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Factors Influencing the Adoption of Improved Agricultural Technologies among Smallholder Farmers in Makurdi, Benue State

Ochimana, G.A., Atanu, M. and Owoicho, J.I.
Department of Agricultural Economics, College of Agricultural Economics and Extension,
Joseph Sarwuan Tarka University Makurdi, Benue State

Corresponding Author: ochimana.gloria@uam.edu.ng

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ABSTRACT

The study analysed the factors influencing smallholder farmers' adoption of improved agricultural technologies in Makurdi, Benue State, Nigeria. A multistage sampling technique was used to select 108 respondents, while data were collected through structured questionnaires and analysed using descriptive and inferential statistics. Results showed that 91.67% of respondents were male, 57.41% were aged 21–40 years, 94.44% were married, and 84.26% had secondary education. Most respondents (92.59%) were farmers, 53.70% had 21–30 years farming experience, 70.37% cultivated 4–7.9 hectares, and 85.19% belonged to cooperatives, although the same proportion lacked extension access. The major technologies adopted were herbicides for land clearing (100%), pesticides for pest control (100%), fertilizers (100%), sowing dates (99.07%), and mechanized tillage (85.19%). Logistic regression results showed that age (-0.009) negatively influenced adoption, while household size (0.4213) positively influenced adoption. Extension services mainly contributed through awareness creation (76.85%), technical support (60.19%), and facilitating access to inputs and credit (56.48%). Major challenges affecting adoption included high cost of technologies (95.37%), lack of access to credit (90.74%), poor distribution channels (86.11%), bad roads (79.63%), poor infrastructure (78.70%), and adherence to traditional farming methods (65.74%). The study recommends improved extension services, rural infrastructure, and digital advisory platforms such as radio, SMS, and WhatsApp groups to enhance technology adoption.

1.0 Introduction

Agriculture plays a fundamental role in economic growth, enhancing food security, poverty reduction and rural development. Smallholder agriculture is one of the principal economic occupations in the world and is the main source of income and employment for 70 percent of the world's poor who live in rural areas and account for 60 percent of global agriculture (Poole, 2017). Estimates show that there are about 500million farms globally which are being cultivated by smallholder farm households with more than 2 billion people making their livelihood from these farms (Abdullah, *et al* 2017). In Africa, agriculture remains a strategic sector and its wealth directly affects economic development, food security, poverty alleviation and social welfare, particularly of countries in Sub-Saharan Africa whose agriculture is dominated by smallholder farmers (Mango et al., 2017).

Smallholder agriculture has been identified to be critical in the creation of employment, improving food security and improving the economy (Fadeyi *et al*.,2022). Despite its importance, agricultural productivity remains low due to several constraints, including limited access to improved agricultural technologies These technologies, which include improved seed varieties, mechanized farming equipment, irrigation systems, and modern pest and disease control methods, have been identified as essential tools for increasing farm yields and improving rural livelihoods (Sennuga *et al*., 2020). Smallholder farmers in Nigeria, particularly those in Makurdi, Benue State, form the backbone of the agricultural sector. However, most of these farmers in Makurdi still rely on traditional farming methods, which limit productivity and hinder their ability to meet growing food demands. Research has shown that the adoption of improved agricultural

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technologies can significantly enhance productivity, increase household income, and contribute to national food security (Chete, 2019).

Improved Agricultural Technologies (IATs) are a collection of principles for on-farm production and post-production processes, aimed at delivering in safe and healthy food and non-food agricultural products, while taking into account economic, social and environmental sustainability (Sennuga, *et al*., 2020). IATs enable farmers to increase their productivity and it covers a range of areas including improved seeds, crop protection, water modern irrigation practices, crop land management, degraded land restoration, integrated pest management, integrated fertilizer management and conservation agriculture (FAO 2010; Sennuga, *et al*., 2020). These technologies are particularly relevant to smallholder farmers in developing countries because they are constrained in several ways, which makes them a priority for development efforts. These farmers for instance, live and farm in areas where rainfall is low and erratic, and soils tend to be infertile. In addition, infrastructure and institutions such as irrigation, input and product markets, and credit as well as extension services tend to be poorly developed (Muzari *et al*., 2012; Sennuga, *et al*., 2020).

Studies have shown that the adoption of these technologies can significantly boost crop yields and reduce post-harvest losses (Adesina *et al*., 2023). However, in Nigeria, particularly among smallholder farmers in Benue State, the adoption rate of these innovations remains low. Younger farmers are generally more open to adopting new technologies, while gender dynamics can influence the type of technologies adopted. In the case of cassava processing technologies among rural women in Benue State, factors such as age and household size were significant in determining adoption levels (Vihi *et al*., 2022). Moreover, the involvement of both male and female farmers in cassava production highlights the importance of considering gender in technology adoption strategies (Onyemma *et al*., 2020). This has led to concerns regarding food security, rural poverty, and the sustainability of small-scale farming systems.

However, several factors influencing the adoption of improved agricultural technologies include socio-economic variables such as education level, farm size, income, and access to extension services (Ogunniyi *et al*., 2021). Education plays a crucial role in the adoption of agricultural technologies. Studies indicate that a higher level of formal education among farmers is associated with increased adoption rates of improved technologies. Given the example, in Benue State, 90% of cassava farmers had some form of formal education, which contributed to their awareness and adoption of improved cassava technologies (Onyemma *et al*., 2020). Similarly, educational attainment was found to positively influence the adoption of improved rice varieties, as it enhances farmers' understanding and ability to implement new technologies effectively (Bello *et al*., 2020). Cultural perceptions, risk aversion, and lack of financial support have also been identified as major barriers to technology uptake. Understanding these factors is crucial for policymakers, agricultural extension agents, and development organizations seeking to enhance technology adoption and improve the livelihoods of smallholder farmers in Benue State.

Despite various government and private sector efforts to promote modern agricultural technologies, smallholder farmers in Benue State continue to face numerous challenges that hinder their adoption of these innovations. Research indicates that low technology adoption rates contribute to poor agricultural productivity, increased vulnerability to climate change, and persistent rural poverty (Ikechi *et al*., 2022). The slow adoption of improved agricultural technologies is a major contributor to this challenge (Fadeyi *et al*., 2022). While research and extension services have promoted modern farming techniques such as improved seed varieties, mechanized equipment, and climate-smart agricultural practices, adoption rates remain low. This has resulted in continued reliance on traditional, low-yield farming methods, leading to food shortages and economic hardship for farming households (Sennuga *et al*., 2020).

However, one major issue is the limited access to information and extension services. In Benue State, limited access to extension services was noted among cassava farmers, which affected the adoption rates of improved technologies (Onyemma *et al*., 2020). The importance of extension contact is further emphasized in the adoption of improved rice varieties, where it was found to have a positive and statistically significant influence (Bello *et al*., 2020). Agricultural extension services, which are supposed to bridge this knowledge gap, are often underfunded and poorly structured, leaving farmers with inadequate support.

Financial constraints have also played a significant role in the low adoption of improved agricultural technologies. Many smallholder

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farmers lack the financial capacity to invest in improved agricultural technologies. High costs associated with purchasing improved seeds, fertilizers, mechanized tools, and irrigation systems deter many farmers from adopting these technologies. Inadequate access to credit facilities further compounds the problem, as most financial institutions require collateral that smallholder farmers do not possess (Chete, 2019). Without financial support, farmers are unable to take advantage of modern farming techniques, leaving them trapped in subsistence agriculture. Many smallholder farmers operate at subsistence levels with limited access to credit facilities, making it difficult for them to afford high-quality seeds, fertilizers, or modern farming tools. Access to credit enables farmers to invest in new technologies, while the affordability of these technologies influences their adoption. In Benue State, the cost of innovation was identified as a barrier to the adoption of agricultural technologies (Fidelugwuowo and Omekwu, 2023). Additionally, the availability and affordability of inputs were major factors influencing the adoption of improved cassava technologies (Onyemma *et al*., 2020).

1.1 Objectives of the Study

i. describe the socio-economic characteristics of the smallholder farmers in the study area;
ii. identify the improved agricultural technologies adopted by farmers in the study area;
iii. determine the factors influencing the adoption of improved agricultural technologies among smallholder farmers in the study area;
iv. identify the challenges faced by smallholder farmers in accessing improved agricultural technologies in the study area.

2.0 Methodology

2.1 The Study Area

The study was carried out in Makurdi Local Government Area Makurdi town is located at Lat. 7° 47 1and 10° 00 1 North and Long 6° 25 1 and 8° 8 1 East of the equator. It is bounded by Guma Local Government Area to the North, Gwer East Local Government to the South, Gwer-West Local Government Area to the South-West and Doma Local Government Area of Nasarawa State to the North-West (Figure 1). It is situated in the Benue Valley on the bank of river Benue. The town is strategically located on the North-South transportation network by road and by rail respectively, between Nasarawa and Enugu States with the total land area of about 810 square kilometers.

What is known as Makurdi today has been in existence since 1912. It started as a typical village composed of scattered Tiv compounds and Jukun fishermen settlement. With the advent of colonialism, Makurdi became a center of river trade, a railway town and an administrative town.

It became a provincial headquarters of Benue Province in 1927, when it was transferred from Abinsi. Following the Local Government reforms of 1970, Makurdi became the headquarters of Makurdi Division. In 1976, following the creation of Benue State out of the Benue Plateau, Makurdi doubles as the State headquarters (capital) as well as the headquarters of Makurdi Local Government Area. The rail road and the trunk 'A' road that connect the Eastern states to the North and the North-East make Makurdi a major cross road center. Makurdi has a population of 226,198 a density of 323 persons per square kilometers as of 1991, the National Population Census data figures, has a population of 300, 377 with a density of over 400 persons per square kilometers as of the 2006 National population census data figures and the highest in the state.

2.2 Population and Sampling Procedure

The population for the study comprised all smallholder farmers actively engaged in crop and/or livestock production in Makurdi Local Government Area of Benue State, Nigeria. A sample size of 108 smallholder farmers was selected for the study.

A multistage sampling technique was used to select respondents for the study. First stage was random selection of seven (7) council wards from Makurdi LGA. Second stage was purposive selection of 1 community from each of the council wards. Third stage was 10% proportionate selection of smallholder farmers from the communities to arrive at a sample size of 108 respondents.

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Table 1: Sample Selection

Council wards	Village community	Number of farmers	Sample selection (10%)
Ankpa	Demekpe	168	17
Agan	Mbakukwa	153	15
Fiidi	Kucha Utebe	162	16
Mbalagh	Anter	159	16
North Bank I	Yagba	142	14
North Bank II	Udei	157	16
Wailamayo	Nyiman Pilla	143	14
Total		**951**	**108**

Source: BNARDA, 2024

2.3 Methods of Data Collection

Primary data were used for the study. The primary data were collected by use of a structured questionnaire consisting of various items based on the specific objectives of the study.

2.4 Method of Data Analysis

The data collected were analyzed using both descriptive and inferential statistics. Specific objective i, ii, and v were analysed using descriptive statistics such as frequency and percentages. Specific objective iii was analysed using logistic regression.

2.5 Model Specification

Binary Logit Regression Model

Using the variables:

Let:

YiY_i =

Binary outcome variable indicating **adoption of agricultural technologies** (1 = adopted, 0 = not adopted)

$$Pi = Pr\,(Yi = 1)P\_i\ = \backslash Pr(Y\_i = 1):$$

Probability that farmer ii adopts agricultural technologies

The **logit model** is specified as:

$$\ln\left(\frac{Pi}{1-Pi}\right) = \beta_0 + \beta_1 Sex_i + \beta_2 Age_i + \beta_3 Household\ Size_i + \beta_4 Years\ in\ School_i + \beta_5 Farming\ Experience_i + \beta_6 FarmSize_i + \beta_7 Annual\ Income_i + \beta_8\ Cooperative\ Membership_i + \beta_9\ Extension\ Access_i + \varepsilon_i$$

Where:

- Sex_i = Sex of the farmer (Male = 1, Female = 0)
- Age_i = Age of the farmer (years)
- Household $Size_i$ = Number of persons in the household
- Years in $School_i$ = Number of years of formal education
- Farming $Experience_i$ = Number of years spent in farming
- Farm $Size_i$ = Farm size in hectares
- Annual $Income_i$ = Annual farm income (in Naira)
- Cooperative $Membership_i$ = Membership of cooperative society (Member = 1, Non-member = 0)
- Extension $Access_i$ = Access to extension services (Access = 1, No access = 0)
- ε_i = Error term

3.0 Results and Discussion

3.1 Socio-economic Characteristics of the Smallholder Farmers

The findings on socioeconomic characteristics of the smallholder farmers is presented in Table 2. The result on sex reveal that the majority (91.67%) of respondents were male, while only 8.33% were female. This indicates that agricultural production in the study area is heavily male-dominated. This suggests that men largely control decision-making processes regarding farming operations, including the adoption of improved agricultural technologies This is in line with the findings of Kundiri *et al.* (2022) who reported that male farmers are more likely to adopt improved maize technologies due to superior access to resources and information. Likewise, Barbra and Sam (2020) found that female farmers often lag in adoption because of land tenure insecurity and cultural constraints, highlighting the need for targeted female empowerment interventions.

The result on age of farmers shows that most (57.41%) of the farmers were within the productive age bracket of 21–40 years, followed by 26.85% within 1–20 years, and only 15.74% above 41 years. This distribution reflects a youthful farming population, which is advantageous for innovation diffusion. Young farmers tend to be more receptive to risk and technology experimentation, making Makurdi a favorable environment for scaling agricultural innovations. This is in line with the findings of Fideluguoo and Omekwu (2023) who reported that younger farmers are more responsive to new

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technologies due to their higher exposure to media and extension activities. Similarly, Kundiri *et al*. (2022) reported that youthful energy enhances adaptability to improved practices.

The result on marital status showed that, a large proportion (94.44%) of the respondents were married, while only 4.63% were single. This reflects a socially stable farming community with strong household structures. Married individuals often seek to improve household welfare, which may drive them to adopt yield-enhancing technologies to meet consumption and financial needs. This fining agrees with Ebojei *et al*. (2012) who reported that married farmers are more inclined to adopt improved inputs to support family responsibilities. Similarly, Olagunju *et al*. (2020) reported that marital stability facilitates access to communal farming resources, further encouraging technology uptake.

The result on household size showed that, most (61.11%) of the respondents had a household size of between 6–10 members, while 37.04% had 1–5 members nd 1.85% had above 11 members. This indicates that respondents had relatively large family sizes. Larger household size provides more family labour, thereby reducing labour constraints associated with the adoption of labour-intensive technologies such as mechanization or row planting. This finding aligns with Makwin *et al*. (2024) who found that household size is positively correlated with the adoption of improved rice technologies in Nigeria. Similarly, Barbra and Sam (2020) reported that farmers with larger family labour pools tend to adopt new technologies more easily.

The findings of educational level reveals that majority (84.26%) of the respondents possessed secondary education (SSCE), 12.04% had primary education (FSLC),1.86% attain tertiary level of education while only 1.85% had no formal education. This implies that most of the respondents are literate and attain a level of formal education. Farmers which are literate had a better chance of understanding and adopting improved technologies. This is consistent with the findings of Barbra and Sam (2020) who reported that literacy enhances farmers' ability to interpret agricultural recommendations. In the same vein, Fidelugwuowo and Omekwu (2023) established that education increases confidence in adopting new technologies.

Years spent in school revealed that majority (61.11%) of the respondents spent between 6-10years in school, while 37.04% spent between 1-5years and 1.85% spent more than 11years in school. This implies that most of the respondents spent time in school and are considered literate enough to understand the adoption of innovations which are very important to production process. This is in line with the findings of Fidelugwuowo and Omekwu (2023) who both reported that farmers who are literate carryout adoption of innovation as early adapters and considered as trail blazers.

The result on major occupation showed that majority (92.59%) of respondents were farmers, while 3.70% were civil servants, 2.78% were traders and 0.93% were artisans. This indicates that most of the respondents in the study area were into farming since the study area is considered agrarian. Agriculture and farming is a predominant occupation of the people in the study area. This is in line with the findings of Kundiri *et al*., (2022) who reported that farming is a major occupation predominantly in Benue State.

Farming experience showed that, more than half (53.70%) of respondents had between 21–30 years of farming experience, 25.00% were had between 11-20years,12.04% had more than 31years and 9.26% had between 1-10years farming experience. This indicates a high level of specialization due to the time spent in farming. By implication, long-term experience coupled with full-time engagement suggests high practical knowledge and readiness to adopt productivity-enhancing technologies. This coincide with the findings of Makwin *et al*. (2024) who reported that experienced farmers are better positioned to evaluate the benefits of innovations. Similar to that of, Kundiri *et al*. (2022) who found out that farmers with more experience are more likely to adopt modern agricultural practices compared to part-time farmers.

Farm size showed that, a significant portion (70.37%) of the farmers cultivates on 4.0 –7.9 hectares, 20.37% cultivates on 8.0 – 11.9hectares, 5.56% on 1.0 – 3.9hectares and 3.70% on more than 12hectares. This indicates that most were small-to-medium scale farmers. By implication, such farmers are well-suited for scalable technologies such as improved seeds, fertilizers, and intermediate mechanization tools. This finding agrees with Fidelugwuowo and Omekwu (203) who found out that, a positive relationship between farm size and mechanization adoption in Nigeria. Likewise, Makwin *et al*. (2024) reported that larger landholdings increase willingness to invest in modern inputs.

The result on annual output reveals that, most (41.67%) of respondents obtain between 1001 –

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2,000kg output, 32.41% obtain between 1 – 1000kg output, 13.89% obtained more than 3,001kg, and 12.04kg obtained between 2,001 – 3,000kg. This indicates that most of the farmers were small scale farmers who obtain meagre output levels because they cultivate small portions of farmlands. This is in line with the findings of Fidelugwuowo and Omekwu (2023), who reported small holder farmers produced lower output level.

Most farmers (58.33%) earned annual income of between ₦2–4 million, 23.15% earn betweenN4,000,001 – N6,000,000; 12.04% earn below N2,000,000 and 6.48% earn more than N6,000,000. This indicates that farmers obtain low income making them small holders which brings about moderate adoption of improved technologies. This is in line with the findings of Makwin *et al* (2024) who reported that income remains a strong determinant of technology adoption. Onyemma *et al*. (2019) also emphasized that cash flow constraints slow adoption unless supported by credit schemes.

The result on membership of cooperative showed that, a high proportion (85.19%) of respondents belonged to cooperatives, while only 14.81% do not belong to cooperative societies. This indicates that farmers are members of cooperatives, and through cooperatives, innovations are introduced for farmers to adopt. Therefore, cooperatives are targeted by extension agents for easy dissemination of innovations to farmers who adopt at a high rate. This is in line with the findings of Fidelugwuowo and Omekwu (2023), who found out that cooperatives are source of origination of some innovations disseminated by research institutes.

The result on extension access showed that majority (85.19%) of respondents do not but only 14.81% had access to extension services. This indicates that farmers in the study area have challenges of getting in contact with extension agents. This could be attributed to bureaucratic bottlenecks or otherwise. By implication, poor extension access may hinder the adoption and correct application of technologies. The findings coincide with Makwin *et al* (2024) who reported that extension access significantly increases adoption probability.

Table 2: Socioeconomic Characteristics of the Smallholder Farmers (n=108)

Variables	Frequency	Percentage
Sex		
Male	99	91.67
Female	9	8.33
Age (years)		
20 and below	29	26.85
21-40	62	57.41
40 and above	17	15.74
Marital Status		
Single	5	4.63
Married	102	94.44
Divorced	1	0.93
Household size		
1-5	40	37.04
6-10	66	61.11
>11	2	1.85
Educational level		
Non-formal	2	1.85
FSLC	13	12.04
SSCE	91	84.26
Tertiary	2	1.86
Years in school		
1-5	40	37.04
6-10	66	61.11
>11	2	1.85
Major occupation		
Farming	100	92.59
Trading	3	2.78
Civil service	4	3.70
Artisan	1	0.93
Farm experience (years)		
1-10	10	9.26
11-20	27	25.00
21-30	58	53.70
>31	13	12.04
Farm size (hectares)		
1-3.9	6	5.56
4-7.9	76	70.37
8-11.9	22	20.37
12>	4	3.70
Annual output (kg)		
1-1000	35	32.41
1001-2000	45	41.67
2001-3000	13	12.04
>3001	15	13.89
Annual income		
<2000,000	13	12.04
2,000,001-4,000,000	63	58.33
4,000,001-6,000,000	25	23.15
>6,000,001	7	6.48
Membership of cooperative		
Yes	92	85.19
No	16	14.81
Extension access		
Yes	16	14.81
No	92	85.19

Source: Field Survey,2025

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3.2 Improved agricultural technologies adopted by farmers

The result on improved agricultural technologies adopted by farmers is presented in Table 3. The result showed that, majority (100%) of the respondents identified use of herbicides for land clearing, use of pesticides for pest control/management and use of fertilizers as the most adopted improved agricultural technologies by farmers. This indicates that farmers mostly adopt the use herbicides, pesticides and fertilizers frequency in their farm for clearing and fertilization of crops. These technologies are mostly adopted due to the high rate of farmer dependency. Nowadays, every farmer tries to save cost of production through land clearing and weeding, which is as a result of scarcity and high cost of labour to perform manual farm operations. The use of agrochemicals assists farmers to increase scale of production, timely planting and harvesting to prevent postharvest losses. This is in line with the findings of Onyemma *et al*.., (2019) and Obasoro *et al*., (2015) who reported that farmers adopt the use of herbicides in land clearing and pest control. Similarly, Eche and Odiaka (2021) identify fertilizer application as source.

The result also revealed the adoption of sowing dates (99.07%), use of mechanized tillage (85.19%), storage facilities (85.19%) by farmers. This indicates that, agricultural production which is targeted toward maximization of output and minimization of cots has made farmers to adopt sowing dates to avert climatic changes which will cause crop damages and reduced yield. Farmers also adopt mechanized tillage operations due to scarcity of manual labour in the rural areas. Storage facilities are also adopted to curb post-harvest losses and provide surplus to the market. Tis is in line with the findings of Mwangi and Kariuki (2015) who reported the adoption of mechanized farming through use of tractors and mini cultivators. Also similar to the findings of Ogunniyi *et al.* (2017) who reported the use of sowing dates for increased plant population and yield. Likewise, Oluwatayo and Adedeji (2019) reported the adoption of storage facilities by farmers in Benue State.

Finally, the result showed that, farmers adopts mechanize harvesting (51.85%), cross breeding program for small ruminants (57.4%), rotator feeders and drinker for chicken (37.96%) and artificial insemination for large ruminants. These findings indicate that farmers in the study area are increasingly embracing modern agricultural and livestock technologies to improve efficiency, productivity, and sustainability. The adoption of crossbreeding suggests strong farmer interest in improving the genetic potential of small ruminants for meat and milk yield. The adoption of mechanized harvesting points to gradual modernization in crop production, reducing drudgery and post-harvest losses. Conversely, the relatively lower adoption of rotator feeders/drinkers and artificial insemination in large ruminants reflects constraints such as limited access to equipment, technical know-how, and affordability. These findings are consistent with Oluwatayo and Adedeji (2019) who reported that Nigerian farmers adopt livestock and crop innovations when they perceive clear benefits in productivity and income. Similarly, Onyemma *et al*.., (2019) observed that artificial insemination adoption in East Africa was hindered by lack of technical skills and limited veterinary infrastructure, despite its high potential for improving cattle genetics. Also, Fidelugwuowo and Omekwu (2023) noted that mechanized farming technologies are increasingly being adopted in Nigeria but remain constrained by cost and limited farmer training.

Table 3: Improved agricultural technologies adopted by farmers

Agricultural technologies	Freq.	Percentage
Use of herbicides for land clearing	108	100.0
Use of pesticides for pest control and management	108	100.0
Use of fertilizers	108	100.0
Sowing dates	107	99.07
Use of mechanized tillage	92	85.19
Mechanized harvesting	56	51.85
Storage facilities	92	85.19
Rotatory feeders and drinkers for chicken	41	37.96
Cross breeding programmes for small ruminants	62	57.41
Artificial insemination for larger ruminants	35	32.41

Source: Field Survey, 2025

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3.3 Factors influencing the adoption of improved agricultural technologies among smallholder farmers

The result on factors influencing the adoption of improved agricultural technologies among smallholder farmers is presented in Table 4. The logistic regression result revealed a Chi-square value of 7.22 with a p-value of 0.6143, indicating that the model was not statistically significant as a whole, and the Pseudo R^2 of 0.0797 suggests limited explanatory power.

Age has a negative coefficient (-0.090) and significant at 5% ($p<0.05$) level of probability. This implies that, increase in age of farmer will lead to a decrease in adoption of improved agricultural technologies.

This shows that, older farmers are less likely to adopt improved agricultural technologies. This suggests that adoption probability decreases as farmer's advance in age, possibly due to risk aversion, reduced flexibility, or preference for traditional practices. This is in line with the findings of Mwangi and Kariuki (2015) who reported that younger farmers are generally more innovative and quicker to adopt new technologies due to greater risk tolerance.

Similarly, Ogunniyi *et al.* (2017) found out that age negatively affects adoption, as older farmers rely more on experience than experimentation.

Household size has a positive coefficient (0.4213) and statistically significant at 10% ($p<0.10$) level of probability. This implies that a person increase in household number will lead to an increase in adoption of improved technologies by 0.4213unit. This indicates that, larger household sizes increase the likelihood of adopting improved technologies. This may be due to the availability of family labor required to implement labor-intensive innovations such as weeding, planting, or fertilizer application. The findings coincide with that of Oluwatayo and Adedeji (2019) who reported that, households with more members have better labor capacity, which enhances technology adoption. Similarly, Eche and Odiaka (2021) reported that larger family sizes positively influence adoption decisions due to the ability to manage farm tasks collectively.

Table 4: Logit regression on factors influencing the adoption of improved agricultural technologies among smallholder farmers

Adoption	Coef.	Std. Err.	*z*	p.>/z/
Constant	2.748	2.500	1.10	0.272
Sex	0.0507	1.2063	0.04	0.966
Age	-0.090**	0.043	-2.10	0.036
Household size	0.4213*	0.241	1.74	0.081
Years in school	-0.2939	0.237	-1.24	0.215
Farming experience	0.0316	0.0736	0.43	0.667
Farm size	0.0471	0.309	0.15	0.879
Annual income	2.110	4.380	0.48	0.630
Membership cooperative	0.893	0.998	0.90	0.371
Extension access	-0.032	0.905	-0.04	0.971
Chi-square	7.22			
Prob. Chi2	0.6143			
Pseudo R2	0.0797			
Log Likelihood	-41.694785			

***, **, * for 1%, 5% and 10% level of significance

3.4 Challenges Faced by Smallholder Farmers in Accessing Improved Agricultural Technologies

The findings presented in Table 6 show that smallholder farmers face several interconnected challenges in accessing improved agricultural technologies. The results suggest that financial, institutional, and infrastructural problems continue to limit the adoption of modern farming innovations in rural areas. These barriers not only reduce farmers' ability to improve productivity and income, but also weaken their capacity to adapt to climate change and achieve sustainable agricultural development. The high percentages recorded across the identified challenges indicate that the problem is widespread and deeply rooted in the socio-economic conditions of rural farming communities.

High cost of technologies, ranked first (95.37%), emerged as the most serious challenge faced by farmers. This finding indicates that many improved agricultural technologies such as mechanized equipment, improved seeds, irrigation facilities, and livestock technologies are

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too expensive for most rural farmers to afford. Although these technologies are designed to improve agricultural productivity, their high cost places them beyond the reach of resource-poor farmers. As a result, many farmers continue to rely on traditional and low-input farming systems that produce low yields and limited income. The high cost of technologies may also be linked to inflation, high importation costs, inadequate government subsidies, and limited local production of agricultural equipment. This situation reduces farmers' ability to respond effectively to changing climatic and economic conditions because they cannot access innovations that would improve their productivity and resilience. This finding agrees with Okonji and Awolu (2021), who reported that affordability remains one of the strongest determinants of technology adoption among smallholder farmers in sub-Saharan Africa.

Lack of access to credit, ranked second (90.74%), further highlights the financial difficulties experienced by rural farmers. Even when farmers are willing to adopt improved technologies, many are unable to do so because they lack the financial support needed to invest in modern farming practices. Formal financial institutions often consider smallholder farming risky due to unpredictable weather conditions, unstable markets, and lack of collateral security. Consequently, many farmers are excluded from loan opportunities that could help them expand production and adopt innovations. Poor access to credit limits farmers' ability to purchase inputs, invest in mechanization, and improve their farming operations. It also reduces their capacity to adapt to climate-related challenges because they cannot finance technologies such as irrigation systems, improved seeds, or storage facilities. This finding supports Onyemma et al. (2020), who noted that weak rural financial systems hinder farmers' ability to adopt agricultural technologies. Similarly, Fidelugwuowo and Omekwu (2023) observed that limited access to credit discourages the adoption of costly innovations among rural farmers.

Poor distribution of technologies by handlers, ranked third (86.11%), points to weaknesses in the dissemination and delivery system of agricultural innovations. This suggests that technologies developed by government agencies and research institutions often do not reach the farmers who need them most, especially those living in remote communities. The persistence of this problem may be associated with weak extension services, poor coordination among stakeholders, corruption, and ineffective monitoring systems. As a result, many farmers remain disconnected from innovations that could improve productivity, food security, and livelihoods. Poor distribution systems also create unequal access between urban and rural farmers and reduce farmers' trust in government agricultural programmes. This finding supports Achukwu et al. (2023), who observed that weak institutional frameworks and logistical challenges limit the effective delivery of technologies to rural farming communities.

Bad roads, ranked fourth (79.63%), also emerged as a major challenge affecting access to improved agricultural technologies. Poor road networks make it difficult for extension agents, input suppliers, and technology distributors to reach rural farming areas. In many cases, transportation costs become very high, leading to increased prices of agricultural inputs and technologies. Poor roads also delay the movement of farm produce and contribute to post-harvest losses, thereby reducing farmers' income and discouraging investment in improved technologies. The persistence of poor transportation infrastructure reflects inadequate government attention to rural development and agricultural support systems. This finding agrees with Barbra and Sam (2020), as well as Achukwu et al. (2023) and Makwin et al. (2024), who identified poor road networks as major barriers to technology adoption among farmers.

Poor infrastructure and basic amenities, ranked fifth (78.70%), further reveal the structural disadvantages faced by rural farming communities. The lack of electricity, potable water, storage facilities, and communication networks limits the effective use of agricultural technologies even when such technologies are available. For instance, technologies that require electricity or proper storage facilities may not function effectively in rural communities where these amenities are absent. Poor infrastructure increases production and transaction costs, discourages private investors from operating in rural areas, and reduces the overall efficiency of agricultural activities. This challenge reflects the broader issue of rural underdevelopment and insufficient government investment in rural infrastructure. The finding is consistent with Adebayo et al. (2018) and Barbra and Sam (2020), who reported that poor infrastructure significantly

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limits the adoption of improved agricultural technologies.

Adherence to traditional farming methods, ranked sixth (65.74%), suggests that socio-cultural and behavioral factors also influence farmers' decisions regarding technology adoption. Many rural farmers continue to depend on indigenous farming practices because they are familiar, cheaper, and perceived to be less risky than modern technologies. Some farmers may also resist change due to low literacy levels, lack of adequate extension education, or fear of failure associated with unfamiliar innovations. Although traditional farming knowledge remains valuable in certain situations, excessive dependence on outdated practices can limit productivity and reduce farmers' ability to cope with modern agricultural challenges such as climate change, pests, and soil degradation. This finding aligns with Makwin et al. (2024), who reported that many farmers still prefer manual tillage operations, and Kundiri et al. (2022), who found that local livestock breeds are often preferred because they are believed to be more resistant to diseases and harsh environmental conditions.

Finally, unavailability of technologies in rural areas, ranked seventh (54.63%), highlights the uneven distribution of agricultural innovations between urban and rural communities. Most agricultural technologies and support services are concentrated in urban centers where infrastructure and institutional facilities are better developed. Consequently, rural farmers are often forced to travel long distances and incur additional costs in order to access improved technologies. This urban-centered distribution pattern limits inclusive agricultural development and places rural farmers at a disadvantage. As a result, many smallholder farmers remain unable to benefit from innovations that could improve their productivity and livelihoods. This finding agrees with Okonji and Awolu (2021) and Ogunniyi et al. (2017), who reported that the concentration of extension services and agricultural technologies in urban areas discourages rural farmers from adopting improved innovations.

Overall, the findings suggest that the challenges faced by smallholder farmers in accessing improved agricultural technologies are multidimensional and require a comprehensive policy response. Addressing these constraints will require improved access to affordable credit, effective subsidy programmes, better rural infrastructure, stronger extension services, and decentralization of technology distribution systems. Government and development agencies should also intensify farmer education and awareness programmes to build confidence in modern technologies and encourage their adoption. Unless these structural, financial, and institutional barriers are adequately addressed, efforts aimed at improving agricultural productivity, food security, and rural development may continue to face significant limitations.

Table 6: Challenges faced by smallholder farmers in accessing improved agricultural technologies

Challenges faced by smallholder farmers	Freq.	Percentage	Rank
Lack of access to credit	98	90.74	2nd
High cost of technologies	103	95.37	1st
Poor distribution of technologies by handlers	93	86.11	3rd
Unavailability of technologies to rural areas	59	54.63	7th
Bad road	86	79.63	4th
Poor infrastructure and basic amenities	85	78.70	5th
Adherence to traditional farming methods	71	65.74	6th

Source: Field Survey, 2025

4.0 Conclusion and Recommendations

The study concludes that the adoption of improved agricultural technologies among smallholder farmers in Makurdi Local Government Area was relatively high, particularly in the use of herbicides, pesticides, fertilisers, and appropriate sowing dates, indicating a strong awareness of productivity-enhancing innovations. However, adoption was significantly influenced by farmers' demographic characteristics, with age negatively affecting uptake while larger household sizes enhanced adoption, suggesting that younger and more labour-endowed households were more receptive to innovations. Extension services played a

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crucial role by raising awareness and providing advisory support, although gaps remained in capacity building and in sustained follow-up. Despite farmers' willingness to embrace new technologies, their efforts were hampered by systemic challenges, including high costs, limited access to credit, poor infrastructure, and ineffective distribution channels. It is therefore recommended that government and NGOs should deploy more extension personnel to rural communities and introduce digital advisory platforms (radio, SMS, WhatsApp groups) for wider reach, policymakers should collaborate with microfinance institutions and cooperatives to provide soft loans, input vouchers, or subsidy schemes targeting active farming households and youth-inclusive mechanization support, innovation grants, and mentorship programs should be introduced to encourage sustained uptake of new technologies by younger farmers.

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