Assessment of the financial inclusion–gender–welfare nexus among smallholder maize farmers in Nigeria

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Abstract

This study investigates the relationships between financial inclusion, gender and household welfare. We used baseline data collected from a randomised control trial survey of maize farmers in Nigeria and computed multidimensional indices for financial inclusion and farmers' household welfare. These indices were then used in a robust seemingly unrelated regression (SUR) model to determine the influence of financial inclusion on farmers' welfare, differentiated by gender. The results of the study show that male-headed households are more financially included and have better welfare status than female-headed households, and that financial inclusion significantly influences the welfare status of farmers. The results also suggest that enhanced financial inclusion increases the likelihood of improving consumption expenditure, employment, assets and social amenities. Thus, the study recommends implementing policies that contribute to increasing financial inclusion and improving the welfare status of farmers.

Key words: financial inclusion, gender, smallholder farmers, welfare, Nigeria

1. Introduction

Agriculture is a vital sector of the Nigerian economy, serving as the largest employer of labour, constituting approximately 70% of the total workforce (National Bureau of Statistics 2010). It also contributes approximately 23% of the country's GDP (Adegbite & Machethe 2020; Balana & Oyeyemi 2022). However, the Nigerian agricultural sector is not as productive as it could be owing to the insufficient use of improved agricultural inputs, inadequate access to credit facilities, poor infrastructure, inadequate access to markets, land and environmental degradation, and inadequate access to extension services (Fowowe 2020; Balana & Oyeyemi 2022; Aina *et al*. 2024). Smallholder farmers contribute the majority of national agricultural production (Fowowe 2020). However, they use crude production techniques, lack information about the best agricultural practices, and make minimal investments in seeds and fertilisers, thereby leading to low yields (Balana & Oyeyemi 2022). These farmers also face constraints relating to rural credit and insurance, along with the high interest rates imposed by financial institutions, which pose significant challenges to agricultural financing in Nigeria. For instance, the share of lending by commercial banks to the agricultural sector was 4.2% in the second quarter of 2019 (Fowowe 2020). This necessitates an increase in the availability of financing to improve the yield and output of Nigerian agriculture.

Policy interventions have brought about an increase in agricultural lending in the country, from 1% in 2011 to 6% in 2015. Nevertheless, access to agricultural credit remains critically low and poses a major challenge for stakeholders in the agricultural sector (Mishra *et al*. 2021). This is further exacerbated by the upward trend in farm inputs and technology prices (Miranda & Vedenov 2001; Awunyo-Vitor 2018). The recent global spike in prices for agricultural inputs (fertiliser, herbicides and labour) is expected to contribute to low agricultural production and food security. Farmers end up struggling to pay for essential inputs, and likely face potential disruptions in their food production and supply. This calls for more financial support for smallholder farmers, who are faced with high input costs and are unable to recoup because of comparatively low market prices for their produce.

Financial inclusion refers to individuals and businesses having access to proper financial services provided by formal institutions, such as savings, access to credit and insurance products, and financial transactions (Demirgüç-Kunt *et al*. 2018), while also having the ability to transact at an affordable cost using a formal account (Popovic *et al*. 2017). This formal account is usually a bank or mobile money account (Demirgüç-Kunt *et al*. 2018; Benami & Carter 2021). Central to the concept of financial inclusion is the accessibility and affordability of financial services and products for all, including low-income people, underprivileged and vulnerable groups such as rural dwellers, and women (World Bank 2014; Omar & Inaba 2020). Financial inclusion contributes to the improvement and promotion of the well-being of the population (Eton *et al*. 2021). This ease of access to financial services is said to potentially effect household welfare through better production, higher income, and the possibility of increased consumption (Banerjee *et al*. 2015; Chakrabarty & Mukherjee 2021).

The economy in Nigeria accommodates a large share of the 1.7 billion financially excluded adults globally (Demirgüç-Kunt *et al*. 2018). The agricultural sector, especially smallholder farmers, constitutes the largest share of financially excluded persons in Nigeria (EFINA 2017; Fowowe 2020). In addition, female smallholder farmers are more financially excluded than their male counterparts. Therefore, there is a need to ensure a gender balance in financial inclusion among smallholder farmers in the country. This would help to reduce inequalities and gender gaps. Regardless of the importance of smallholder agriculture and financial inclusion for sustainable outcomes (HLPE 2013), there is a dearth of empirical evidence for the nature of financial inclusion among smallholder farmers, and how gender differences in financial inclusion among smallholder farmers in Nigeria could be linked to household welfare. Therefore, the main objective of this study was to assess the financial inclusion–

gender–welfare nexus among smallholder maize farmers in Nigeria. The specific objectives of this study were to identify the financial inclusion and welfare status of smallholder maize farmers based on gender, identify the determinants of the financial inclusion of smallholder maize farmers based on gender, and examine the effects of financial inclusion on smallholder farmers' household welfare.

2. Materials and methods

2.1 Study area

The study was conducted in three of the six agroecological zones in Nigeria. The zones selected are the Guinea savannah, the derived savannah and the rainforest zones, which cover more than half of the entire land mass of the country (Ayinde *et al*. 2024). These zones are in the Niger, Kwara, Oyo and Osun states of Nigeria, and are states that are prominent in terms of maize production. The climatic cover of these zones is tropical and comprises two major seasons: the dry season and the wet season. The vegetation cover is a mix of forest and grass belts, and farming is the predominant occupation in this area.

2.2 Sampling procedure and data collection

This study used baseline data collected through a multistage random sampling procedure for a randomised controlled trial survey. These included a random selection of 40 communities from the block of communities in each of the three agroecological zones. using the list of communities in the zones. This created a total of 120 communities that were selected across the Osun, Oyo, Kwara and Niger states. Finally, 50 farmers were randomly selected from each community using the household list. Thus, a total of 6 000 farmers were sampled and received and responded to questionnaires during the baseline data collection.

The data of a total of a total of 3 544 farmers were extracted and used for analysis in this study. This selection was based on the household head status of the respondents, and included both male and female household heads. Female-headed households generally are households headed by a divorced or widowed woman.

2.3 Data analysis

This study presents robust results on the link between multidimensional financial inclusion and multidimensional welfare based on gender. In the first part of the analysis, a multidimensional welfare index (MWI) was constructed as a measure of household welfare. We also computed a multidimensional financial inclusion index (FII). (The summary of the domains, indicators and weights used in the calculations can be found in Appendix 1 and Appendix 2.) We then used these indices to investigate the relationship between financial inclusion and welfare based on the gender of the household head. Thus, the welfare model is expressed as:

$$Y_{ij} = \alpha + \gamma FI_{ij} + \eta X_{ij} + \epsilon_{ij}, \tag{1}$$

where Yij is the MWI for household i and gender j; FIij is the financial inclusion index for each household; Xij is a matrix of the socio-economic characteristics of an individual household; ϵij is the error component; and γ and η are parameter estimates. We estimated equation (1) using the constructed welfare indices as the dependent variable (Yij).

2.4 The multidimensional financial inclusion and welfare index

This study adopted a three-stage standardisation approach to develop a multidimensional financial inclusion index (MFII) and a welfare index (MWI) for smallholder farmers in rural Nigeria. The estimation of the financial inclusion index (FII) using the three domains can be written mathematically as follows:

$$\text{FI}_i = f(FP, FC, FW) + ei, \tag{2}$$

where FI_i is the FII for the ith farmer; e_i is the error term; and FP, FC and FW are the three domains: FP = financial participation, FC = financial capability, and FW = financial well-being.

The financial inclusion index (FII) what was estimated used a weighted average approach, where each indicator contributed equally to the overall index. The relevant index for a particular domain was constructed by averaging the indicators, as follows:

$$\text{DI}_k = \sum_{j=1}^{M} Zindj / M, \tag{3}$$

where DI_k is the index for domain k and M is the number of indicators used to construct the index. After the construction of each domain index, the multidimensional FII for the household head was constructed using the formula in Equation (4).

$$\text{FI}_i = \sum_{i=1}^{n} wiDIi / \sum_{i=1}^{n} wi, \tag{4}$$

where w_i is the weight determined by the number of indicators used to construct each domain, and n is the sample size.

This index estimation approach was adopted for both the multidimensional financial inclusion index and the welfare index. The MWI was developed from the five domains of the welfare index (5DWI): assets, social amenities, consumption expenditure, water, and employment. The domains for assets specifically comprise communication assets and mobility asset indicators, while the consumption expenditure domain comprises expenditure on food and health, and expenditure on school and house indicators. The water domain comprises access to drinking water and the water supply conditions. The employment domain comprises the number of employed and sources of income indicators, whereas the social amenities domain comprises access to good roads and access to electricity. Because each indicator was measured on a different scale, there was a need for standardisation of the indicators. The approach used to measure 'life expectancy' in Human Development Reports was then adopted and used for the study. This approach minimises aggregation errors using three levels of standardisation. Since each indicator used in the index measurement has been standardised, there was no need to extract the variables' eigenvalues using principal component analysis (PCA).

In addition, the farmers who were household heads were categorised into two groups following the approach of Briguglio *et al*. (2009) and Chishimba and Wilson (2021), such that any farmer with an estimated FII score of 0.66 and above was said to be more financially included, while a farmer with less than that was said to be excluded.

2.5 Logit model

The logit model was used to model dichotomous outcome variables. The model was used to analyse the determinants of financial inclusion among farmers. The regression model fits a linear model describing the relationship between the dependent and explanatory variables.

The logistic function is written explicitly as

$$\text{logit}(P_i) = \ln\left(\frac{P_i}{1-P_i}\right) = Y_i = \beta_0 + \beta_1 X_1 + \mathcal{E}, \tag{5}$$

where Y_i = financial inclusion status (dummy 1 = yes, 0 = otherwise);
$\frac{P_i}{1-P_i}$ = ratio of the probability that a farmer is financially included to the probability that a farmer is financially excluded;
X = explanatory variables, and
$\mathcal{E}$ = the error term.

2.6 Seemingly unrelated regression (SUR) model

To explore the influence of financial inclusion on the household welfare of farmers, this study adopted the seemingly unrelated regression (SUR) model. This is because the SUR model allows for a combined estimation of multiple regression models. However, the SUR model was assumed to have correlated error terms across equations. The equations in an SUR system seem unrelated in the sense that none of the dependent variables appear in the set of independent variables of the other equations. Thus, the SUR model is expressed as:

$$y' = x'\theta + \varepsilon', \tag{6}$$

where y' is $(1 \times m)$ vector indicating the m SUR equations; $x' = (x_1, \dots ., x_k)$ ' is a vector of independent variables; ε' is a $(1 \times m)$ vector of disturbances of order; and θ' is a matrix of coefficients of order $(m \times k)$, i.e. k' is the number of parameters for each of the m seemingly unrelated simultaneous regression equations. The model assumes its error components are identically and independently distributed (iid), with zero means and a covariance matrix of Σ, i.e. $\varepsilon'|x \sim iid\ (0, Σ)$. The five welfare indicators are defined as a set of five simultaneous equations:

$$\begin{aligned}
WI_{i1} &= \beta_1 FI_i + \gamma_1 X_{i1} + \varepsilon_{i1} \qquad WI_{i2} = \beta_2 FI_i + \gamma_2 X_{i2} + \varepsilon_{i2} \\
WI_{i3} &= \beta_3 FI_i + \gamma_3 X_{i3} + \varepsilon_{i3} \\
WI_{i4} &= \beta_4 FI_i + \gamma_4 X_{i4} + \varepsilon_{i4} \\
WI_{i5} &= \beta_5 FI_i + \gamma_5 X_{i5} + \varepsilon_{i5},
\end{aligned} \tag{7}$$

where $WI_{i1}, WI_{i2}, WI_{i3}, WI_{i4}$ and WI_{i5} are the five welfare domains considered in this study; FI represents financial inclusion indices of the households; X_{i1} to X_{i4} are independent variables for the five equations; and $\beta_{1,2,\dots 5}$ and $\gamma_{1,2,\dots 5}$ are parameters of the five equations to be estimated. The SUR model can also be used when some or all the dependent variables are not continuous variables.

3. Results and discussions

3.1 Descriptive statistics of socio-economic characteristics

This section presents summary statistics of the variables used in this study (Table 1). Male farmers cultivated an average land size of 1.11 hectares, and the average age of the farmers was 47 years. The average number of years of schooling of male farmers was eight years. These male farmers had an average household size of four members, and average farming experience of 24 years, achieving an average maize yield of 2 970 kg/ha. The average credit that farmers were able to obtain was ₦19 476.

Table 1: Descriptive statistics of socio-economic characteristics

Variable	Male (n = 2 966)		Female (n = 578)	
	Mean	Std. err	Mean	Std. err
Age	47.71	0.228	56.79	0.413
Education	8.00	0.101	2.25	0.168
Household size	4.56	0.039	3.35	0.071
Distance to market	4.58	0.086	4.67	0.204
Farming experience	24.24	0.247	25.58	0.568
Farm size	1.12	0.023	0.94	0.039
Yield	2 970.36	142.43	2 722.57	372.30
Access to internet	0.17	0.007	0.01	0.004
Land tenure	0.61	0.009	0.75	0.018
Household income	13.05	0.015	12.55	0.032
Extension agent	0.27	0.008	0.21	0.017
Ecology	1.99	0.015	1.83	0.034
Membership	0.61	0.009	0.08	0.011
Own a bank account	0.50	0.009	0.52	0.021
Save in bank	0.44	0.009	0.21	0.017
Credit access	0.15	0.007	0.13	0.014
Amount of credit obtained	19 476.47	4 098.76	11 346.89	3 157.31
Own a mobile phone	0.91	0.005	0.84	0.015
Insurance access	0.04	0.004	0.02	0.006
Member of informal savings group	0.12	0.006	0.06	0.01

Female farmers cultivated an average land size of 0.94 hectares. Their average age was 56 years, with a household size of approximately three members. The average number of years of schooling for female farmers was two years. The farmers had an average farming experience of 25 years and an average maize yield of 2 722 kg/ha. The average number of credit farmers were able to obtain was ₦11 347 per annum.

3.2 Financial inclusion index

This section presents the findings of the developed multidimensional financial inclusion index (Table 2). The results show that, for male farmers, about 56% of male household heads had access to formal financial services; however, only 43% still used formal financial services. About 15% of farmers had no barriers to formal financial services. The results further show a low level of financial literacy, with only 9% of the farmers having attended at least one training session on financial education. About 32% of the farmers had a saving, insurance or credit plan. The majority (86%) of farmers indicated that they had trust in financial service providers. Adegbite (2021) indicates that most rural smallholder farmers have trust in formal sources, including banks, savings groups, bank agents, microfinance, mobile money providers, and mobile money agents. The results further show that the majority of farmers (61.36%) were sometimes able to pay bills. In terms of financial resilience, only 5% of the farmers would be able to meet an emergency financial need to the value of approximately ₦100 000.

Furthermore, the results show that only about 32% of the farmers were able to save a little or afford luxury goods, while having just enough funds for food and clothes.

While these results are similar but lower for female farmers, the results show that more female farmers have a saving plan and financial capability than their male counterparts. In terms of financial inclusion status, the male farmers had a share of 86% of the total financial inclusion. The result of the multidimensional financial inclusion index, which determines the level of financial inclusion of rural smallholder farmers, showed that male farmers had an MFII of 0.38, while female farmers had an MFII of 0.31. This is statistically different at the 1% level of significance, implying that male farmers are financially more included than female farmers. The findings also imply that rural smallholder farmers in the study area are characterised by a low level of financial inclusion, which therefore means that it is unable to sustainably transform smallholder agriculture in Nigeria.

Table 2: Summary of the multidimensional financial inclusion index (MFII)

Variable	Male (%)	Female (%)
Access to financial services	56.58	56.57
Usage of financial services	43.53	21.45
No barrier to financial services	14.87	12.98
Financial education	8.63	5.54
Having a savings plan	32.70	38.75
Trust financial services	85.87	80.45
Can pay bills	61.36	46.37
Ability to save ₦100 000 monthly	5.29	2.08
Ability to have enough money for expenses	31.86	16.09
Financial participation	31.83	18.86
Financial capability	31.93	33.22
Financial wellbeing	24.95	10.03
Financial inclusion	45.21	36.81
Share	86.19	13.81
	Male (Index)	Female (Index)
Financial inclusion index	0.38	0.31
Guinea savannah	0.36	0.29
Derived savannah	0.42	0.33
Rainforest	0.36	0.32

T-test: t = 10.6914, probability = 0.0000

3.3 Welfare index

This section presents a descriptive analysis of the sub-indicators of the domains used to develop the multidimensional welfare index (MWI) disaggregated by gender (Table 3). The results show that, for almost all sub-indicators, male farmers had a better status than their female counterparts. However, in terms of number of income sources, female farmers (50%) fared better than male farmers (37%). In addition, in terms of employment, female farmers (99.8%) had a better status than male farmers (58.4%). Sakyi-Nyarko *et al*. (2022) note that rural poor households employ children to assist with the day-to-day activities of the household business. This is more likely for female-headed households than for male-headed households, and could increase the employment status of the households.

The MWI shows that male-headed households had a value of 0.46, while the female-headed households had a value of 0.43. This difference is statistically significant at the 1% level. Male farmers accounted for 84% of the total welfare index. Based on the agroecological zone of the farmers, the male farmers had an MWI of 0.49, 0.47 and 0.41 for farmers in the Guinea savannah, derived savannah and rainforest respectively, while the female farmers had an MWI of 0.46, 0.42 and 0.39 in the Guinea savannah, derived savannah and the rainforest respectively. For both male and

female farmers, those based in the Guinea savannah had the highest welfare status. These findings imply that rural smallholder farmers have a low level of welfare. Furthermore, male farmers have a higher level of welfare than their female counterparts in all locations.

Table 3: Summary of the multidimensional welfare inclusion index

Variable	Male (%)	Female (%)
Communication asset	94.64	86.33
Mobility assets	14.16	2.25
Food and health expenditure	99.73	99.83
School and house expenditure	83.41	64.53
Access to good water	84.59	83.39
Condition of water supply	23.57	23.88
Working household members	35.43	20.76
Sources of income	36.99	50
Access to good road	91.34	94.98
Access to electricity	66.49	64.88
Asset	94.78	94.98
Expenditure	99.83	60.03
Water	85.03	84.26
Employment	58.40	99.83
Social amenities	94.40	86.68
Welfare status	50.47	43.94
Share	84.48	15.52
	Male (Index)	Female (Index)
Welfare index	0.46	0.43
Guinea savannah	0.46	0.29
Derived savannah	0.42	0.33
Rainforest	0.39	0.32

t-test: t = 4.1501, probability = 0.0000

3.4 Determinants of financial inclusion

Table 4 presents the results of the estimation of the marginal effects of the determinants of farmers' financial inclusion. As shown in the table, the variables that affect the financial inclusion status of both male- and female-headed households are educational status, household size, distance to market, land ownership status, household income, access to extension services, ecology, and access to the internet.

For male farmers, education level positively influenced their financial inclusion status. The results show that the probability of financial inclusion increases with higher levels of education, by approximately 23%. This implies that those with higher educational levels are financially more included than those with lower educational levels. This result is consistent with the findings of Peprah *et al*. (2020), who asserted that a higher education level could predispose farmers to financial literacy and the use of financial products and services for financial inclusion. In addition, an increase in the number of employed persons and the household income of the male-headed household increased the probability of being financially included by 3% and 1%, respectively. This implies that, when the number of income sources and household income increase, male farmers' financial inclusion status increases. This is in line with the findings of Ibrahim *et al*. (2019). Household land title status had a significantly positive coefficient. This implies that households with legal land titles are more likely to be financially included. This is consistent with previous studies, which have found that legal land titles can be used as collateral to access credit facilities at banks. Access to information and communications technology (ICT), such as phone, internet and extension services, increased the farmers' probability of being financially included. Similar findings have been reported in previous

studies in Nigeria (Abor *et al*. 2018; Fowowe 2020). However, distance to the market negatively influenced the probability that the farmers were financially included. This implies that the farther the market, the less likely farmers are to be financially included. This could be a result of the fact that distant markets could hinder market participation because farmers might have to incur huge costs for transportation, which would reduce their farm income and hence influence their financial inclusion. The results also show that the location of farmers negatively influenced their financial inclusion. This implies that male-headed farming households based in the derived savannah zone have a probability of being financially included by about 13% when compared to those in the Guinea savannah zone, and the probability of male farmers in the rainforest being financially included is reduced by 4.75% when compared to those in the Guinea savannah agroecological zone.

For female-headed households, the number of employed household members, land ownership status and ecology had a positive influence on their probability of being financially included. The result implies that an increase in the number of persons gainfully employed in the household, and whether they owned their farmland, increased their probability of being financially included by 3% and 21%, respectively. Thus, it is possible that an increase in the number of employed persons in a household could increase the household's financial resources. The increased need for household members to engage in income-generating activities to cater for the daily subsistence of the household may consequently increase access to financial services. In addition, female-headed households with land titles could increase their farming activities and their productivity, which may increase their access to financial services. In a study done in Nigeria, Fowowe (2020) found that an increase in agricultural productivity increased the farmers' financial inclusion status. The results also showed that female-headed households in the derived and rainforest zones were more likely to be financially included by 19% and 15%, respectively compared to those based in the Guinea savannah agroecological zone. This result is in line with Adegbite's (2021) finding that smallholder farmers in the southern part of Nigeria are more financially included than those in other geopolitical zones of the country. The results also show that younger female household heads are approximately 0.4% more likely to be financially included than their older counterparts. This may be due to the affinity of younger female farmers for access to financial services to enable them to expand their production to increase profitability.

Table 4: Logit regression estimate of the determinants of financial inclusion

Variables	Male		Female	
	Odds ratio	**Marginal effect**	**Odds ratio**	**Marginal effect**
Age	1.001 (0.003)	0.001 (0.001)	0.980 (0.010)	-0.004 (0.002)**
Education	1.749 (0.226)***	0.126 (0.029)***	1.095 (0.167)	0.020 (0.033)
Employed household size	1.147 (0.032)***	0.031 (0.006)***	1.176 (0.094)	0.035 (0.017)**
Distance to market	0.961 (0.009)***	-0.009 (0.002)***	1.018 (0.019)	0.004 (0.004)
Farm size	0.964 (0.033)	-0.008 (0.008)	0.930 (0.091)	-0.016 (0.021)
Yield	1.000 (5.66E-06)	1.97E-06 (1.27E-06)	1.002 (0.001)	4.25E-06 (3.07E-06)
Land tenure	0.694 (0.058)***	0.083 (0.019)***	0.359 (0.084)***	0.211 (0.043)***
Household income	1.001 (7.92E-08)***	1.16E-07 (1.73E-08)***	1 (2.92E-07)	1.25E-08 (6.28E-08)
Extension agent	0.707 (0.065)***	0.078 (0.021)***	2.233 (1.021)*	0.161 (0.083)**
Ecology				
Derived savannah	1.742 (0.172)***	0.129 (0.023)***	2.373 (0.552)***	0.189 (0.049)***
Rainforest	0.812 (0.085)**	-0.047 (0.023)**	1.997 (0.491)***	0.154 (0.053)***
Access to internet	1.199 (0.120)*	0.041 (0.023)*	0.738 (0.185)	-0.066 (0.055)
Constant	0.565 (0.121)***		4.676 (3.263)**	
LR chi^2	285.46		63.45	
Prob > chi^2	0.000		0.000	
Pseudo R^2	0.0699		0.082	
Log likelihood	-1 899.529		-357.196	

Notes: Standard errors in parentheses; *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.1$

3.5 Influence of financial inclusion on household welfare

This section presents the results of the seemingly unrelated regressions used to estimate the relationship between financial inclusion and selected household and individual welfare indicators (expenditure, employment, water, assets and social amenities). The results are presented in Tables 5 and 6, respectively.

The coefficients that are positive and significant throughout all equations for the male-headed households in Table 5 are financial inclusion, age and education. Interestingly, the results of the male-headed households indicate that being older, having a higher educational status, being financially included, and having access to extension services positively influence their access to social amenities. This could be due to the fact that having higher educational status, financial inclusion status and access to extension services/information could determine their choice of and demand for better access to social amenities. Meanwhile, their land ownership status, distance to the market, and ecological location are negatively associated with their access to social amenities. This result implies that factors such as land ownership, distance to market and ecological location, especially being based in the Guinea savannah zone, do not increase their access to social amenities

In terms of employment, being older, having a larger household size, having access to the internet, being financially included, owning farmland, and having a higher household income positively influence their household employment status. This result implies that male farmers have improved their employment status through an increase in these factors. Male household heads' access to extension services and their location negatively influence their access to employment.

In terms of the water domain, age, household size, financial inclusion and access to the internet positively influenced access to good water supply, while farm size, land ownership status and location negatively influenced access to a good water supply. This result implies that, as the male-headed household head increases in age and his household size becomes larger, being financially included and having access to the internet increase his access to a good water supply. For the expenditure domain, the factors that positively influenced household consumption expenditure included age, education, household size, farm size, yield, access to the internet, financial inclusion, land tenure, household income and location. This implies that, as these factors increase, household consumption expenditure increases. This finding supports those of Chakrabarty and Mukherjee (2021) and Sakyi-Nyarko *et al*. (2022).

For the asset domain, age, education, household size, distance to market, access to the internet, financial inclusion, household income, access to extension agents and location positively influenced the asset level of the farmers. This implies that the higher these factors are, the higher the likelihood of an increase in household assets. Land ownership status and farm size negatively influenced asset levels. This implies that, when male farmers do not legally own farmland, having a smaller farm size is likely to reduce their asset level. Therefore, these results indicate that financial inclusion increases male farmers' welfare across the entire welfare domain. This is in support of the findings of Sakyi-Nyarko *et al*. (2022).

Table 5: The results of the influence of financial inclusion on the welfare of male-headed households

Variables	Access	Employment	Water	Expenditure	Asset
Age	0.002***	0.0021***	0.001*	0.002***	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Education	0.002**	0.003	-0.001	0.001***	0.002
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Household size	0.004	0.034***	0.004*	0.005***	0.010***
	(0.003)	(0.003)	(0.003)	(0.000)	(0.002)
Dist. to market	-0.005***	0.002	0.001	-0.001	0.002***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Farm size	0.002	-0.007	-0.008*	0.003***	-0.009***
	(0.004)	(0.005)	(0.004)	(0.001)	(0.003)
Yield	-6.34e-07	1.90e-07	-3.65e-07	3.43e-07***	-2.28e-07
	(6.75e-07)	(7.64e-07)	(6.98e-07)	(1.08e-07)	(4.85e-07)
Access to internet	-0.007	0.031*	0.060***	0.013***	0.093***
	(0.015)	(0.017)	(0.015)	(0.002)	(0.011)
Financial inclusion	0.144***	0.060***	0.027**	0.011***	0.058***
	(0.011)	(0.012)	(0.011)	(0.002)	(0.008)
Land tenure	-0.022**	0.0364***	-0.019*	0.005***	-0.024***
	(0.011)	(0.013)	(0.011)	(0.002)	(0.008)
Household income	0.003	0.089***	0.003	0.012***	0.029***
	(0.007)	(0.007)	(0.007)	(0.001)	(0.005)
Extension agent	0.034***	-0.083***	0.015	-0.004	0.047***
	(0.012)	(0.013)	(0.012)	(0.002)	(0.008)
Ecology	-0.072	-0.062	-0.119***	0.005***	0.033***
	(0.007)	(0.007)	(0.007)	(0.001)	(0.005)
Constant	0.742	-0.967	0.673***	-0.168***	-0.041
	(0.085)	(0.096)	(0.088)	(0.014)	(0.061)
RMSE	0.278	0.315	0.288	0.044	0.200
R-squared	0.129	0.172	0.114	0.183	0.135
Chi^2	442.38	617.35	381.22	666.22	460.92
p > chi^2	0.000	0.000	0.000	0.000	0.000
Breusch–Pagan test of independence: chi^2 (10) = 340.888; probability = 0.000					

Notes: Number of observations: 3 427; standard errors in parentheses; *** = p < 0.01, ** = p < 0.05, * = p < 0.1

Table 6 presents the results of the SUR model of the influence of financial inclusion on the welfare of female household head farmers. The results indicate that financial inclusion does not influence all welfare factors. The financial inclusion of female-headed households significantly influences their access to social amenities, consumption expenditure and assets. This implies that, as these women farmers are financially included, they could demand better access to social amenities to increase their consumption expenditure and asset levels. Previous studies (Chai *et al*. 2015; Chakrabarty & Mandi 2019; Bharadwaj & Suri 2020; Chakrabarty & Mukherjee 2021) have reported similar results.

Table 6: Results of the influence of financial inclusion on welfare among female-headed households

Variables	Access	Employment	Water	Expenditure	Asset
Age	0.003	-0.002	-0.001	0.005***	0.001
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
Education	0.001	0.003	0.004	-0.005	0.005*
	(0.002)	(0.000)	(0.003)	(0.003)	(0.003)
Household size	0.015***	0.004***	0.011	0.062***	0.012*
	(0.005)	(0.001)	(0.008)	(0.008)	(0.007)
Distance to market	0.003	-0.003	0.003	0.002	-0.004*
	(0.002)	(0.000)	(0.003)	(0.003)	(0.002)
Farm size	0.003	0.001	-0.045	0.005	-0.008
	(0.008)	(0.001)	(0.013)	(0.013)	(0.012)
Yield	-1.71e-06**	4.20e-08	-2.54e-07***	-3.71e-07	1.23e-07
	(8.38e-07)	(1.29e-07)	(1.41e-06)	(1.40e-06)	(1.30e-06)
Access to internet	0.114	0.020*	-0.051	-0.156	-0.400***
	(0.073)	(0.011)	(0.122)	(0.122)	(0.113)
Financial inclusion	0.060***	0.001	-0.015	0.052**	0.140***
	(0.015)	(0.002)	(0.026)	(0.026)	(0.024)
Land tenure	-0.012	-0.001	0.009	0.001	-0.019
	(0.017)	(0.003)	(0.029)	(0.029)	(0.027)
Household income	0.033***	0.011***	0.004	0.095***	-0.027*
	(0.010)	(0.002)	(0.017)	(0.017)	(0.015)
Extension agent	0.012	-0.005*	0.064**	-0.075**	0.011
	(0.018)	(0.003)	(0.031)	(0.031)	(0.029)
Ecology	0.038***	0.003*	-0.102***	-0.030*	-0.092***
	(0.010)	(0.002)	(0.016)	(0.016)	(0.015)
Constant	-0.147	-0.115***	0.706***	-1.259***	1.172***
	(0.128)	(0.020)	(0.214)	(0.214)	(0.198)
RMSE	0.174	0.027	0.292	0.291	0.270
R-squared	0.128	0.194	0.108	0.194	0.151
Chi^2	85.05	138.88	69.80	138.94	102.93
$p > $ chi^2	0.000	0.000	0.000	0.000	0.000
Breusch–Pagan test of independence: chi^2 (10) = 88.063, probability = 0.000					

Notes: Observations: 3 427; Standard errors in parentheses; *** = p < 0.01, ** = p < 0.05, * = p < 0.1

Other factors that positively influenced female farmers' access to social amenities included household income, household size, and ecological location. This result implies that, as these factors increase, households' access to social amenities increases. However, the results show that an increase in yield did not significantly increase access to social amenities. The most plausible explanation for this could be that increases in the yield of crops planted by women farmers, which gives rise to higher income, does not increase their demand for social amenities, as there could be other pressing financial issues to be catered for in the household.

Regarding the employment domain, household size, access to the internet, household income and ecological location increased employment status. This could be because, as the household size increases, it increases the number of persons to be catered for; therefore, this may increase the number of household members searching for employment to meet the domestic needs of the household.

For the expenditure domain, the age of the household head, household size and household income positively influenced household consumption expenditure. This implies that, as these factors increase, the consumption expenditure of the household increases, while factors such as access to extension services and ecological location of the farmers significantly reduce the consumption expenditure of the household. Lastly, educational level and household size positively influenced the asset levels of

female farmers, while distance to the market, access to the internet, household income and ecological location significantly reduced the asset levels of female farmers. This finding implies that these factors do not increase the asset levels of female-headed households.

4. Conclusion

The need for a good understanding of the relationship between financial inclusion and the household welfare of smallholder farmers has become a significant concern in agricultural development. This study contributes significantly to the literature by computing a gender-disaggregated multidimensional index for financial inclusion and a multidimensional welfare index to show the relationship between financial inclusion, gender and household welfare. The study confirms earlier studies that rural smallholder farmers are characterised by a low level of financial inclusion and welfare status, with male farmers having a higher level of financial inclusion and welfare than their female counterparts at all locations. However, this study shows that a number of significant factors, such as the age of the farmer, the number of employed persons, land tenure and location of the female-headed households need to be considered to ensure a reduction in the gender gap in financial inclusion. The study also shows that financial inclusion significantly influences the welfare status of both male and female farmers, which implies that an increase in access to financial services leads to an increase in the welfare status of farmers. This is especially the case in female-headed households, which are more marginal compared to their male counterparts. This study also observed that improved financial inclusion increases the probability of improving outcomes relating to consumption expenditure, employment, water, assets and social amenities for male farmers, and access to social amenities, consumption expenditure and assets for female-headed farming households. Thus, there is a clear policy implication: enhancing financial inclusion will significantly contribute to better welfare status towards the attainment of the sustainable development goals (SDGs) in the country.

The study therefore recommends that policies should be implemented that will contribute to increasing financial inclusion and improving the welfare status of farmers (especially female household heads. Such policies could include increasing farmers' access to financial services, especially digital and point-of-sale (POS) services in rural areas, as well as implementing sensitisation programmes on financial literacy and financial products.

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Appendix 1: Summary of the adapted financial inclusion domains, indicators and weighting

Domain	Indicator	Description	Relative weight
Financial participation	Access	Rural smallholder farmer has a personal formal account with bank financial institution, non-bank financial institution or mobile money service provider.	1/9
	Usage	Rural smallholder farmer has used a formal account with at least one financial service provider for up to 90 days.	1/9
	No barrier	No barrier is reported by the rural smallholder farmer.	1/9
Financial capability	Financial literacy	Rural smallholder farmer is able to indicate at least one of the financial services offered by the formal institution used; OR can indicate at least one type of financial activity for which he or she can use mobile money; OR at least recalls one name of any mobile money provider, without aid.	1/9
	Financial planning	Rural smallholder farmer has at least one of the following: a savings plan, investment plan, living will, retirement plan, insurance plan; OR currently has: a credit plan, goal savings plan or contractual savings plan for school fees, and a savings or payment plan for agricultural inputs.	1/9
	Consumer protection	Rural smallholder farmer fully trusts or somewhat trusts at least one formal financial source.	1/9
Financial well-being	Control over finance	Rural smallholder farmer makes either sole or joint decisions regarding daily expenses; OR is able to always or sometimes pay bills.	1/9
	Financial resilience	Possible or somewhat possible for a rural smallholder farmer to come up with 100 000 naira to pay for an emergency within the next month; OR always or sometimes has emergency funds to cover unplanned expenses.	1/9
	Financial situation	Rural smallholder farmer is from a household with at least enough money for food and clothes only, and at most is able to afford certain expensive goods.	1/9

Appendix 2: Summary of the adapted welfare domains, indicators and weighting

Domain	Indicator	Description	Relative weight
Asset	Communication asset	Rural smallholder farmer's household has any of the following: radio, television, landline phone, mobile phone, computer, internet at home.	1/10
	Mobility asset	Rural smallholder farmer's household has any of the following: car/pick-up/truck/van, motorcycle/tricycle, bicycle, four-wheel tractor, canoe/boat.	1/10
Consumption expenditure	Expenditure on health and food	Rural smallholder farmer's household can afford at least the mean expenditure on health and food per month in the study area.	1/10
	Expenditure on schooling and house	Rural smallholder farmer's household can afford at least the mean expenditure on schooling and housing per annum in the study area.	1/10
Water	Access to good drinking water	Rural smallholder farmer's main source of drinking water is tap water or borehole water.	1/10
	Condition of water supply	Rural smallholder farmer's source of water supply is in good condition.	1/10
Employment	Employed	At least two members of the rural smallholder farmer's household is employed.	1/10
	Number of income sources	Rural smallholder farmer's household has at least the average number of income sources in the study area.	1/10
Social amenities	Access to good road	Rural smallholder farmer's household has access to a good road.	1/10
	Access to electricity	Rural smallholder farmer's household has access to an electricity supply.	1/10