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A GENDERED COMPARATIVE ANALYSIS OF NET FARM INCOME AND ITS DETERMINANTS AMONG BAMBARA GROUNDNUT FARMERS IN NORTHEAST NIGERIA

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ABSTRACT

This study examined gender-based differences in net farm income and its determinants among Bambara groundnut farmers in Northeast Nigeria. A multi-stage sampling technique was employed to select 360 male and 360 female smallholder Bambara groundnut farmers from three selected states in the region. Primary data were collected using a structured questionnaire. Descriptive statistics, farm budgeting model, independent z-test, and log-linear multiple regression model were employed for the analysis. The results revealed that the mean net farm income of male and female Bambara groundnut farmers was ₦838,145.57 and ₦1,040,863.77, respectively, indicating a significant difference between the groups. For male farmers, age (δ_1 = -0.542, $p < 0.05$), level of education (δ_3 = 0.609, $p < 0.01$), off-farm income (δ_4 = 1.011, $p < 0.01$), farm size (δ_6 = 1.281, $p < 0.01$), extension visits (δ_{13} = 0.561, $p < 0.01$), farming experience (δ_{14} = 0.733, $p < 0.05$), factor productivity and efficiency indices significantly influenced net farm income. While for female farmers, age (δ_1 = -0.710, $p < 0.01$), marital status (δ_2 = 0.247, $p < 0.01$), household size (δ_5 = 0.138, $p < 0.10$), farm size (δ_6 = 1.589, $p < 0.01$), interest amount (δ_7 = 0.289, $p < 0.01$), farming experience (δ_{14} = 1.129, $p < 0.01$), amount of credit obtained (δ_{15} = 1.341, $p < 0.01$), factor productivity and efficiency indices were significant. The study concludes that gender differences exist in both income levels and determinants, necessitating gender-responsive policies to improve access to resources, credit and extension services.

Keywords: Gender, Net-farm income, Bambara groundnut production, Northeast Nigeria

INTRODUCTION

The global challenge of achieving food security for an ever-increasing population has placed renewed urgency on the agricultural sector, especially in Sub-Saharan Africa where food supply remains unstable (Hemathilake and Gunathilake, 2022). While global agricultural productivity has grown over the decades, it has not kept pace with demographic pressures, and emerging evidence reveals that crop yields are increasingly lagging behind population growth (Hemathilake and Gunathilake, 2022; Ogunlesi et al., 2018). To address this, researchers and policymakers advocate for both an expansion in the cultivation of underutilized crops and greater efficiency in resource use. One such crop with untapped potential is the Bambara groundnut (Vigna subterranea), which, although historically significant, remains neglected in Nigerian agriculture (Onuche, Ibitoye and Anthony, 2020).

In Nigeria, Bambara groundnut production is predominantly small-scale and subsistence-oriented, with women constituting the majority of its cultivators (Mubaiwa et al., 2018). Despite its resilience to harsh environmental conditions and its nutritional value, it has not received adequate policy attention, leading to limited adoption and low commercial scale output. Consequently, there is an urgent need to reevaluate the economic viability of this crop, particularly in the context of rural livelihoods in Northeast Nigeria where poverty remains prevalent and agriculture constitutes the primary occupation (National Bureau of Statistics, 2017). Recognizing the potential of this crop to improve household income and food security requires a rigorous examination of its net farm income performance among producers.

Net farm income is a critical measure of financial performance and sustainability of farming enterprises. It captures the actual returns accrued after deducting the cost of production and reflects the economic rewards to farm households (Prager, Tulman and Durst, 2018). Farmers are rational economic agents driven primarily by profit maximization motives. Hence, any investigation into the financial dynamics of Bambara groundnut farming must center on profitability metrics such as gross margin, return on investment, and net income. Understanding how these measures vary across gender is essential, particularly in contexts where gender-based disparities in access to inputs, credit, land, and technology exist and impact economic outcomes (FAO, 2020; Henry et al., 2023). In the Northeastern region of Nigeria, factors such as banditry, climate shocks, and dwindling land holdings have further constrained agricultural productivity. These conditions, coupled with a lack of empirical data on gendered differences in net farm income, productivity, and efficiency, call for an urgent investigation. While previous studies have

emphasized technical and allocative efficiency, this study aims to advance the literature by focusing explicitly on net farm income and its gender-specific determinants.

Nigeria continues to grapple with persistent hunger, poverty, and low agricultural productivity despite various intervention programs. Although food crop production has received policy attention, underutilized legumes like Bambara groundnut remain on the margins. In the Northeast region, the production of Bambara groundnut is constrained by poor resource utilization, limited technological uptake, and traditional farming practices (Aviara et al., 2013). Moreover, the crop is often relegated to women and regarded as a subsistence-level endeavor, despite its commercial potential (Adegboyega et al., 2021). The presence of gender disparities in agricultural production further complicates this challenge. Women frequently face systemic obstacles in accessing productive resources, which undermines their efficiency and net income generation potential (FAO, 2020). Furthermore, little is known about how gender differences affect net farm income outcomes among Bambara groundnut farmers in Northeast Nigeria, particularly in the context of ongoing rural insecurity and shrinking arable land. A critical gap in literature remains in understanding not just the productivity, but the actual financial returns from farming activities disaggregated by gender. Empirical evidence on the comparative net farm income of male and female Bambara groundnut farmers is scarce, as is information on how socio-economic factors, factor productivity, and efficiency influence these outcomes. Understanding these dynamics is essential for informing inclusive policies and directing targeted interventions that can improve profitability, encourage the adoption of this resilient crop, and uplift smallholder farmers from poverty. Against this backdrop, this study's aim is to conduct a gender-based comparative analysis of net farm income and its determinants among Bambara groundnut farmers in Northeast Nigeria.

The specific objectives are to:

- Estimate the net farm income of male and female Bambara groundnut farmers
- Compare the net farm income of male and female Bambara groundnut farmers
- Determine the effects of factor productivity, efficiency, and socioeconomic factors on the net farm income of male and female Bambara groundnut farmers in the study area

The following null hypotheses were tested in this study:

H_{O1}: There is no significant difference in the net farm income of male and female Bambara groundnut farmers

H_{O2}: Factor productivity, efficiency (technical, allocative, economic), and socioeconomic factors have no significant influence on the net farm income of male and female Bambara groundnut farmers in the study area

This study contributes meaningfully to the literature on agricultural development by offering a gender-sensitive analysis of net farm income among Bambara groundnut farmers in a marginalized region of Nigeria. By focusing on net returns rather than productivity metrics alone, the study provides a more accurate reflection of farm-level financial performance and household welfare. The findings will be instrumental for policymakers, development practitioners, and donors aiming to improve rural livelihoods through inclusive agricultural policies. Additionally, the study will enhance awareness of Bambara groundnut as a climate-resilient crop capable of addressing food security, nutrition, and income generation in semi-arid regions. It offers actionable insights for designing gender-responsive extension services, input subsidy programs, and credit facilities that can bridge existing gender gaps and boost profitability among smallholder farmers.

Theoretical Framework

This study is underpinned by the Profit Maximization Theory, a classical economic model which posits that producers act rationally to maximize their profit by choosing optimal combinations of inputs and outputs. In the context of Bambara groundnut farming, farmers allocate limited resources such as land, labor, and capital to achieve the highest possible net returns from their farming enterprise. Net farm income is an appropriate proxy for profit, and its comparison across gender provides insights into the efficiency and effectiveness of resource use under varying socio-economic and environmental conditions. This model enables the assessment of production decisions and income outcomes in light of market and non-market constraints, particularly gender-specific barriers to input access.

Empirical Studies

Empirical studies have increasingly acknowledged the role of net farm income as a central indicator of agricultural performance. Katcha (2023) identified key determinants of profitability in Bambara nut production to include farm size, seed, labor, herbicide use, age, and education. Similarly, Bethrand and Abam (2022) emphasized the significance of processing technology in enhancing returns, while Ibe et al. (2022) highlighted the importance of access to credit and market information. Falola et al. (2022) found that factors such as distance to market, high cost of inputs, and pest incidence significantly affect profitability. These studies underscore the multifaceted nature of income generation in farming, involving input efficiency, socio-economic characteristics, and infrastructural elements. However, most existing studies have not adequately examined these dynamics from a gender-disaggregated perspective. The roles of male and female farmers in Bambara groundnut production remain poorly documented, with limited empirical

insights on how gender differences translate to disparities in net farm income. As such, this study seeks to fill this knowledge gap by offering a nuanced, comparative analysis of the economic returns accruing to male and female Bambara groundnut farmers in Northeast Nigeria.

METHODOLOGY

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 crops grown in the area include cassava, rice, yam, maize, millet, potato, sorghum, cowpea, cotton, groundnut, Bambara nut, and watermelon. The farmers are also known for rearing of livestock. The average annual rainfall in the area ranges from 250 mm around Nguru (Borno State) to 1310 mm around Sugu (Adamawa State), while average annual temperature ranges from 200°C to 400°C (NAERLS/PCU, 2014). The region falls within the Sahel, Sudan and Guinea Savanna vegetation zones. 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.

Sampling Procedure

In selecting respondents for this study, a two-stage purposive and two stage random sampling was used for this study. The purposive sampling was based on the availability of valid household Bambara nut farmers in the study area. Out of the six States in the Northeast; Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe, a purposive sampling method was used first to select three States out of the six states in the zone. The states with the evidence of valid or contact household Bambara nut farmers were selected for the study. The States are Adamawa State, Bauchi State and Taraba State. The second stage is a purposive selection of six local government areas from each of the selected state that showed evidence of household Bambara nut farmers in the area making it a total of eighteen (18) local government areas. Thirdly two communities were randomly selected from each local government area making it a total of thirty-six (36) communities. From each community, a stratified random sampling technique was used to select ten (10) female and ten (10) male Bambara nut farmers making three hundred and sixty (360) male and three hundred and sixty (360) female Bambara nut farmers. In total, seven hundred and twenty (720) Bambara nut farmers were used for this study. The sample frame which is the list of Bambara Nut farmers in the selected communities were compiled with the assistance of staff of Agricultural Development Programme (ADP), resident extension agents, officials of farmers association and community leaders. Primary data was collected from the respondents using a well-structured questionnaire that was administered to the respondents using the Paper-Assisted Personal Interview (PAPI) method. The questionnaire was validated by three experts from the department of Agricultural Economics, University of Nigeria, Nsukka. Data analysis utilised descriptive statistics and econometric models, including the farm budgeting model, independent z-test, and log-linear multiple regression model.

The farm budgeting model that was used to estimate the costs and returns associated with the Bambara groundnut production for male and female farmers in the region was done by computing the gross margins (GM) as well as the corresponding net farm incomes (NFI).The farm budgeting model following Ibeun et al. (2018) and Adewumi et al. (2018) was used and is specified in equations (1) and (2) as:

$$GM = \sum_{i=1}^{n} P_{yi} Y_i - \sum_{j=1}^{m} P_{xj} X_j \quad \text{----------(1)}$$

$$NFI = \sum_{i=1}^{n} P_{yi} Y_i - \sum_{j=1}^{m} P_{xj} X_j - \sum_{k=1}^{o} F_k \quad \text{--------(2)}$$

where;
GM = Gross Margin,
NFI = Net farm income,
Yi = Output of Bambara groundnut per farmer (where i = 1, 2, 3, ..., n farmers),
P_{yi} = Unit price of Bambara groundnut,
X_j = Quantity of the variable inputs (where j =, 1, 2, 3, ..., m variable inputs),
P_{xj} = Price per unit of variable inputs, and
F_k = Cost of fixed inputs (where k =, 1, 2, 3, ..., 0 fixed inputs).

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

$$Z_{cal} = \frac{\bar{Q}_i - \bar{Q}_j}{\sqrt{\frac{S^2\bar{Q}_i}{w_i} + \frac{S^2\bar{Q}_j}{w_j}}} \quad \text{----------(3)}$$

Where;
$\bar{Q}_i$= Mean net farm income of male Bambara groundnut farmers;
$\bar{Q}_j$= Mean net farm income of female Bambara groundnut farmers;
$S^2\bar{Q}_i$ = Standard deviation of the net farm income of male Bambara groundnut farmers;
$S^2\bar{Q}_j$=Standard deviation of the net farm income of female Bambara groundnut farmers;

w_i = Number of male Bambara groundnut farmers that will be sampled;
w_j = Number of female Bambara groundnut farmers that will be sampled.
The z-statistic from the test in equation (3) was used to test hypothesis one.

The log-linear multiple regression model used to analyse the effects of factor productivity, efficiency and socioeconomic factors on the net farm income of male and female Bambara groundnut farmers in the study area is fitted as:

$$NFI_i = \delta_0 + \delta_1 lnQ_1 + \delta_2 lnQ_2 + \delta_3 lnQ_3 + \delta_4 lnQ_4 + \delta_5 lnQ_5 + \ldots\ldots + \delta_{15} lnQ_{15} + e_i \text{ ----------(4)}$$

Where; Q_1 represents the age of the farmer (years), Q_2 represents the marital status (Dummy, 1 = married and 0 = otherwise), Q_3 represents the level of education (years spent in school), Q_4 represents the off-farm income (Naira), Q_5 represents the household size (Headcount of persons living in the same house and eats from same pot), Q_6 represents the farm size for cultivating Bambara groundnut (hectares), Q_7 represents the interest on borrowed capital (Naira), Q_8 represents the cooperative membership (Member =1, Non-member = 0), Q_9 represents the factor productivity index of the i^{th} farmers, Q_{10} represents the technical efficiency index of the i^{th} farmers, Q_{11} represents the allocative efficiency index of the i^{th} farmers, Q_{12} represents the economic efficiency index of the i^{th} farmers, Q_{13} represents the extension contacts (No. of visits), Q_{14} represents the farming experience (number of years spent on Bambara groundnut production), Q_{15} represents the value of credit obtained from microcredit banks (₦), Ln represents the natural logarithm, δ_0 represents the intercept term, $\delta_1 - \delta_{15}$ represents the parameters to be estimated, e_i represents the error term. The t-statistic for each of the variables from the log-linear multiple regression analysis was used to test hypothesis two.

RESULTS AND DISCUSSION

Estimation of the Net-Farm Income of Male and Female Bambara Nut Farmers

The result of the estimated net-farm income for male and female farmers is presented in Table 2. The result shows that male Bambara groundnut farmers realized an average revenue of ₦1,386,396.77, producing an average output of 21.44 bags (65kg Bag equivalent), while female farmers realized ₦1,503,725.00, producing an average output of 23.76 bags (65kg Bag equivalent). Male farmers earned ₦117,328.23 less than their female counterparts. Female farmers produced 2.32 bags more than male farmers. The total input costs for male farmers were ₦548,251.20, compared to ₦462,861.23 for female farmers. Male farmers invested ₦85,389.97 more than female farmers. The total variable cost for male farmers was ₦498,637.45 (91.0% of the total cost) and for female farmers, it was ₦355,517.11 (76.8% of the total cost). Labour costs were 74.7% for male farmers and 52.5% for female farmers. Fertilizer costs were 2.7% for male farmers and 3.5% for female farmers. The total fixed cost for male farmers was ₦49,613.75 (9.0% of the total cost), while for female farmers, it was ₦107,344.12 (23.2% of the total cost). Land rent was 6.6% for male farmers and 20.4% for female farmers. This suggests higher land rent investment by female farmers, indicating unequal land access. The net-farm income for male farmers was ₦838,145.57, while for female farmers, it was ₦1,040,863.77. Female farmers earned ₦202,718.20 more than male farmers, likely due to better resource management and efficiency. This finding suggests that female farmers, when given access to productive resources, can achieve equal or even higher returns than male farmers. It highlights the importance of promoting efficiency-enhancing practices, particularly among women. The result also implies that improving women's access to credit, inputs, and extension services could further increase agricultural productivity and household income. Additionally, it supports the argument for gender-responsive agricultural policies, as female farmers may utilize limited resources more efficiently. This is consistent with studies such as Udry et al. (1995), which showed that differences in productivity are often due to resource allocation inefficiencies rather than gender itself. Similarly, Doss (2018) and FAO (2011) reported that women can be as productive as men when given equal access to inputs, and in some cases demonstrate higher efficiency in resource utilization. However, the result contrasts with findings like Omonona et al. (2010), which reported lower income among female farmers, largely due to limited access to land, credit, and inputs. This suggests that when such constraints are reduced—as may be the case in this study—female farmers can outperform their male counterparts.

Table 2: Average estimation of the net-farm income of male and female Bambara groundnut farmers in northeast Nigeria

Variable	Male		Female	
	Value (₦)	Percent	Value (₦)	Percent
A. Revenue				
Bambara groundnut output (65kg Bag) per farmer per hectare	21.44		23.76	
Price per 65kg Bag (₦)	64,673.55		63,285.13	
Total Revenue (₦)	1,386,396.77		1,503,725.00	
B. Cost of Variable Inputs				
Labour(₦/man-days)	409,788.98	74.7	242,827.72	52.5
Quantity of Bambara Seed used (₦/kg)	20,212.5	3.7	26,272.92	5.7
Quantity of Fertilizer used (₦/kg)	14,773.61	2.7	16,060.36	3.5
Quantity of Pesticide used (₦/litre)	21,495.0	3.9	22,553.33	4.9
Quantity of Herbicides used(₦/litre)	32,367.36	5.9	47,802.78	10.3
Total Variable Cost(₦)	498,637.45	91	355,517.11	76.8
C. Fixed Cost				
Land rent (₦/ha)	35,939.71	6.6	94,586.62	20.4
Depreciation (₦)	13,674.04	2.5	12,757.50	2.8
Total Fixed Cost (₦)	49,613.75	9.0	107,344.12	23.2
Total Cost (₦)	548,251.20		462,861.23	
Gross margins	887,759.32		1,148,207.89	
Net-farm Income	838,145.57		1,040,863.77	
Total number of observations	360		360	

Source: Field survey data, 2024
Note: The percentage values are computed from the total cost

Comparison of the Net-Farm Income of Male and Female Bambara Nut Farmers

The comparison of the net-farm income of male and female Bambara nut farmers across in the northeast region of Nigeria was done using the independent sample z-test distribution. The result of the test of significant difference between the estimated male and female farmers net-farm income is presented in Table 3.

Table 3: Test of significance difference in Net farm income between male and female Bambara groundnut farmers in Northeast Nigeria

Variable	Mean	Std. Deviation	Std. Error Mean	Df	z-statistic
Male	838,145.57	460,635.26	24,277.61		
Female	1,040,863.77	513,650.94	27,071.78		
Difference	-202,718.20	709,498.72	37,393.87	359	-5.421***

Source: Field survey data, 2024
Note: *** signifies 1% level of significance.

Table 3 reveals that the mean net-farm income of female Bambara groundnut farmers was ₦1,040,863.77, which is statistically and significantly higher than the mean net-farm income of male farmers, which was ₦838,145.57 ($z = -5.421$, $p < 0.05$). This significant difference indicates that female Bambara groundnut farmers in the northeast region earned a significantly higher net-farm income compared to male farmers, reflecting the overall better financial performance of female Bambara nut farmers in this region. This finding supports the findings of Agboola, Atakiti, and Afolabi (2019) who noted that female smallholder farmers achieved higher net-farm incomes than male farmers due to their efficient resource management and adoption of diversified farming practices and this contributed to their higher earnings. Onyemauwa and Nwachukwu (2020) found similar results among cassava farmers in Abia State, noting that female farmers' meticulous crop management and efficient use of inputs significantly boosted their agricultural productivity and income. Similarly, Oluwaseun and Adeoye (2022) found that female farmers in Ogun State had higher net-farm incomes, largely owing to efficient farm management practices and better access to extension services.

Determinants of Net Farm Income of Male and Female Bambara Nut Farmers

The result of the log-linear regression model employed to analyse the effects of factor productivity, efficiency and socioeconomic factors on the net-farm income of male and female Bambara groundnut farmers in northeast Nigeria is presented in Table 4.

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Table 4: Log linear regression result of the effects of factor productivity, efficiency and socioeconomic factors on the net-farm income of male and female Bambara groundnut farmers in northeast Nigeria

Variable		Male		Female	
	Parameters	Coefficient	t-value	Coefficient	t-value
Constant	δ_0	12.959	26.852***	13.100	17.392***
Age of farmer	δ_1	-0.542	-2.376**	-0.710	-3.396***
Marital status	δ_2	-0.016	-1.274	0.247	3.240***
Level of education	δ_3	0.609	2.483**	0.034	0.989
Off farm income	δ_4	1.011	3.679***	0.023	0.816
Household size	δ_5	-0.005	-0.239	0.138	1.962*
Farm size	δ_6	1.281	6.384***	1.589	8.811***
Interest Amount	δ_7	0.032	0.649	0.289	3.259***
Cooperative membership	δ_8	-0.030	-1.324	0.013	0.238
Factor productivity index	δ_9	0.987	7.485***	1.060	9.550***
Technical efficiency index	δ_{10}	0.080	1.490	0.932	6.045***
Allocative efficiency index	δ_{11}	0.135	1.923*	1.144	2.826***
Economic efficiency index	δ_{12}	0.034	0.391	0.087	0.904
Extension visits	δ_{13}	0.561	2.387***	-0.013	-0.284
Farming experience	δ_{14}	0.733	2.352**	1.129	3.894***
Amount of credit obtained	δ_{15}	0.032	0.697	1.341	4.651***
R-square		0.914		0.942	
Adjusted R-square		0.912		0.937	
F-statistics		194.314***		227.677***	
Total number of observations		360		360	

Source: Field survey data, 2024

Note: *** signifies 1% level of significance, ** signifies 5% level of significance, * signifies 10% level of significance.

The result in Table 4 shows that the male farmers' model had an R-square value of 0.914, indicating that the explanatory variables included in the model accounted for 91.4% of the variation in net-farm income, The F-statistic value of 194.314 is significant at the 1% level, indicating that the model was well specified. Female farmers' model had an R-square value of 0.942, indicating that the explanatory variables included in the model accounted for 94.2% of the variations in net-farm income of female BG farmers. The F-statistic value of 227.677 is significant at the 1% level, indicating that the model was well specified.

The significant factors that influenced the net farm income of male farmers included age, level of education, off-farm income, farm size, factor productivity index, technical efficiency index, allocative efficiency index, and farming experience. For female farmers, the significant factors influencing their net farm income were age, marital status, household size, farm size, factor productivity index, technical efficiency index, allocative efficiency index, economic efficiency index, farming experience, and the amount of credit obtained.

For male farmers, age of farmer (δ_1 = -0.542; t = -2.376) was negatively associated with net-farm income at the 5 percent level. This indicates that older male farmers earned significantly lower net income. This is possibly due to declining labour efficiency or slower adoption of modern practices. This aligns with Oladeebo and Oladeebo (2019), who found that younger farmers are more productive and adaptable to modern farming techniques. Oyekale and Adeoti (2019) also reported that older farmers are less likely to adopt new technologies, leading to lower productivity and income. Moreover, Yusuf et al. (2020) observed that aging farmers face more significant health challenges, which negatively impact their performance. Level of education (δ_3 = 0.609; t = 2.483) had a positive and significant effect at the 5 percent level, implying that more educated male farmers were better positioned to access and apply productive technologies. This finding aligns with Asante et al. (2018) also reported that education improves farmers' skills in resource management and the application of modern technologies, leading to better income.

Off-farm income (δ_4 = 1.011; t = 3.679) was also positively significant at the 1 percent level. This suggests that supplementary income streams enhance investment capacity and reduces financial vulnerability. This finding aligns with Babatunde and Qaim (2019) who noted that off-farm income allows farmers to invest in improved agricultural inputs and technologies. Farm size (δ_6 = 1.281; t = 6.384) was positively associated with net-farm income at the 1 percent level. This implies that increase in farm size leads to increase in net farm income. This affirms the role of scale of production in improving net-farm income. This finding collaborates with Jayne et al.

(2018) who observed that larger farms benefit from better resource allocation and access to credit and markets. Similarly, factor productivity index (δ_9 = 0.987; t = 7.485) and allocative efficiency index (δ_{11} = 0.135; t = 1.923) were positively associated with net-farm income and significant at the 1 and 10 percent levels respectively. This implies that increases in factor productivity and allocative efficiency of the farmers leads to increase in their net farm income. This further demonstrates that optimal input use and effective resource allocation were essential drivers of higher net income. This finding aligns with Abdulai and Huffman (2016) who noted that improvements in productivity are directly linked to higher farm incomes. Similarly, it aligns with Fulginiti and Perrin (2018) who reported that factor productivity significantly affects agricultural income and sustainability.

Lastly, farming experience (δ_{14} = 0.733; t = 2.352) was positively associated with net income at the 5 percent level. This indicates that the more years of farming experience a farmer possesses, the higher their net farm income. This reinforces the importance of experiential knowledge in guiding decision-making. Experienced farmers typically have a deeper understanding of effective farming practices, local climatic conditions, and market dynamics. They are better equipped to make informed decisions about crop selection, pest management, and resource allocation. This accumulated knowledge and skillset lead to improved productivity and cost-efficiency, thereby enhancing profitability. This finding is supported by Wang et al. (2020) who also reported that experienced farmers are more efficient in resource utilization, leading to higher incomes.

Among female farmers, age of farmer (δ_1 = -0.710; t = -3.396) was negatively associated with income at the 1 percent level, mirroring the trend observed among male farmers. This implies an inverse relationship suggesting that an increase in age leads to a decrease in net-farm income among female BG farmers in the region. Marital status (δ_2 = 0.247; t = 3.240) was positively significant at the 1 percent level as it relates with net farm income. This suggests that being married influences net-farm income of female farmers. Married individuals might benefit from spousal support and joint decision-making, leading to better farm management. Also, married women have lots of responsibilities in the family to fulfil including catering for the needs of household members. Such responsibility will make them get more committed to their farming business so as to generate income from there to cater for the needs of their family members. It also indicates labour availability among married female farmers. This finding supports that of Umeh and Chukwu (2021) who reported that married farmers tend to have higher farm incomes due to better household labour allocation and economic support.

Household size (δ_5 = 0.138; t = 1.962) was positively associated with income and significant at the 10 percent level. This implies that increase in household size leads to increase in the net-farm income of the female farmers and vice versa. Larger household sizes provide more family labour, which can be advantageous in labour-intensive farming activities. Such increase will reduce the cost of hiring labour and of the total cost of production hence increasing the net farm income. This finding aligns with Adenuga et al. (2019) who noted that larger households have better labour allocation that leads to increased productivity and income. The effect of farm size (δ_6 = 1.589; t = 8.811) and factor productivity (δ_9 = 1.060; t = 9.550) remained strongly positive as they relate with net farm income and each of these variables is significant at the 1 percent level. This implies that increase in farm size and factor productivity leads to increase in net farm income. Larger farm sizes generally lead to higher net-farm income due to economies of scale and more efficient use of resources. Increased productivity is associated with enhanced efficiency and effectiveness in the adoption of improved agricultural practices which leads to higher yields, reduced costs, and increased competitiveness. All of these aptitudes contribute to higher net farm income for farmers. Producing more with the same or fewer inputs allows female farmers to spread their fixed costs over a larger output thereby reducing the per-unit cost of production and hence increase profitability.

Technical efficiency index (δ_{10} = 0.932; t = 6.045) and allocative efficiency index (δ_{11} = 1.144; t = 2.826) were positive in their relationship with net farm income and each of these variables were significant at the 1 percent level. This implies that increase in both technical and allocative efficiencies of female BG farmers leads to increase in net farm income and vice versa. A technically efficient farmer maximizes output from a given set of inputs and utilizes resources such as labour, land, capital, and inputs like seeds, agrochemicals, and fertilizers in the most effective way possible, minimizing waste and production costs while maximizing output. Therefore, higher technical efficiency leads to higher net farm income. When farmers achieve allocative efficiency, they effectively balance the use of inputs such as labour, land, capital, seeds, and fertilizers according to their relative costs and productivity contributions. This ensures that resources are not wasted and that production processes are cost-effective, leading to reduced production costs and increased profitability. As a result, allocatively efficient female farmers achieves higher net farm income by maximizing their output while minimizing unnecessary expenditures.

This finding aligns with Bravo-Ureta et al. (2017) and Coelli et al. (2018). Interest amount (δ_7 = 0.289; t = 3.259), amount of credit obtained (δ_{15} = 1.341; t = 4.651) and farming experience (δ_{14} = 1.129;

t = 3.894) were all positively relates to net farm income and statistically significant at the 1 percent level. This implies that increase in interest amount, amount of credit obtained and years of farming experience of female BG farmers leads to increase in net farm income and vice versa. This further indicates that financial access and experiential knowledge are crucial income drivers for female farmers. High-interest rates are expected to negate the benefits of investments made with borrowed funds, leading to financial strain. If interest payments become too high relative to the farm's income, it could lead to a debt burden. This scenario might initially show a positive relationship, but if the debt becomes unsustainable, it could eventually harm the farm's financial health. However, the seemingly counterintuitive positive relationship between interest amount paid and net farm income could mean that female farmers have better access to credit and utilized it optimally to earn higher returns that enables them copy with high interest charges. These findings align with Onumah et al. (2019), Wang et al. (2020), Ali et al. (2021), Odongo et al. (2020), Njeru et al. (2022), Ojo, Smith, & Ahmed (2019) and Adewumi, & Oladejo (2020).

4. CONCLUSION AND POLICY RECOMMENDATIONS

This study which focused on gender-based comparative analysis of net farm income and its determinants among Bambara groundnut farmers in Northeast Nigeria has shown that female farmers significantly earned more net farm income than their male counterpart. These results suggest that female farmers are more efficient or perhaps have better access to resources or markets that contribute to their higher profitability. Findings indicate that while some factors—such as factor productivity, technical efficiency, allocative efficiency, and farming experience—significantly influence the net farm income of both male and female farmers, other factors exhibit gender-specific effects. For male farmers, age, level of education, off-farm income, and farm size were the key determinants of income. In contrast, for female farmers, economic efficiency, marital status, household size, and access to credit played a significant role. These differences highlight the need for gender-sensitive agricultural policies and interventions that address the unique factors affecting male and female farmers' productivity and income. The study recommends that there is need to target female Bambara nut farmers with tailored support programs to further enhance their net farm income. This could include providing access to resources, markets, and training on sustainable agricultural practices, as well as empowering them to share their expertise with male farmers, ultimately leading to improved overall agricultural productivity and income in the region. There is also need to provide personalized agricultural training and advisory services that address the specific factors influencing net farm income. Both male and female Bambara nut farmers should focus on enhancing their productivity and efficiency by improving their technical, allocative, and economic efficiency, as well as increasing their farming experience. Additionally, prioritizing education, generating off-farm income, and utilizing credit effectively are crucial strategies for ultimately increasing their net farm income.

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