + v_i, \tag{5}$$

where $c_i = \begin{Bmatrix} 1 \ if \ c_i^* > 0 \\ 0 \ if \ c_i^* \le 0 \end{Bmatrix}$

where γ is a vector of unobserved parameters to be estimated, z is a vector of observed explanatory variables influencing the decision to commercialize, and v is an independently and identically distributed error term. The latent variable model describes the process that generates observed farmers' decisions towards commercialization of BG. The two error terms, e_i and v_i, follow a bivariate normal distribution with mean vector zero and covariance matrix:

$$\begin{bmatrix} \sigma_1^2 & \rho\sigma_1 \\ \rho\sigma_1 & 1 \end{bmatrix} \tag{6}$$

where ρ is the covariance estimate of the correlation between the two error terms, indicating how unobservable variables that influence welfare correlate with unobservable variables that influence decision to commercialize. A statistically significant test of $\rho = 0$ indicates evidence of selectivity bias, giving credence to the endogenous treatment effect as opposed to the simple OLS regression. A positive value of ρ indicates that unobserved variables that increase welfare tend to be associated with unobserved variables that increase the likelihood of commercializing. A negative value shows that unobserved variables that increase welfare occur with unobserved factors that decrease the likelihood of commercializing (Cameron and Trivedi 2010).

Empirical Model

We regress the natural log of welfare (measured in terms of household expenditure) on commercialization and other variables as follows:

$$lnw_i = b_0 + \sum_{k=1}^{7} b_k x_{k,i} + \gamma_i \lambda_i + e_i \tag{7}$$

where λ is the Inverse of Mills Ratio (IMR), which measures the ratio of the probability density function of the standard normal distribution to its cumulative distribution function. The IMR is generated from the treatment equation before being included in the substantive model to estimate the effect of commercialization on welfare.

The treatment equation is empirically specified as

$$c_i = \gamma_0 + \sum_{j=1}^{10} \gamma_j z_{j,i} + v_i \tag{8}$$

Results and Discussion

Descriptive Statistics of Variables Used in the Estimation Model

Table 1 shows the descriptive statistics of the variables used in the estimation of the models. The sample involved 39% male and 61% female farmers. On average, farmers allocated 72% of their total farmland to the production of BG. In fact, some farmers allocated all their plots to the cultivation of the legume. These are perhaps the mono-croppers. Also 65% of the farmers produced BG beyond home requirements for consumption. We categorized these farmers as commercially oriented while the subsistence farmers were those who produced just enough for home consumption. This is the dependent variable for the selection equation of the treatment effect model. The average welfare (in Naira) was 37,049.12, ranging from 9,798.65 and 268,337.29. The average age of the farmers was 42 years also ranging from 19 to 83 years. This shows that the BG farmers were young adult. This is good for the long-term production of the crop. The educational background of the farmers is quite encouraging, considering the fact that the highest percentage of them had secondary education (38%), followed by tertiary education (26%), primary education (18%) and vocational education (4%). The percentage of farmers with no formal education was 14%. A high level of formal education augur well for quick technology uptake and other modern forms of farming and marketing of agricultural produce (Sheikh et al. 2003).

With respect to the perception variables, as indicated earlier, the Likert scale was given as 1 for strongly agreed SA and 4 strongly disagreed (SD). The mean scores for almost the perception variables are approximately 2.00. This means that on a whole the respondents agreed with the statement they were given about BG. For instance, with the mean scores of 2.13 and 2.14, respectively, the respondents generally agreed with the statements that “Bambara groundnut is drought tolerant” and “Bambara groundnut requires little or no fertilizer or manure.” Similarly, the respondents agreed with the statements that Bambara groundnut as a food security crop is readily available (2.34); it is affordable (2.36) and it is accessible (2.37).

However, with the mean score of 2.51, there was less agreement among respondents with the statement that BG is less tedious to cultivate.

The average household size was 6.89 ranging from 1 to 18 members. Only 26% of the respondents indicated that there was a legume market in their community. Also, 72 farmers had tarred roads leading to their communities. Similarly, technology used on the farms as a whole (BG farms and other farms) was traditional (manual). For instance, 75%, 68%, and 92% used traditional means (manual means) to apply fertilizer, weed, and plough their farms respectively. We took equal samples of farmers from Kwande (50%) and Gboko (50%) LGAs. The total sample consisted of 39% males and 61% females confirming the general notion that BG is women's crop (Adzawla et al. 2016b).

Farmers' Perceptions of BG as a Climate-Resilient and Food Security Crop and its Effect on Land Allocation to BG Production

The first objective was to investigate the extent to which respondents' perceptions about BG as a climate-resilient/drought tolerant and food security crop influence the proportion of land allocated to BG production. BG was perceived as a climate-resilient crop/drought tolerant, suggesting that the greater the farmer knowledge in regards to the reality of climate change and the crop's resilience to climate change, the greater the proportion of land she/he would allocate to BG. A large proportion of land allocated to the production of a crop does not necessarily mean higher output. Intensification of production may sometimes even lead to higher output per unit area of land than just increasing the area cultivated (extensification) with less proportional increase in output per land area.

From the results in Table 2, eight of the variables are significant in explaining the dependent variable (i.e., proportion of land allocated to BG production). While three variables are negatively related to the dependent variable, the other five significant variables are positively related to the dependent variable. The Wald chi-square test is significant at 1% indicating that the explanatory variables jointly determine the dependent variable. Also, the pseudo R-squared is almost 50% implying that the model is good in that the estimator was able to predict 50% of the variation in the dependent variable. Normally, in the estimation of a fractional regression model, the marginal effects are relevant. However, discussion on this is not considered due to the very low values of 0.001 or less.

It should be recalled that the Likert scale used to measure the dependent variable was such that one (1) represents strongly agreed (SA) while four (4) represents strongly disagreed (SD). This means that the negative coefficient of the climate change-related perception variable "bambara groundnut requires little rainfall" and "bambara groundnut requires little fertilizer or manure" implies that farmers who perceived that bambara groundnut is a resilient crop that does well with less rainfall and poor soils, allocated a greater proportion of their total farmland (72%) to its production. Negative signs for coefficients indicate the agreement on the independent variables. In Adzawla et al. (2016b) also, a majority of the farmers shared the

Table 2 Determinants of bambara groundnut land share

Variable	Coefficient	Standard error	Marginal effect	Standard error
Age	0.0276**	0.0107	0.000002***	0.0000009
Primary education	0.5078	0.5093	0.000057	0.000055
Secondary education	0.1678	0.4546	0.000016	0.000041
Tertiary education	0.5606	0.4749	0.000037	0.000036
Vocational education	1.3409*	0.7670	0.000064*	0.000037
Perception rainfall	−0.419***	0.1468	−0.000035***	0.000012
Food availability perception	−0.3953*	0.2154	−0.000033*	0.000018
Food accessibility perception	0.1571	0.3002	0.000013	0.000025
Food affordability perception	0.4768*	0.2439	0.000040*	0.000020
Fertilizer perception	−0.3926**	0.1571	−0.000033**	0.000013
Perception on BG is tedious	0.4627***	0.1183	0.000038***	0.000010
Domain (LGA)	19.2889***	0.2598	0.001601***	0.000165
Constant	−1.4424	0.9632		

N = 300
Wald chi2(12) = 11002.92
Prob>chi2 = 0.0000
Pseudo R^2 = 0.5018

Note: *** and ** and *represent 1%, 5% and 10% significant levels respectively

opinion that BG requires little rainfall and does not require the use of fertilizers. The policy implication of this finding is that if more farmers were to expand the area of their farms under BG, then there would be the need for awareness of the reality of climate change and the resilience of BG to thrive in drought condition or harsh climatic environments. Wasula et al. (2014) also found that there was limited knowledge about the importance of BG in the Kakamega county of Kenya. However, in the case of the perception that BG cultivation is tedious, the positive sign means that farmers who perceived this allocated a smaller proportion of their farmland to cultivating the crop. This is also plausible and instructive.

Similarly, farmers who perceived that BG was a food security crop, in terms of it being available, allocated a greater percentage of their farmland to its cultivation. However, farmers who perceived that the crop was affordable cultivated less. Both findings are plausible because if the crop is affordable, then one can decide to cultivate less and concentrate on major cash crops so that incomes from the sale of such cash crops may be used to buy BG. The negative coefficient of the "availability" variable is also as expected because availability does not necessarily mean that one can have it for free. In other words, if the crop is available but there is no money to buy it, then you have to cultivate (more of) it. In the Wasula et al. (2014) study, 92% of the respondents perceived that the production of BG ensures food security because it is drought and pest resistant.

Furthermore, the positive sign of the coefficient of the education variable shows that the smallholder farmers with vocational education (mostly full-time farmers without formal education) cultivated BG more than those with formal education. Such farmers are likely to know more about the indigenous crop and climate-resilient nature of BG and therefore allocate more of their farmlands to cultivation of BG. This finding was consistent with Adzawla et al. (2016a) where the probability of going into BG cultivation was lower for famers who had formal education. In the studies by Awunyo-Vitor et al. (2013), Donkoh et al. (2013) and Shehu et al. (2010) farmers with formal education were more technically efficient than those with little or no formal education (including vocational education). Hence, any policy intended to upscale the production of BG could therefore target smallholder farmers that have both formal education and vocational skills.

The positive coefficient of the age variable also indicates that the older farmers have a greater probability of allocating a greater proportion of their farmlands to BG cultivation than the relatively young farmers. This is also plausible, considering that BG is an indigenous crop which has been with the farmers for a long time. The danger, however, is that if the young farmers are not aware and educated about the good characteristics of the crop, BG may remain a crop for the older generation without formal education and prone to extinction. Therefore, there is an urgent need to bring young farmers on board the cultivation of BG.

Further, Kwande farmers tend to allocate more of their farmlands to BG than Gboko farmers. This is also plausible because Kwande has high agricultural potentials, including longer growing season and market access.

Effect of Bambara Groundnut Commercial Orientation on Farmers' Welfare

The second objective of the study was to determine the effect of commercial orientation of BG on the welfare (consumption expenditure) of farmers' household. This was done by estimating a treatment effect model with the commercialization equation being the selection equation and the welfare being the substantive equation. The negative coefficients are indications that the responses tend to zero while positive signs means otherwise (please refer to results in Table 1).

From Table 3, the factors that are significant in influencing the market orientation of farmers are the climate change (rainfall) variable, the availability of a legume market in their community, and the technology variables. The results indicate that the probability of a farmer going commercial in the production of BG was greater for farmers who perceived that BG required less rainfall. This is logical because with this knowledge, the farmer would expand the BG farm so as to realize greater output for sale. Similarly, with the farmers' orientation to go commercial, they would want to be oriented towards modern/improved technology adoption rather than maintaining traditional production methods. The results indicate that the probability of going commercial was lower for farmers who did fertilizer application and weeding manually as opposed to those who used modern or improved technologies

Table 3 Factors influencing the commercialization of bambara groundnut

Variable	Coefficient	Standard error
Age	0.0002	0.0097
Household size	0.0027	0.0389
Food availability perception	0.1984	0.1463
Rainfall perception	−0.2729***	0.0926
Fertilizer perception	0.1204	0.1402
Legume market	−0.6761***	0.2399
Nature of road	0.0723	0.2238
Fertilizer application technology	−0.5698**	0.2577
Weeding technology	−0.5022***	0.1868
Ploughing technology	−0.6048**	0.2934
Constant	1.5980	0.9844

N = 125
Wald chi2 (8) = 78.88
Prob>chi2 = 0.0000
Wald test of independent equations (rho): chi2(1) = 22.28
Prob>chi2 = 0.0000

Note: ***, ** and *represent 1%, 5% and 10% significant levels respectively

on their farms. Similarly, the negative sign of the legume market variable is inconsistent with the a priori expectation. It was expected that the availability of legume markets in a community would motivate farmers to go into commercial production of BG. But theoretically (and in practice), availability of a market in a location of production may not necessarily encourage production since markets serve to move commodities from a point of surplus to a point of scarcity (Olayide et al. 2009b). It implies that BG may be found in higher concentration outside its primary area of production or ex situ markets.

Table 4 shows the results of the determinants of welfare of farmers. The positive and significant sign of the commercialization variable confirms the a priori expectation that producing BG on a commercial basis would lead to increased welfare of farmers. It should be noted that producing in commercial quantities (marketable surplus) does not only increase the welfare of the producers but it goes to bring development to the community and indeed the nation as a whole. Of course, this is based on the assumption that BG does not crowd out the production of other staple crops. Farmers with formal primary and secondary education also have a greater welfare than those without formal education. This is also consistent with our a priori expectation because farmers with formal education have access to information and efficient farm management practices. The negative sign on household size variable is also consistent with other findings. This is, arguably, because large household size is an indication that the household has more persons to feed (assuming that the income level is fixed), which means that the household would be poor or have relatively low welfare index. Adzawla et al. (2016a) and Donkoh et al. (2014) also found negative correlation between household size and welfare.

Table 4 The Determinants of farmers' welfare

Variable	Coefficient	Standard error
Age	–0.0082	0.0056
Primary education	0.3528*	0.1815
Secondary education	0.2755*	0.1558
Tertiary education	0.1261	0.1665
Vocational education	0.2397	0.2329
Household size	–0.1129***	0.0219
Output	0.0602	0.0593
Commercialization	0.7872***	0.1845
Constant	9.1551***	0.5734

Note: *** and *represent 1%, and 10% significant levels respectively

The non-significance of the output variable is surprising because the expectation was that farmers who increased output would have increase welfare. However, the significance of the commercialization variable is instructive as it implies that increased output may not necessarily lead to increased welfare, but it is when the output is sold that it would necessarily lead to increased welfare. The results also revealed that the increase in output may be used to satisfy domestic food and nutrition needs of the households, and not necessarily for generating income for the households.

Conclusion and Recommendations

This chapter investigated the extent to which farmers' perceptions about BG as a drought-tolerant, climate-resilient, and food security crop influence the allocation of their farmlands to the production of the indigenous legume. It also estimated the effect of commercialization of BG on the welfare of smallholder farmers. A total of 300 smallholder farmers were sampled from Kwande and Gboko local government areas of Benue State, Nigeria, through a multistage sampling technique. A fractional regression model was estimated to analyze the extent to which farmers' perceptions about BG as a drought-tolerant, climate-resilient,food security, and nutrition crop influence the allocation of their farmlands to the production of the indigenous legume while a treatment effect model was also estimated to analyze the effect of commercialization of BG on the welfare of smallholder farmers.

It was found that the percentage of farmers' total farmlands allocated to BG production was high for the following: older farmers; farmers who had vocational/extension service training; farmers who perceived that BG production requires less rainfall (that is, drought tolerant); farmers who perceived that BG production requires less manure/fertilizer; farmers who perceived that BG is a food security crop and is available; and farmers who lived in area of high agricultural potential as opposed to those who lived in area of low agricultural potential. The percentage of farmers' total farmland allocated to BG production was also high for the following: farmers who perceived that the cultivation of BG was less tedious; and farmers who perceived that BG as a food security and nutrition crop. Similarly, the following categories of farmers were more commercially oriented: those who perceived that BG production requires less rainfall (climate resilient); farmers who had a legume market outside their community; farmers who adopted modern/improved methods of applying fertilizers and herbicides.

Household welfare was also relatively high for commercially oriented farmers, farmers with small household size, and those who had primary education. The following conclusions can be made from the key findings: BG is cultivated because it is perceived as a climate resilient, food security, and nutrition crop. This is a good motivation and incentive to scale up the production of the crop. Secondly, commercializing BG can help to increase farmers' welfare. It is hereby recommended for promotion as a welfare-improving crop. Thirdly, awareness and education should be given to farmers about the crop's characteristics as a drought resilient, food security, and nutrition crop.

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