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Factor Productivity of Male and Female Bambara Groundnut Farmers in Northeast, Nigeria

Chinwe Prisca Osayi[1*], Anselm Anibueze Enete[2] & Nnaemeka Andegbe Chukwuone[2]

[1]Department of Agricultural Economics and Extension, Federal University Wukari, Taraba State, Nigeria

[2]Department of Agricultural Economics, University of Nigeria Nsukka, Nigeria

orcid.org/0000-0002-4487-2148
orcid.org/0000-0003-3280-1753
orcid.org/0000-0003-3510-4152

Corresponding Author: **Chinwe Prisca Osayi**

Abstract: Increasing agricultural productivity is very crucial for ensuring sufficient food supply for the growing population. Low factor productivity is a bottleneck to stimulating economic growth and enhancing food security. The study estimated and compared the total and partial factor productivity of Bambara groundnut production and also analyzed their determinants. It adopted a survey design. A multistage sampling technique was used to select 720 smallholder Bambara groundnut farmers. Primary data was collected from the farmers using a well-structured questionnaire. The partial and total factor productivity measures, constant elasticity model as well as a paired samples z- test were used to realize the objectives. The results showed that the female farmers had higher revenue from Bambara groundnut farming than their male counterparts. Three factors (land, labor and other material inputs) were productive for both male and female Bambara groundnut farmers. However, labor had the least productivity index among the three factors for both male and female Bambara groundnut farmers. The male farmers significantly had higher total and partial factor productivity of land and other material inputs whereas the female farmers significantly had higher total and partial factor productivity of labor. Age, net farm income, farming experience, farm size, level of education, access to credit, banditry/herdsmen attack and household size among others, were the significant factors that determined both total and partial factor productivity of the farmers. Any policy aimed at improving the factor productivity (total and partial) of male and female Bambara Groundnut farmers should target the significant factors influencing their productivity.

Keywords: Bambara groundnut, Constant elasticity model, Factor Productivity, Z-Test

Introduction:

The primary aim of the global community is to enhance agricultural productivity in order to ensure a sufficient food supply for the expanding population (Hemathilake & Gunathilake, 2022). Recent research statistics have revealed that agricultural production has significantly stalled, and the yield of major grain crops is much lower than the world's population growth rate (Hemathilake & Gunathilake, 2022). Fluctuations in food supply remain a major challenge, particularly in Sub-Saharan Africa, where improving agricultural productivity has been found to contribute significantly to food security (Ogunlesi, et al., 2018). Ensuring food security for the growing global population is a big challenge, and the growing of different crops like nuts has played a crucial role in food security (Ebe et al., 2018). In recent years, productivity research has garnered significant attention from economists and policymakers due to the belief that meaningful economic development and welfare improvement cannot be achieved without productivity growth. This growth is of utmost importance as it not only increases the output of the agricultural sector but also enhances its competitiveness in both domestic and international markets (Muhammad & Ather, 2015). Moreover, the exponential growth in agricultural productivity has a profound impact on the enhancement of rural standards of living, as it effectively amplifies the overall income generated through agricultural activities in developing economies.

The efficiency with which inputs are utilized in the production process, specifically in terms of their combined effect on output is called Factor Productivity (Raza & Lin, 2022). It is a measure of the productivity of all inputs or factors of production, such as physical capital, labor, and human capital, in generating output (Nakashima et al., 2022). Technological change and more efficient methods of production are often considered the main drivers of factor productivity growth, which in turn serves as an indicator of long-term economic growth (Zheng et al., 2020). Factor productivity consists of total factor productivity (TFP) and partial factor productivity (PFP) (Dusha, 2019). TFP, which represents Total Factor Productivity, is a valuable metric that quantifies the relationship between the overall output, which includes an array of both crop and livestock products, and the total production inputs, including labor, land, and capital (Dusha, 2019). This measurement serves as a comprehensive indicator, shedding light on the efficiency and effectiveness of the production process, as it captures the extent to which inputs are utilized to generate the final output.Partial factor productivity (PFP) measures, specifically labor and land productivity, they are commonly employed for the evaluation of agricultural production performance due to their ease of estimation (Gaitán-Cremaschi et al., 2017). Notably, these measures of productivity typically exhibit higher growth rates compared to TFP since advancements in land and labor productivity may arise from more intensive utilization of inputs, such as fertilizer and machinery, rather than a direct increase in TFP (Kvasha, 2019). In instances where productivity escalates without a

corresponding increase in inputs, TFP stands as the sole source of growth, Kvasha further buttressed.

Increased Factor productivity is one of the strong alternatives for stimulating economic growth and enhancing food security (Audu & Aye, 2014). It is one of the major instruments to end extreme poverty and hunger, enhance growth in the sector leading to employment creation, elevated income, increased food consumption and nutrition for the population (Oyinboet al., 2015). However it is undermined by gender-related constraints and unequal access to productive resources as well as opportunities (Obisesan, 2014). Production of nuts in the northeast part of Nigeria is challenged by such factors as low productivity, inefficiency of the farmers leading to low standard of living among farming households (Dagachi & Olorunsanya, 2023). In northeast Nigeria Bambara groundnut is being produced alongside other forms of nuts as food security crops and it is an underutilized legume species, ordinarily regarded as a ‘‘poor man’s’’ crop, and mostly known as a ‘‘women’s crop’’ grown only to achieve family food security (Adegboyega et al., 2021). Men also engage in Bambara groundnut production in northeast Nigeria (Ibrahim et al., 2018). It was also recently declared one of the ‘‘crops for the new millennium’’ and it reportedly ticks the box as a crop for achieving food security (Olanrewaju et al., 2022).

However, despite that Bambara groundnut is efficient at, supporting sustainable land uses, fostering pastoral improvement, boosting food assurance, and promoting nourishment, the level of its production in the region is low compared to peanuts (*Arachis hypogea*) and cowpeas (*Vigna unguiculata*) whose production dominated the region (Muhammad *et al.*, 2020). This may be due to lack of understanding of the level of factor productivity and efficiency of resource use expected to bring about desired increase in production and profitability of Bambara groundnut production in the region.

Many empirical studies on Bambara groundnuts production have done little in uncovering the factor productivity in the production of this nuts and how this has translated to improving the welfare of farmers in the northeast region of Nigeria. As population of people in the region in particular and in Nigeria in general continues to rise at an annual population growth rate of 2.6% (World Bank, 2020), total land holding per household in the region is becoming smaller and smaller, implying that the opportunity to increase the productivity of Bambara groundnut farmers through farm size expansion is becoming nil. As a result, measuring the factor productivity is highly important to improve production and productivity with a given level of resources and lack of understanding of the levels of factor productivity in Bambara groundnuts production in the region poses serious threat to effective policy decisions that will help to increase the level of production and profitability of farmers in the region and to encourage the

involvement of more farmers in the production of Bambara groundnuts in the region. A number of studies have looked at ways of improving the productivity of farmers in developing countries (Abdulai et al., 2013; Onuche & Oladipo, 2020), however, very few studies have assessed the factor productivity of Bambara groundnut farmers and their determinants in northeast Nigeria based on the current economic state of the country and the heightened banditry crisis facing farmers in the northeast Nigeria and this work tends to fill the gap.

Materials and Methods:

The Study was conducted in Northeast, Nigeria. The area is one of the zones in Nigeria. The states in this area includes: Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe. It shares boundaries with Chad Republics and Cameroon to the east, Plateau and Benue States to the South, Kano and Jigawa States to the West and Niger Republic to the North. The area lies between latitudes 7° 30' and 14° North of the equator and longitudes 9° and 15° East of the Greenwich meridian. It occupies less than one-third of Nigeria's total area and have population of 26 million, or 12% of the country's population (Worldometer, 2021). Some of the major crops grown in the area include rice, yam, maize, millet, potato, sorghum, cowpea, and Bambara groundnut (Ojanuga, 2006). The farmers are also known for rearing of livestock. The Climatic Condition of the area is marked by two seasonal variations; the dry season that is experienced between October to April and the rainy season from June to September with a little break in August commonly called the August break. Bambara nut, a seasonal legume is grown widely in the area, during rainy season.

In selecting respondents for this study, a 2 stage purposive and 2 stage random sampling was used for this study. The purposive sampling was based on the availability of valid household Bambara groundnut farmers in the study area. Out of the 6 States in the North East, a purposive sampling method was used first to select 3 States in the zone. The states with the evidence of valid or contact household Bambara groundnut farmers were selected for the study. The States are Adamawa State, Bauchi State and Taraba State. The second stage is a purposive selection of 6 local government areas from each of the selected state that showed evidence of household Bambara groundnut farmers in the area making it a total of 18 local government areas. Thirdly 2 communities were randomly selected from each local government area making it a total of 36 communities. From each community, a stratified random sampling technique was used to select 10 female and 10 male Bambara groundnut farmers making 360 male and 360 female Bambara groundnut farmers. In total, 720 Bambara groundnut farmers were used for this study. The sample frame which is the list of Bambara groundnut farmers in the selected communities were compiled with the assistance of staff of Agricultural Development Program (ADP), resident

extension agents, officials of farmers association and community leaders. Primary data, collected with the aid of a well-structured questionnaire were used in the study. The questionnaire was validated by three experts from the department of Agricultural Economics, University of Nigeria, Nsukka. The partial and total factor productivity measures, constant elasticity model (log linear regression model), as well as a paired samples z- test were used to realize the objectives.

Factor productivity (total and partial)

The factor productivity of Bambara groundnut farmers was assessed through the utilization of both partial and total factor productivity measures. Partial factor productivity (PFP) entails the calculation of the ratio between the output quantity or value and a single input or its corresponding value. On the other hand, total factor productivity (TFP) involves the computation of the ratio between the total output quantity or gross value and the quantity or value of all inputs employed in the process (Ebe, et al., 2018). Therefore, to estimate the partial factor productivity (PFP), and total factor productivity (TFP) of the factors used in the production of Bambara groundnut along gender line, the productivity indices were estimated thus:

$$\text{Total factor productivity (TFP)}_i = \frac{\text{Value of the quantity of Bambara groundnut Output (₦)}}{\text{Total value of inputs used (₦)}} \quad (1)$$

$$\text{Partial factor productivity (TFP)}_i = \frac{\text{Value of the quantity of Bambara groundnut Output (₦)}}{\text{Value of a particular inputs used (₦)}} \quad (2)$$

The partial factor productivity of land, labor and other material inputs used in the production of Bambara groundnut in the study area is expressed as:

$$\text{Land productivity (TFP)}_i = \frac{\text{Value of the quantity of Bambara groundnut Output (₦)}}{\text{Value of land used (₦)}} \quad (3)$$

$$\text{Labor productivity (TFP)}_i = \frac{\text{Value of the quantity of Bambara groundnut Output (₦)}}{\text{Value of labor used (₦)}} \quad (4)$$

$$\text{Other material inputs productivity (TFP)}_I = \frac{\text{Value of the quantity of Bambara groundnut Output (₦)}}{\text{Value of other material inputs used (₦)}} \quad (5)$$

Where subscript i is stance for (1) Male Bambara groundnut farmers and (2) Female Bambara groundnut farmers.

The paired samples z-test was used to compare the factor productivity of male and female Bambara groundnut farmers in northeast region of Nigeria and is explicitly specified in line with Ikoro (2021) as;

$$Z_{cal} = \frac{\bar{X}_i - \bar{X}_j}{\sqrt{\frac{S^2\bar{X}_i}{n_i} + \frac{S^2\bar{X}_j}{n_j}}} \quad (6)$$

Where;

$\bar{X}_i$= mean factor productivity of male Bambara groundnut farmers;

$\bar{X}_j$= mean factor productivity of female Bambara groundnut farmers;

$S^2\bar{X}_i$ = standard deviation of the factor productivity of male Bambara groundnut farmers;

$S^2\bar{X}_j$=standard deviation of the factor productivity of female Bambara groundnut farmers;

n_i= number of male Bambara groundnut farmers that were sampled;

n_j= number of female Bambara groundnut farmers that were be sampled.

Constant elasticity model (log-linear multiple regression model)

The determinants of factor productivity in Bambara groundnut production was achieved using constant elasticity model (log-linear multiple regression model). The constant elasticity model ensures that all the variables are transformed to their log forms which help to stabilize the heteroscedastic response variance thereby improve the model fit of the data. Transformations eliminates interactions and heteroscedasticity, leading to greater tenability of assumptions, increased sensitivity of main effects significance tests, and simpler interpretations in moderated regression and analysis of variance models. The constant elasticity model also regarded as the log-linear regression model is explicitly specified in line with Akpan et al. (2011) as:

$$\text{Log(TFP)}_j = \beta_0 + \beta_1\text{log}Z_1 + \beta_2\text{log}Z_2 + \beta_3\text{log}Z_3 + \beta_4\text{log}Z_4 + \beta_5\text{log}Z_5 + \beta_6\text{log}Z_6 + \beta_7\text{log}Z_7 + \beta_8\text{log}Z_8 + \beta_9\text{log}Z_9 + \beta_{10}\text{log}Z_{10} + \beta_{11}\text{log}Z_{11} + \mu \quad (7)$$

Where;

TFP = Total factor productivity (measured as the ratio of the value of Bambara groundnut output to the value of total inputs used, measured in naira)

Z_1 = Age of respondents in years

Z_2 = Net farm income of the farmers in naira

Z_3 = Farming experience of farmers in years

Z_4 = Household size (head count of individual in a household the eats from the same pots)

Z_5 = Land/tenure security status (Dummy, Ownership = 1, Otherwise = 0)

Z_6 = Farm size in hectares

Z_7 = Level of education in years spent in schooling

Z_8 = Access to credit (Yes = 1; No =0)

Z_9 = Extension visits (number of contacts with extension worker in the last production year)

Z_{10} = Banditry/herdsmen attacks (number of occurrences of attacked on farmland by bandits/ herdsmen)

Z_{11} = Distance to farmland in kilometer

μ_i = Error term

$\beta_0 - \beta_{12}$= Parameters to be estimated.

j = Stance for (1) Male Bambara groundnut farmers, and (2) Female Bambara groundnut farmers.

log = Stance for natural logarithm.

Equation (7) was also used to estimate the partial factor productivity of land, labor and other material inputs for male and female Bambara groundnut farmers in the study area.

Results

Factor productivity of male and female Bambara groundnut farmers in Northeast Nigeria

The productivity was estimated using partial and total factor productivity. The gross values of output of Bambara groundnut of the male and female farmers, alongside the values of each production factor are presented in Table 1 along with the respective productivity indices of the production factors. The Table 1 shows that on the average, the female Bambara groundnut farmers realized N1,503,725.00 from Bambara groundnut production, while male farmers realized N1,386,396.77. Averagely, female Bambara groundnut farmers earned N117328.23 than their male counterpart. The total cost of inputs utilized by female Bambara groundnut farmers in achieving this revenue was N450,103.73 while the male Bambara groundnut farmers utilized N534,577.16 for the same production purpose in the last production year. It also shows that land had partial productivity indices of 15.90 for female Bambara groundnut farmers and 38.58 for male farmers. Labor had partial productivity indices of 6.19 for female Bambara groundnut farmers and 3.38 for male farmers, while other material inputs (seeds, agro-chemicals and fertilizer) had partial productivity indices of 13.34 for female Bambara groundnut farmers and 15.60 for male farmers. The result shows that the three factors were productive for both male and female Bambara groundnut farmers as each one of them was more than one. The findings further indicate that labor had the least productivity index among the three factors for both male and female Bambara groundnut farmers. The total factor productivity for male and female farmers were 3.34 and 2.59 respectively. This shows that the total factors for both male and female Bambara groundnut farmers were productive.

Table 2 shows that the total factor productivity, and partial factor productivity of land, labor and other material inputs of female and male Bambara groundnut

farmers in Northeast Nigeria differs significantly. The result shows that female Bambara groundnut farmers significantly had higher TFP (z=8.284 at P<0.05) and partial factor productivity of labor (z =21.072 at P<0.05) than their male counterparts whereas the male Bambara groundnut farmers significantly had higher land partial factor productivity (z=4.477 at P<0.05) and other material inputs partial factor productivity (z=3.497 at P<0.05) than their female counterparts.

Determinants of total and partial factor productivity of Bambara groundnut farmers

Table 3 shows the result of the constant elasticity model of the determinants of total factor productivity of male and female Bambara groundnut farmers in the study area. The result shows that the explanatory variables included in the model accounted for 61.6% and 67.5% variations in the female and male models respectively. The results further shows that age, net farm income, farm size and level of education were the significant factors that determined the total factor productivity of male Bambara groundnut farmers in Northeast Nigeria. Age was negatively signed whereas net farm income, farm size and level of education were positively signed. Similarly, age, net farm income, household size, farm size, level of education, access to credit and banditry/herdsmen attacks were the significant factors that determined the total factor productivity of female Bambara groundnut farmers in northeast Nigeria. Age and banditry/herdsmen attacks were negatively signed whereas net farm income, household size, farm size, level of education, and access to credit were positively signed.

Table 4 shows the regression results of the determinants of partial factor productivity of land, labor and other material inputs for male and female Bambara groundnut farmers in the study area. The result shows that land partial productivity for male and female Bambara groundnut farmers in the study area was determined by such factors as age, net farm income, farming experience, household size, tenure security status, farm size, level of education, and distance to farmland. Age of the respondents, net farm income, tenure security status, and farm size was positively signed while level of education and distance to farmland were negatively signed in the factors influencing land partial productivity of male Bambara groundnut farmers. Age of the respondents, net farm income, farming experience, household size, tenure security status, and farm size positively influenced the land partial factor productivity of female Bambara groundnut farmers whereas, distance to farmland negatively influenced it. The result in Table 4 further shows that age and level of education negatively influenced the labor partial factor productivity of male Bambara groundnut farmers whereas, net farm income, and farm size positively influenced it. Also, age, level of education and banditry/herdsmen attack were negatively sighed in influencing the labor partial productivity of female Bambara groundnut farmers whereas, net farm income,

household size and access to credit had positive influence. Furthermore, net farm income, farm size and level of education positively influenced the other material inputs partial factor productivity for male Bambara groundnut farmers in the study area. However, net farm income, farm size and level of education positively influenced the other material inputs partial factor productivity for female Bambara nut farmers while age negatively influenced it.

Discussion

The study provides detailed insights into the factor productivity dynamics of male and female Bambara groundnut farmers in Northeast Nigeria. The productivity was measured using both partial and total factor productivity (TFP), highlighting significant gender differences in agricultural performance. The average revenue from Bambara groundnut production was significantly higher for female farmers compared to male farmers. This indicates that female farmers earned more than their male counterparts. The higher revenue among female farmers aligns with findings by Peterman et al. (2014), who noted that female farmers often manage their resources more efficiently and may be more focused on high-value crops or marketing strategies that yield better returns and with Adeyemo et al. (2019) who found women excel in utilizing limited resources effectively as well as with Bello and Salisu (2021), who highlighted women's crucial role in labor-intensive activities, showcasing their efficiency in managing agricultural processes. It also aligns with Edeh and Okwu (2019) who supports this finding, emphasizing women's proficiency in farm supervision and financial management. Despite the higher revenue, the total cost of inputs utilized by female farmers was lower than that of male farmers. This cost efficiency among female farmers is supported by Kilic et al. (2015), who found that women tend to achieve higher productivity per unit cost due to their meticulous management of limited resources. The partial productivity index for land was higher for male farmers compared to female farmers. This suggests that male farmers might be utilizing larger areas of land more intensively. Masterson (2007) found similar results, where larger farms managed by men often showed higher land productivity due to economies of scale and better access to land resources. Female farmers had a higher partial productivity index for labor compared to male farmers. This could be attributed to the more effective allocation and utilization of labor by female farmers, possibly leveraging household labor more efficiently. Croppenstedt et al. (2013) highlighted that women often rely on family labor, which can be more cost-effective and better managed, leading to higher labor productivity. Male farmers showed a slightly higher partial productivity index for other material inputs compared to female farmers. This may reflect better access to and use of inputs like seeds, agrochemicals, and fertilizers by male farmers, which enhances productivity. Asante et al. (2018) noted that men typically have better access to agricultural inputs and extension services, which can lead to higher productivity.

The total factor productivity (TFP) was higher for male farmers (3.34) than for female farmers (2.59). However, the overall productivity for both male and female farmers was greater than one, indicating that both groups were productive. The higher TFP for male farmers could be due to their larger farm sizes and better access to resources, as discussed by Bezu et al. (2014), who emphasized the role of resource access in enhancing productivity.
To determine whether a significant difference exists in the total and partial factor productivity of male and female Bambara groundnut farmers, a paired-wise z-test was conducted. The results, which are presented in Table 2, provides a comprehensive analysis of the comparative productivity metrics between the two groups, shedding light on gender-based efficiency disparities in agricultural practices within the region.

Female farmers had significantly higher Total Factor Productivity (TFP) ($z=8.284$, $P<0.05$) than male farmers. This higher Total Factor Productivity among female farmers underscores their efficiency in utilizing available resources, even with potentially fewer inputs. This finding supports the argument by Ragasa et al. (2013) that female farmers often achieve higher productivity when given equal access to resources. Female farmers also had significantly higher partial factor productivity of labor ($z=21.072$, $P<0.05$). This result highlights the critical role of labor management in female-led farms and aligns with Tirivayi et al. (2016), who found that women's agricultural practices often result in higher labor efficiency. Male farmers had significantly higher land partial factor productivity ($z=4.477$, $P<0.05$) and partial factor productivity of other material inputs ($z=3.497$, $P<0.05$). These results are consistent with studies by Kilic et al. (2015), which indicate that men often have better access to utilization of physical and material resources. The male farmers' advantage in land and input productivity is supported by research highlighting men's better access to resources and technologies (Meinzen-Dick et al., 2019). These results indicate that female farmers significantly excel in overall resource use and labor management, while male farmers are more effective in land and material input utilization. These findings illustrate the differential efficiencies in resource utilization between male and female farmers, highlighting the importance of equitable resource access to enhance productivity across genders.

The result in Table 3 shows that age was negatively signed whereas net farm income, farm size and level of education were positively signed in their influence on the Total Factor Productivity of male Bambara groundnut farmers This result implies that increase in the age of male farmers leads to a decrease in their total factor productivity, and vice versa. An increase in age may not allow male farmers to easily manage land, labor, and other inputs or to easily adopt improved technology that can enhance their productivity. This finding aligns with Ajide (2022), who found that older farmers exhibit lower Total Factor Productivity due to

reduced physical strength and slower adaptation to modern farming practices. The result also implies that increase in net farm income, farm size and level of education leads to increase in the Total Factor Productivity of the male farmers and vice versa. In the model that determined the Total Factor Productivity of female Bambara groundnut farmers, age and banditry/herdsmen attacks were negatively signed whereas net farm income, household size, farm size, level of education, and access to credit were positively signed This implies that increase in net farm income, household size, farm size, level of education, and access to credit leads to increases in the Total Factor Productivity of female farmers while increase in age and banditry/herdsmen attacks reduces the Total Factor Productivity of female Bambara groundnut farmers. This finding is consistent with Oluyole et al. (2020) who found that older farmers tend to have lower productivity, Aregbesola et al. (2021) who found that net farm income, farming experience, farm size, and level of education enhance productivity, World Bank (2020) which highlights the importance of household size and extension services in improving productivity, and Abdulraheem et al. (2020) who found that insecurity affects agricultural productivity.

The determinants of partial factor productivity for male and female Bambara nut farmers are presented in Table 4. shows that increases in age, net farm income, farming experience, household size, land/tenure security status, farm size, level of education, extension visits, and access to credit lead to an increase in land Partial Factor Productivity among farmers across the state and region for male and female farmers. However, the increase in distance to farmland reduced the land Partial Factor Productivity of male and female Bambara Groundnut farmers across states and regions. Older farmers may be more likely to adopt new practices or invest in land improvements, leading to less land being used for Bambara nut production. Higher-income farmers are more likely to invest in Bambara nut production, leading to more land being used for this purpose. More experienced farmers are better equipped to manage Bambara nut production, leading to more land being dedicated to this crop. Larger households may provide more labor for farming, enabling farmers to cultivate more land for Bambara nut production. Larger farms may allocate more land to Bambara nut production due to economies of scale. Better-educated farmers are more likely to adopt improved practices and technologies, leading to more efficient land use for Bambara nut production. Greater distances may increase transportation costs and reduce farmers' ability to manage their land effectively, leading to less land being used for Bambara nut production. Credit enables farmers to invest in inputs and technologies, leading to more land being used for Bambara nut production. Insecurity and attacks on farms may disrupt farming activities, leading to less land being used for Bambara nut production. This finding aligns with Adeolu et al. (2020) whose studies show that the variables of net farm income, farming experience, household size, land/tenure security status, farm size, level of education, extension visits, access to credit, age, distance to farmland, and

banditry/herdsmen attacks as important determinants of land use among smallholder farmers in Nigeria.

The results for labor partial productivity shows that increases in net farm income, farm size, and level of education lead to an increase in labor productivity of male farmers, while increases in net farm income, level of education, and access to credit lead to an increase in labor productivity of female farmers. However, while an increase in the age of the respondents and level of education reduced the labor productivity of male Bambara Groundnut farmers, an increase in the age of the respondents, level of education, and distance to farmland and banditry/herdsmen attacks reduced the labor productivity of female Bambara Groundnut farmers.

The results for other material inputs suggest that increases in net farm income, farming experience, farm size and level of education and lead to an increase in other inputs productivity of male and female BG farmers in the study area. However, increase in the age of the respondents reduced the other inputs productivity of the female Bambara Groundnut farmers in the study area. Higher net farm income provides the financial resources necessary to invest in improved seeds, fertilizers, and other inputs (Oyinbo et al., 2019). Farming experience equips farmers with better knowledge and skills for efficient input use (Ayinde et al., 2017). Education increases farmers' awareness and ability to utilize modern inputs (Okoye et al., 2018).

Conclusion and Recommendations

The findings indicate notable gender differences in the productivity of Bambara groundnut farmers in Northeast Nigeria. Female farmers exhibited higher overall revenue and greater efficiency in labor use, while male farmers showed higher productivity in land use and material input management. These differences highlight the importance of targeted interventions to support both male and female farmers, addressing specific constraints and enhancing resource access and management practices for improved agricultural productivity. The study recommends that policies aimed at improving access to credit and inputs for female farmers can improve their productivity levels. Male farmers should be encouraged to adopt more efficient farming practices to improve their productivity levels. Government programs aimed at reducing banditry/herdsmen attacks and improving tenure security can improve productivity levels for both male and female farmers.

Conflict of interest

The authors hereby declare that no conflict of interest exists.

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Authors' Contributions

Osayi, C.P. wrote the paper, Enete, A.A. and Chukwuone. N. A.; reviewed and supervised the work. All authors have read and approved the final version for publication

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Table 1: Average values of Bambara groundnut Output and Production Factors in Northeast Nigeria-

S/N	Variables	Female	Male
A.	**Revenue**		
	Total Revenue	1,503,725.00	1,386,396.77
B.	**Cost of Input variables**		
	Land	94,586.62	35,939.71
	Labor	242,827.72	409,788.98
	Other materials inputs (Seeds, agrochemicals and Fertilizer)	112,689.39	88,848.47
	Total input costs	**450,103.73**	**534,577.16**
C.	**Factor productivity indices**		
	Total factor productivity (TFP)	3.34	2.59
	Partial factor productivity of land	15.90	38.58
	Partial factor productivity of Labor	6.19	3.38
	Partial factor productivity of other material inputs	13.34	15.60
	Sample Size	360	360

Source: Field Survey Data, 2024

Table 2: Test of significance difference between male and female Bambara groundnut farmers in Northeast Nigeria in terms of their total and partial factor productivities

Variable	Mean	Std. Deviation	Std. Error Mean	Df	z-statistic
Total factor productivity (TFP)					
Female	3.342	0.737	0.039		
Male	2.587	1.450	0.076		
Difference	0.755	1.729	0.091	359	8.284***
Partial factor productivity of land					
Female	15.898	4.551	0.240		
Male	38.579	96.011	5.060		
Difference	-22.681	96.132	5.067	359	-4.477***
Partial factor productivity of Labor					
Female	6.187	1.910	0.101		
Male	3.379	1.818	0.096		
Difference	2.808	2.529	0.133	359	21.072***
Partial factor productivity of Other Input materials					
Female	13.337	2.938	0.155		
Male	15.598	11.084	0.584		
Difference	-2.261	12.267	0.647	359	-3.497***

Source: Field survey data, 2024

Values bearing asterisks differ significantly (P<0.01).

Table 3: Result of the log-linear multiple regression model for the estimation of the determinants of total factor productivity of male and female Bambara groundnut farmers in northeast Nigeria

Variable	Male	Female
Constant	11.698(16.712)***	11.574(11.468)***
Age of respondents	-0.197(-4.572)***	-0.07(-2.339)**
Net farm income	0.948 (20.575)***	0.95(12.572)***
Farming experience	0.046(1.949)	-0.026(-1.424)
Household size	0.001(0.053)	0.039(2.284)**
Land/tenure security status	0.021(1.317)	0.001(0.075)
Farm size	0.409(9.082)***	0.794(7.125)***
Level of education	0.070(2.795)***	0.047(2.783)***
Distance to farmland	-0.031(-1.245)	0.016(0.977)
Extension visits	0.016(0.394)	0.049(2.025)
Access to credit	-0.028(-1.02)	0.046(2.553)**
Banditry/herdsmen attacks	0.021(0.632)	-0.043(-2.174)**
R-square	0.616	0.675
Adjusted R-square	0.604	0.665
F-statistics	50.399***	65.602***

Source: Field survey data, 2024. NB: *** and ** signified at 1, and 5% level of significance, respectively. Values outside the brackets are the estimated coefficients while values in parenthesis are t-values.

Table 4: Result of the log-linear multiple regression model for the estimation of the determinants of partial factor productivity of male and female Bambara groundnut farmers in northeast Nigeria

	Land		Labor		Other Inputs materials	
Variable	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Constant	7.993 (12.155)***	6.526 (10.639)***	9.775 (13.413)	5.288 (9.308)***	9.018 (11.746)***	8.588 (10.98)***
Age of respondents	0.130 (4.849)***	0.121 (5.260)***	-0.26 (5.271)***	-0.11 (2.139)**	-0.061 (-1.418)	-0.101 (4.350)***
Net farm income	1.196 (4.729)***	2.026 (6.608)***	0.922 (7.426)***	0.34 (2.592)**	0.985 (9.370)***	1.110 (8.823)***
Farming experience	-0.007 (-0.495)	0.032 (2.302)*	0.05 (1.861)	-0.03 (-0.959)	0.051 (2.162)*	0.003 (0.181)

		*			*	
Household size	0.011 (0.699)	0.033 (2.486)**	-0.009 (-0.293)	0.052 (1.759)	0.032 (1.240)	0.008 (0.584)
Land/tenure security status	0.023 (2.247)**	0.016 (2.100)**	0.026 (1.392)	0.004 (0.246)	0.016 (0.974)	0.008 (0.971)
Farm size	1.007 (7.563)***	2.107 (4.411)***	0.355 (4.425)***	0.156 (0.81)	0.511 (3.825)***	0.837 (9.628)***
Level of education	-0.052 (3.345)***	-0.002 (-0.151)	-0.078 (2.718)***	-0.100 (3.415)***	0.055 (2.196)**	0.035 (2.625)**
Distance to farmland	-0.085 (5.489)***	-0.061 (4.870)***	-0.04 (-1.415)	0.017 (0.611)	-0.027 (-1.094)	0.010 (0.815)
Extension visits	0.031 (1.229)	0.033 (1.756)	0.029 (0.631)	0.07 (1.679)	0.015 (0.377)	0.002 (0.122)
Access to credit	0.014 (0.809)	0.005 (0.364)	0.026 (0.835)	0.066 (2.120)**	0.011 (0.414)	0.011 (0.772)
Banditry/herdsmen attacks	-0.009 (-0.42)	0.009 (0.574)	0.031 (0.824)	-0.077 (2.247)**	-0.012 (-0.373)	-0.017 (-1.101)
R-square	0.848	0.904	0.53	0.523	0.669	0.742
Adjusted R-square	0.847	0.901	0.515	0.499	0.659	0.736
F-statistics	74.791***	96.058***	35.299***	9.079***	63.513***	67.488***

Source: Field survey data, 2024. NB: *** and **signified at 1, and 5% level of significance, respectively. Values outside the brackets are the estimated coefficients while values in parenthesis are t-values.