inteGrity Research Journals

Journal of Agricultural Science and Practice
Volume 10(4), pages 50-61, August 2025
Article Number: 60BD5B8A1
ISSN: 2536-7072
https://doi.org/10.31248/JASP2025.530
https://integrityresjournals.org/journal/JASP

Full Length Research

An analysis of the adoption and extent of adoption of good agricultural practices among arable crop farmers in Borno State, Nigeria

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Received 3rd April 2025; Accepted 20th June 2025

ABSTRACT: The study analysed socio-economic factors influencing the adoption of Good Agricultural Practices (GAPs) among arable crop farmers in Borno State, Nigeria. A multistage random sampling technique was employed to select 390 farmers from a sample frame of 15,450 obtained from BOSADP. The sampling process involved purposive selection of 3 local government areas based on the intensity of GAPs activities. The second and third stages involved a random and proportionate selection of 113 extension cells and 390 sample size. Data was collected through structured questionnaires and analysed using descriptive statistics and logit regression models. Results revealed that 90.26% of farmers adopted GAPs, with 75.28% demonstrating a high adoption level. Key adopted practices included fertiliser application, seed treatment, and timely land preparation. High GAPs adoption was attributed to the adoption of simple, less capital-intensive practices (timely planting, use of organic manure). Social and agricultural support provided by non-governmental organisations (NGOs) to reduce poverty and boost food production among displaced victims of insurgency served as a buffer for GAPs adoption. Socio-economic factors such as farm size (β=-0.125, p<0.05), membership in cooperatives (β =-0.939, p<0.01), and access to credit (β =-1.240, p<0.01) were found to be significant and negative. Limited access to extension services (93.59%) and inadequate access to credit (72.82%) were important constraints against GAP adoption. However, social and financial interventions to poor farming households from NGOs minimised the negative effects, further facilitating GAP adoption. The study recommends strengthening and improving cooperative organisations to promote knowledge on GAPs benefits to farmers; provide credit schemes specifically for GAPs adoption and target small and medium-scale farmers, while providing special program design for large-scale farmers. Further research is also recommended to understand the dynamics of cooperatives and credit structures in non-conflict regions.

Keywords: Adoption, arable crops, Borno State, good agricultural practices, Nigeria, socio-economic factors.

INTRODUCTION

One of the primary objectives of Nigeria's agricultural development is to transition from low-productivity subsistence farming to a high-productivity agro-industrial economy through improved technology adoption (Nkwuagba and Nkamnebe, 2024). This shift involves replacing traditional farming methods with modern, science-based approaches that incorporate new technologies and farming systems. Given that a significant portion of the rural poor depends on crop production for 8livelihood (Muhammed, et al. 2019), the adoption of Good Agricultural Practices (GAPs) is essential for enhancing productivity, efficiency, and income. GAPs, introduced by the Food and Agriculture Organisation (FAO), provide a framework for sustainable and profitable food production by promoting modern farming practices (Kharel *et al*., 2022). GAPs framework is built around four primary objectives that include Food Safety; Implementing practices that minimize microbial, chemical, and physical hazards in food products. Environmental Protection: Adopting methods that conserve natural resources and minimise environmental impacts. Safeguarding Worker Welfare: Ensuring fair treatment, safe working conditions, and adequate training. Promoting Sustainable Agriculture: Encouraging practices that support long-term sustainability (FAO, 2024).

The adoption of GAPs is crucial for Nigeria's agricultural growth, ensuring higher-quality and safer food production, improving farmers' livelihoods, and enhancing market access (FAO, 2021). By optimising farm management, GAPs help stabilise yields, reduce post-harvest losses, and increase farm income (Rahman *et al.*, 2024). Additionally, adherence to GAPs protects farmers from market risks and food safety issues arising from poorly managed farms, reinforcing consumer confidence in agricultural products. The FAO's GAP framework outlines key components such as soil and water management, crop protection, animal health, post-harvest handling, waste management, and environmental conservation, all of which contribute to food security (Omolehin *et al*., 2024). The potential of GAPs in promoting food security and improving livelihoods among farming households has been explicated in several research (Omotoso and Omotayo, 2024; John and Ntoh, 2024; Olumide, 2024).

Despite various government initiatives, including the Fadama Projects, FAO programs, African Development Programme, and the Borno State Agricultural Development Programme (BOSAP), food insecurity persists due to challenges such as land degradation, pest outbreaks, low technology adoption, and limited market access (Roumasset, 2004; Adeyemo *et al*., 2025). These initiatives aim to improve agricultural productivity through GAPs by promoting climate-smart techniques, enhanced crop varieties, efficient fertilisation methods, and better post-harvest handling (FAO, 2019). Moreover, there exists a critical gap in empirical data on the extent of GAP adoption among crop farmers in Borno State. For these reasons, the study seeks to analyse the level of GAPs adoption and provide empirical data on the adoption level of GAPs in the study area. The main objective of this research is to assess the adoption of good agricultural practices (GAPs) among arable crop farmers in Borno State, Nigeria. The specific objectives of the study are to:

1. describe the socio-economic characteristics (age, sex, educational level, marital status, cooperative membership, access to credit, extension contact, farm size) of the farmers.
2. identify the respondent's sources of information on Good Agricultural Practices.
3. examine the adoption and level of adoption of Good Agricultural Practices among the farmers; and
4. determine the socio-economic factors (age, sex, educational level, marital status, cooperative membership, access to credit, extension contact, farm size) influencing the level of adoption of Good Agricultural Practices.

METHODOLOGY

Borno State is located within latitude 12°08'60.00" N, longitude 12° 53'59.99" E. The State, which has an area of 61,435 square kilometres, shares borders with the Republic of Niger to the north, the Republic of Chad to the northeast and Cameroon Republic to the east. It also shares borders with Adamawa State to the south, Gombe State to the southwest, and Yobe State to the West (Figure 1). The state comprises 27 Local Government Areas (LGA). The population of Borno State from the 2006 census was 4,171,104. The projected population of Borno State in 2024 is 7,171,104 with an annual growth rate of 3% (National Population Commission, NPC, 2021). The majority of the people are farmers, and Agriculture is the mainstay of the economy. The annual rainfall ranges from 600 mm in the north to 1200 mm in the south and extends over a growing season of between 100 and 180 days. Annual rainfall varies from year to year, with decreasing trends during the past two decades. The temperature ranges from 13.6 to 31.9ºC in January and 9.0 to 28.5 ºC in August (Audu *et al.* 2023). In Borno State, agriculture is characterised by small-scale and subsistence production systems. Although the mainstay of the economy in Borno State is based on agriculture, a greater part of the rural areas is occupied by subsistence farming (Bwala *et al.*, 2021). Arable crops and livestock produced include maize, millet, sorghum, rice, and wheat. Borno state is also known for its cultivation of cowpeas, groundnuts, soya beans and Bambara nuts. Prominent fruits produced in the state include orange, lemon, mango, and guava. There is also an abundance of cassava and sweet potato alongside vegetables such as tomatoes, pepper, onions, okra, pumpkin, and melon. Tree crops: gum Arabic and ginger, mango, orange, and sweet melon. Livestock and fish: cattle, sheep, goats, pigs, poultry, rabbits, and fish of different varieties (NBS, 2019). In Borno State, agriculture contributes up to 65 per cent of the State's gross domestic product. With the recent insecurity in Borno State, food production (crop/animal and fishing) declined to a low level, with 90% of farmers experiencing low production, while 89% recorded reduced income and increased hunger (Cadre Harmonise, 2023). Virtually, 942% of food consumed in Borno is imported either in the form of credit or gift from non-governmental organisations (NGOs), World Food Program (WFP), and civil societies, among others (World Bank, 2018).

Sampling technique

Borno State has three Agricultural zones, namely, Zone 1, Zone 2 and Zone 3. Each of the Agricultural zones comprises nine Local Government Areas. The first stage involved purposive selection of three Local Government Areas from each zone based on the intensity of agricultural production which were Zone 1: Biu, Kwaya Kusar and Bayo were selected in Zone 1, in Zone 2: Bama, Konduga

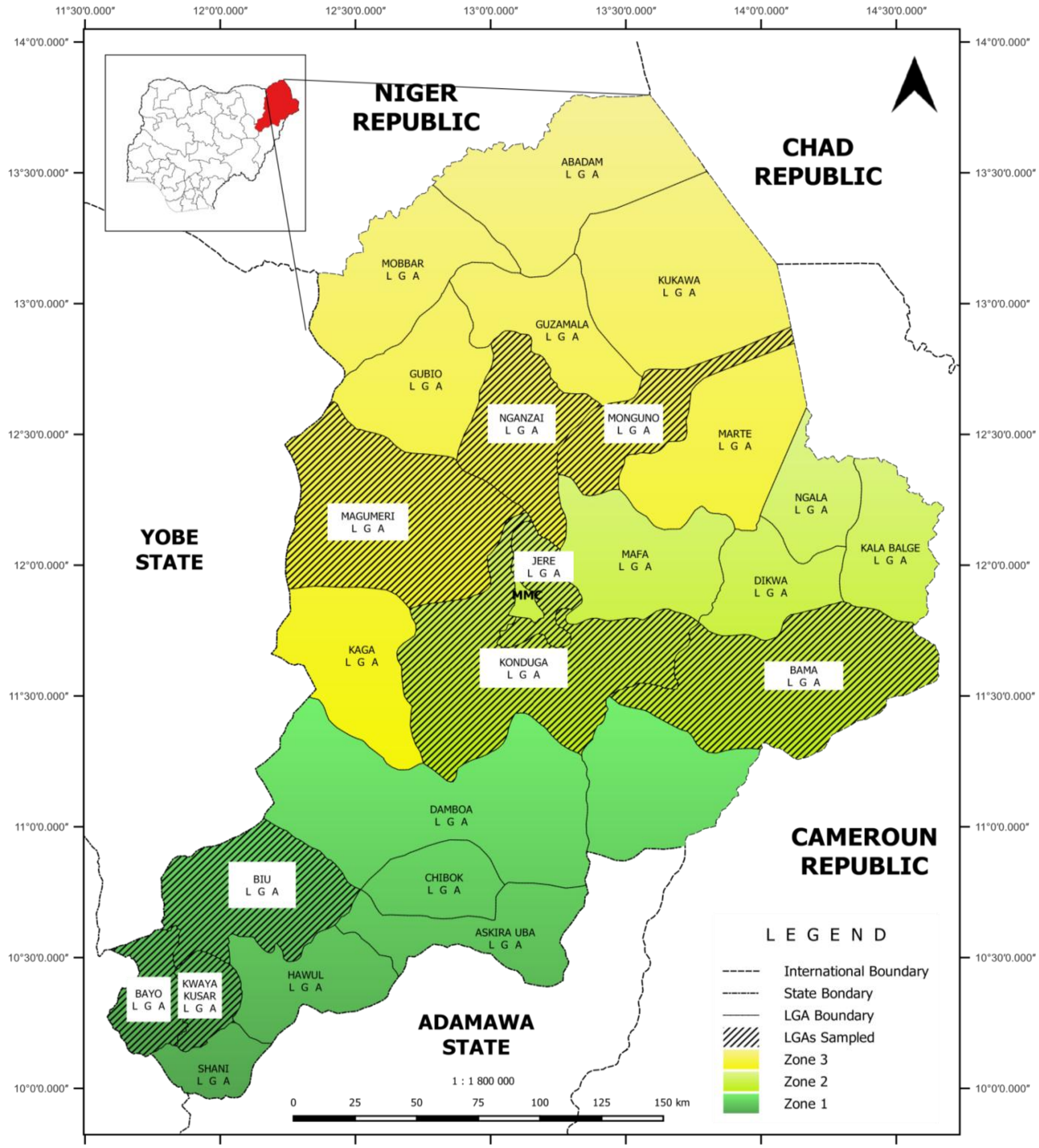

Figure 1. Borno State showing Agricultural Zones and Local Government Areas Sampled. Drown: Geo Information System (GIS) University of Maiduguri, Borno State (2022).

and Jere, in Zone 3: Magumeri, Nganzai and Monguno, giving a total of 9 LGAs (Table 1). The Second stage involved a proportionate selection of 131 Agricultural blocks and 119 extension cells. In the third stage, farmers were randomly selected proportionate to the number of farmers from each of the selected extension cells. A list of 15,450 registered farmers obtained from BOSADP was used as the sample frame. A total of 390 farmers were finally selected using the Yamane (1967) formula. Thus,

$$n = \frac{N}{1+N(e)^2}$$

Where: n = Sample size, N = the finite population of crop farmers, 1 = constant, e = margin error.

$$n = \frac{15450}{1+15450(0.05)^2}$$

n = 390

Table 1. Sampling procedure.

S/N	L.G. A	Extension Blocks	Extension Block Selected	Extension Cells	Extension Cells Selected	Registered Farmers	Farmers Selected
1.	Biu	16	11	30	15	2900	77
2.	Bayo	10	7	12	9	1100	29
3.	KwayaKusar	13	9	16	10	1400	37
4.	Bama	80	54	28	14	1500	40
5.	Konduga2	11	8	16	9	1000	27
6.	Jere	14	10	12	8	1600	42
7.	Magumeri	15	11	20	13	2000	53
8.	Nganzai	12	10	12	9	1000	27
9.	Monguno	16	11	25	14	2950	78
Total	9	187	131	171	119	15450	410

Source: Field Survey, 2023.

Thus, the required size is 390, and the sample size is adjusted by 5% to 410 because some of the entries were invalid. In the last stage, the sample size is distributed proportionally to all the selected Local Governments in the study area based on the registered farmers' population size (Table 1).

Descriptive statistics in the form of frequencies, mean, and percentage were used to achieve objectives (i, ii). A five-point Likert scale was used to determine (objective iii) the level of adoption of GAPs. The Likert scale is rated as: 1=Very low adoption, 2 = Low adoption, 3 = Moderate adoption, 4 = High adoption and 5 = Very high adoption. The mean value of 3 was used as the cutoff mark to rank the responses.

5 + 4 + 3 + 2 + 1 = 15/5 = 3

Since the scale ranges from 1 – 5, the midpoint of 3 provides a clear distinction between low and moderate to high adoption levels for easy interpretation. Any mean response of ≥ 3 was considered a high adopter, while a mean score of ≤ 3 was considered a low adopter. GAPs to be considered in the study includes: Hybrid seeds, timely land preparation, fertilizer for planting, timely and clean weeding, insect pest control (field), timely harvesting, proper drying of the crops (using recommended moisture level), seed treatment, intensified manure application, mulching, value addition, market linkage, site selection technique, use of recommended dosage of herbicides, insecticides, improved method of storage, inter and intra raw recommended spacing, crop rotation, successive cropping, use of urea deep placement and timely planting.

Binary logit regression was used to achieve objective (iv), which is the socio-economic factors influencing the level of adoption of GAPs. Logistics regression was used to measure the influence of socio-economic factors on the level of adoption of GAPs among farmers. Yuniarsih *et al.* (2024) used binary logit regression to analyse the level of adoption of GAPs in Urban innovative farming in Indonesia. The model is stated thus:

$$Log\ (Y_i) = Ln\left[\frac{P_1}{1-P_1}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + e \ldots (3.4)$$

$$2Yi = \begin{cases} 1 & \text{if the } ith \text{ farmer is High Adopter*} \\ 0 & \text{if the } ith \text{ farmer is Low Adopter} \end{cases}$$

*If an ith farmer's mean score in the level of adoption of GAP is 3 and above, s/he is considered a high adopter and but if the mean score is less than 3, the farmer is considered a low adopter.

Where: X_1= Sex (1=Male, 0=Female), X_2 = Education (Number of years spent in formal education), X_3 = Farm size (hectares), X_4= Membership of Farmer Cooperative (1=Yes, No = 0), X_5= Access to credit (1=Yes, 0=No), and X_6 = Access to Extension contact (1=Yes, 0=No).

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

The socio-economic characteristics of arable crop farmers in this study include age, gender, marital status, education level, land ownership, household size, farm size, income, information sources, credit access, organisational membership, and extension services. Table 2 shows that 73.85% of respondents were male, while 26.15% were female, indicating male dominance in arable farming due to family responsibilities such as providing food, education, shelter, and healthcare. This aligns with Shodipe *et al.* (2024), who reported that males constituted 60% of arable

Table 2 Distribution of respondents based on socio-economic factors (n=390).

Socio-economic factors	Frequency	Percentage
Gender		
Male	102	73.85
Female	288	26.15
Marital status		
Divorced	25	6.41
Married	297	76.15
Single	68	17.44
Level of Education		
Non-forma2l	80	20.51
Primary	41	10.51
Secondary	128	32.82
Tertiary	141	36.15
Membership of Cooperatives		
No	184	47.18
Yes	206	52.82
Access to credit		
No	284	72.82
Yes	106	27.18
Access to extension services		
No	365	93.59
Yes	25	6.41
System of land ownership		
Family	137	35.13
Hired	150	38.46
None	1	0.26
Others	20	5.13
Personal	82	21.03

Source: Field Survey (2023).

farmers in southeastern Nigeria. The lower female participation in Borno State may stem from socio-cultural and religious constraints.

Contrastingly, Nwaiwu (2015) found that 70.5% of arable farmers in southeastern Nigeria were female, likely due to their significant role in farm activities, including cultivation, weeding, harvesting, and processing. Women in rural areas contribute substantially to food production and food security (Vuntade and Mzuza, 2022). Onya *et al*. (2019) reported that 55% of arable farmers in Ikwuano, Abia State, were male household heads, highlighting cultural norms that often limit women's enterprise autonomy.

Marital status analysis shows that 76.15% of farmers were married, reinforcing the role of family responsibilities in farming engagement. This supports Muhammad *et al.* (2019), who recount that married individuals are more involved in farming to support their families. Ibidapo *et al*. (2018) similarly found that 62.4% of arable farmers were married, while 16.4% were widowed, 14.8% single, and 6.4% divorced, reflecting marriage as a key characteristic of rural farmers.

Several factors influence the adoption of Good Agricultural Practices (GAPs), including age, farmer interaction, cultural inclination, financial status, and extension service quality. While education plays a role, it is not the primary driver. Table 2 shows that 36.15% of farmers had a tertiary education and 32.82% had secondary education, indicating a high literacy rate that aids in understanding agricultural messages. Alabi and Oshobugie (2020) found lower education levels among northern Nigerian farmers, while Ibidapo *et al.* (2018) reported that 50.5% had primary education, affecting access to economic activities and agricultural technologies. Onya *et al.* (2019) noted that 60% of Ikwuano farmers had secondary education, and Igwe (2019) found that most Ebonyi farmers had secondary education as their highest qualification.

Table 2 shows that 52.82% of farmers belonged to cooperatives, aligning with Nowfal *et al*. (2025), who highlighted cooperatives' role in enhancing access to inputs, credit, and information. Offor et al. (2018) emphasised cooperatives' importance in reducing input costs and ensuring financial access. However, credit

Table 3. Descriptive statistics of some socio-economic continuous variables.

Variables	Mean	Std	Minimum	Maximum
Age	43.015	12.778	19	80
Household Size	8.104	5.92	1	34
Farm size	3.314	2.02	0.45	10
Average Annual Income	1176219	1438386	10,000	9,000,000

Source: Field Survey (2023).

access remains a challenge, with 72.82% lacking access, limiting productivity. Olagunju *et al.* (2019) found that 45% of southwestern Nigerian farmers had credit access, while Ololade and Olagunju (2013) noted that credit enables investment in machinery and improved farming techniques. Oboh and Kushwaha (2009) highlighted the important role of accessing credit in irrigation and pest control. Inadequate access to credit facilities in the study area suggests a distinct disadvantage to the adoption of favourable farming techniques to boost agriculture and increase farm income.

Extension services were found to be inadequate, with only 6.41% having access, clearly indicating an important challenge to GAPs adoption. Habib (2014) found that 50% of Ghanaian vegetable farmers had extension access, improving agricultural knowledge and sustainability of vegetable cultivation. Landownership is another key factor; 38.46% of farmers hired land, 35.13% used family land, and only 21.03% owned land. Fasona *et al.* (2022) found that land tenure security impacts investment and productivity.

The mean age of farmers is 43 years (SD = 12.778), indicating a balanced mix of youthful energy and experience. This aligns with Nkwuagba and Nkamnebe (2024), who found a mean age of 49 years among cassava farmers in Jigawa State, reinforcing the idea that most farmers are within their peak productive years. Household size averaged 8.1 (SD = 5.92), ranging from 1 to 34 members, reflecting significant variability in family labour availability. Onyemauwa *et al.* (2023) reported a comparable average household size of 6-10 in Cross River, Nigeria, indicating the reliance on family labour in rural farming communities. The mean farm size is 3.314 hectares (SD = 2.02), suggesting that most farmers operate on a small scale. This aligns with Chichongue et al. (2019), who reported an average farm size of 2.5 hectares in Nigeria. Smaller farms may limit mechanisation but support intensive cropping. Farmers' average annual income is ₦1,176,219 (SD = ₦1,438,386), ranging from ₦10,000 to ₦9,000,000, highlighting income disparities, as shown in Table 3. Access to agricultural information is dominated by Borno ADP, used by 83.33% of farmers. Ogunlela and Ogunlela (2021) emphasised the importance of localised agricultural programs in transferring modern farming techniques, enhancing productivity and sustainability

Fadama, a World Bank-funded project, was a key source of GAPs information for 62.31% of farmers, emphasising its strong community-driven approach. This aligns with Ngoma *et al*. (2024), who found that participatory projects boost technology adoption. Social media, used by 51.03% of farmers, reflects the growing role of digital platforms in rural areas, as noted by Lythreatis *et al.* (2022). Radio, a trusted medium for 41.54% of farmers, remains effective in rural areas due to its accessibility and local language broadcasts (Yusuf, 2020). These findings align with studies in Nigeria and Tanzania, where extension services, radio, and mobile phones are primary agricultural information sources (Shodipe *et al*. 2024, Nyamba, 2021).

Source of information on Good Agricultural Practices (GAPs)

The results in Table 4 show the distribution of respondents according to sources of GAPs information. From the table, the Borno Agricultural Development Programme (ADP) is the most widely used source of information for GAPs, followed by Fadama and social media. This is consistent with previous studies that emphasise the importance of institutional sources of information in agricultural development (Waje *et al.,* 2024). The high reliance on Borno ADP and Fadama can be attributed to their proximity to farmers and the tailored nature of their information, which addresses specific local needs. The significant role of social media in disseminating agricultural information is also noteworthy. Studies have shown that social media platforms can facilitate access to information, especially among younger farmers (Iwuchukwu *et al.* 2019).

The quality and reliability of information from different sources can significantly impact farmers' adoption decisions. According to Adangara *et al.* (2022), Farmers may be more likely to adopt practices or technologies if they perceive the information as trustworthy, relevant, and applicable to their context. Based on the results obtained, reliance on research institutions like IITA and N2Africa was relatively low, probably due to limited access or lack of awareness of the respondents about the activities of the institutions.

Adoption and level of adoption of Good Agricultural Practices (GAPs)

This section presents an analysis of the adoption of Good

Table 4 Distribution of respondents based on source of information on Good Agricultural Practices (GAPs) (N=352).

Source of Information	*Frequency	Percentage
Borno ADP	325	83.33
FADAMA	243	62.31
Social media	199	51.03
Radio	162	41.54
IITA	107	27.44
N2Africa	85	21.79
IFAD	43	11.03
Family and other Farmers	42	9.11

Source: Field Survey, 2023 *Multiple Responses exist.

Table 5. Adoption and Level of Adoption of Good Agricultural Practices (GAPs) among arable crop farmers in Borno State.

Variables	Frequency	Percentage
Not adopted	38	9.74
Adopted	352	90.26
Adoption level		
High	265	75.28
Low	87	24.28
Total	352	100

Source: Field work (2023).

Agricultural Practices (GAPs) among arable crop farmers in Borno State, Nigeria. It examines the extent and level of adoption among the sampled farmers, focusing specifically on the 352 respondents out of 390 who have adopted GAPs. Out of a total of 390 farmers surveyed, 352 (90.26%) adopted GAPs, while only 38 (9.74%) did not (Table 5).

The high adoption rate of GAPs in Borno State indicates strong recognition of GAPs' benefits in improving productivity, sustainability, and environmental stewardship. A majority (75.28%) of the 352 adopters demonstrated a high level of integration, likely due to access to resources and financial incentives (Pawlak and Kolodziejczak, 2020). Although access to credit and extension services was low in the study area, incentives in the form of fertilisers, improved seed varieties, training support and social interventions from non-governmental organisations resulted in a high rate of adoption. These tally with reports from IFPRI (2023) and BMC Nutrition (2024), where they elucidate how vulnerable farming households in conflict-affected communities benefited from targeted interventions of NGOs tailored to boost production. Key drivers cited in Conley and Udry (2010) include extension services, economic benefits such as higher yields and income, and social dynamics like peer influence.

Understanding and addressing these barriers can boost overall adoption. High engagement with GAPs improves livelihoods and food security, while low adoption may widen productivity gaps within the farming community.

Respondents' level of adoption of good agricultural practices (GAPS)

Table 6 provides a detailed breakdown of the adoption levels of various Good Agricultural Practices (GAPs) among arable crop farmers in Borno State, Nigeria. Each practice is evaluated based on the mean adoption score and standard deviation, providing insight into the consistency and extent of practice adoption.

The adoption of Good Agricultural Practices (GAPs) among farmers in Borno State varies across different practices. High adoption is observed in timely land preparation (M = 4.07, SD = 0.84), fertilizer use (M = 3.77, SD = 1.00), clean weeding (M = 3.95, SD = 1.02), insect pest control (M = 3.67, SD = 1.42), and timely harvesting (M = 3.46, SD = 1.00). These findings align with a study emphasising their role in enhancing productivity and sustainability (Ogunlela and Ogunlela, 2021; Nowfal *et al*., 2025).

Practices like seed treatment (M = 3.98, SD = 1.05), manure application (M = 3.67, SD = 1.04), mulching (M = 3.44, SD = 1.09), market linkage (M = 3.57, SD = 1.16), and crop rotation (M = 3.56, SD = 1.12) also show strong adoption, suggesting awareness of their benefits for soil health, moisture conservation, and market access

Table 6. Distribution of respondents based on the level of adoption of Good Agricultural Practices (GAPS).

Good Agricultural Practices	Mean	Standard deviation	Remarks
Hybrid seeds	2.371795	1.16597	Low
Timely land preparation	4.069231	.83666	High
Fertiliser for planting	3.774359	.99568	High
Timely and clean weeding	3.946154	1.01768	High
Insect pest control (field)	3.671795	1.41945	High
Timely harvesting	3.464103	.99536	High
Proper drying of the crops (using recommended moisture level)	2.758974	.96503	Low
Seed treatment	3.984615	1.05339	High
Intensified manure application	3.671795	1.03763	High
Mulching	3.438462	1.09326	High
Value addition	3.320513	1.06272	High
Market linkage	3.571795	1.16272	High
Site selection technique	3.774359	1.30555	High
Use of the recommended dosage of herbicides, insecticides.	3.851282	1.03019	High
Improved method of storage	2.633333	1.02932	Low
Inter and intra raw recommended spacing	3.892308	1.30893	High
Crop rotation	3.556412	1.11947	High
Successive cropping	2.461538	1.00457	Low
Use of urea deep Placement	2.371795	1.01645	Low
Timely planting	3.528205	1.05452	High

Source: Field Survey, 2023.

(Chukwuma *et al.,* 2023).

Conversely, hybrid seeds (M = 2.37, SD = 1.17), proper drying (M = 2.76, SD = 0.97), improved storage (M = 2.63, SD = 1.03), and successive cropping (M = 2.46, SD = 1.00) have low adoption, likely due to cost, lack of awareness, or inadequate facilities (Bilal and Jaghdani, 2024). Addressing these barriers through improved access, training, and financial incentives can further enhance GAP adoption.

Socio-economic factors influencing the level of adoption of (GAPs)

Table 7 presents logistic regression results on socio-economic factors influencing GAP adoption among 352 farmers. The significant constant term (1.87, $p < 0.001$) represents the log odds of adoption when predictors are zero. Model fit is confirmed by an LR Chi² of 21.61 ($p = 0.0014$), indicating the variables collectively explain adoption variation. Low multicollinearity (VIF = 1.24) and a non-significant outlier test (hatsq = -0.19, $p = 0.493$) enhance model robustness. Access to credit positively influences adoption, while agricultural association membership shows an unexpected negative effect, highlighting the need for targeted policy interventions.

The coefficient for sex is -0.0238925, with a large standard error (0.2944263) and a non-significant z-value of -0.08 ($p = 0.935$). This suggests that gender does not significantly influence GAP adoption in this study, aligning with findings in other agricultural contexts (Anigbogu *et al.*, 2018). Similar studies have indicated that gender is not a decisive factor in determining the adoption of Good Agricultural Practices (GAPs) when socio-economic variables are accounted for. Doss (2001) highlighted that access to resources and household dynamics, rather than gender alone, are more significant in the adoption of agricultural technology. Ragasa (2012) found that although women face structural barriers, these do not make gender a direct determinant of adoption when resources and extension services are equally available. Likewise, Peterman and Quisumbing (2014) analysed agricultural productivity in Sub-Saharan Africa and noted that gender disparities in adoption are more closely linked to resource inequities than to gender itself.

The coefficient for education is -0.0704216, also non-significant ($p = 0.849$), indicating that educational attainment does not significantly affect GAP adoption. This finding is consistent with studies on technology adoption in agriculture (Ngono and Meughoyi, 2022). Several factors may explain this result. First, in many rural agricultural settings, formal education may not directly relate to or improve farmers' understanding of advanced agricultural techniques such as GAPs. If the extension curriculum does not incorporate practical agricultural training, higher formal education levels may not translate into better adoption. Second, farmers often rely more on experiential knowledge, local traditions, and peer learning than on formal education. Practical experience and extension services may play a more crucial role in decision-making

Table 7. Logit results on socio-economic factors influencing the level of adoption of GAPs.

Variables	Coefficient	Standard error	z-value	Prob >|z|
Sex	-0.0238925	0.2944263	-0.08	0.935
Education	-0.0704216	0.3695659	-0.19	0.849
Farm Size	-0.1250464**	0.0606829	-2.06	0.039
Membership of Cooperatives	-0.9392567***	0.3042572	-3.09	0.002
Access to credit	1.240503***	0.3491348	3.55	0.000
Access to extension service	-0.1028168	0.292443	-0.35	0.725
Constant	1.873584	0.5216463	3.59	0.000
LR Chi2	21.61***			
Prob > Chi2	0.0014			
Mean VIF	1.24			
Hatsq	-0.1900711	0.2773972	-0.69	0.493
Pearson Chi2	108.90			
Prob > Chi2	0.3776			

Field Survey, 2023; *** Significant at 1% level ** Significant at 5% level, LR is Log likelihood Ratio, VIF is variance inflation factor.

regarding GAP adoption. Additionally, even if farmers are educated, their adoption of GAPs may be more influenced by access to resources, extension services, and training programs tailored to promote these practices. Economic constraints may also limit the adoption of GAPs despite education; even if education increases awareness, factors such as limited access to credit, markets, and input might prevent farmers from adopting GAPs. Similar findings have been reported by Ogada *et al*. (2014) and Arslan *et al.* (2022), who emphasised that economic and social factors often outweigh the influence of formal education on the adoption of agricultural practices.

The negative coefficient for farm size (-0.1250464) suggests that smaller farms are more likely to adopt GAPs than larger farms, a finding that is statistically significant ($p = 0.039$). This challenges conventional wisdom, which often associates larger farms with higher rates of technology adoption due to economies of scale. One possible explanation is risk aversion among smallholders. Smaller farms face higher production risks due to limited resources and their inability to absorb shocks (Nwaogwugwu *et al.,* 2024). As a survival strategy, they may adopt GAPs to improve soil health, crop yields, and resource efficiency. Touch *et al.* (2024) noted that risk management is a crucial driver of technology adoption among smallholders, particularly in volatile agricultural environments. Oyetunde-Usman *et al.* (2021) found that farms with higher family labour availability were more likely to adopt conservation agriculture practices. Furthermore, smaller farms might be more integrated into local markets that demand sustainable agricultural products, thus incentivising them to adopt GAPs. Chichongue *et al*. (2019) observed that smallholder participation in organic and fair-trade markets has been increasing, driven by economic and environmental concerns.

Membership in a cooperative association has a significant negative coefficient (-0.9392567, $p = 0.002$), indicating that farmers who belong to associations are less likely to adopt GAPs. This contradicts the expected role of associations in facilitating technology adoption through knowledge exchange and collective action. Several factors may explain this unexpected result. Associations may suffer from poor internal governance, where leaders monopolise information or resources, reducing incentives for members to adopt new practices (Rondot and Collion, 2001). Some associations may prioritise short-term economic benefits, such as market access or input procurement, over knowledge dissemination and capacity-building related to GAPs (Barham and Chitemi, 2009). Bureaucratic inefficiencies in large associations may also limit effective communication and coordination, making it harder to promote the adoption of new technologies. Additionally, association members may face social pressures to conform to traditional practices, particularly if the group is predominantly composed of risk-averse farmers (Pannell *et al.,* 2006). In some contexts, mistrust in extension services or external actors promoting GAPs may also discourage adoption (Teng, 2005). To address these issues, policies should focus on improving the internal governance and transparency of associations while ensuring that they provide targeted technical support and training for GAP adoption.

Access to credit plays a crucial role in facilitating the adoption of agricultural technologies, particularly GAPs. The coefficient of 1.240503 ($p < 0.001$) indicates a strong positive relationship, signifying that farmers with better financial access are more likely to adopt GAPs. This finding is consistent with studies emphasising the importance of credit availability in enhancing agricultural productivity and technology adoption. Farmers often encounter financial barriers when adopting new agricultural practices, especially those requiring initial investments in inputs, tools, or training. Access to credit alleviates these constraints by enabling farmers to invest in improved seeds, fertilisers, irrigation systems, and other essential innovations. Pawlak and Kolodziejczak (2020) highlighted that financial capital could reduce liquidity constraints in developing countries, allowing farmers to make more efficient investment decisions. Similar studies, such as those by Adewale et al. (2022), found that access to credit significantly boosts agricultural productivity by supporting the adoption of advanced practices. Omolehin *et al.* (2024) demonstrated that farmers with access to credit are more likely to implement high-yielding crop varieties and improved irrigation techniques. Likewise, Rahman *et al.* (2024) reported that credit access positively influenced both technology adoption and farm productivity. Awotide *et al.* (2015) further emphasised that access to formal credit enhances farm productivity and profitability by facilitating investment in improved agricultural practices.

Access to credit is particularly crucial in smallholder agriculture, where financial limitations often restrict investment in new practices. Credit provides the necessary liquidity for farmers to take advantage of the long-term benefits associated with GAPs. Additionally, credit strengthens the overall sustainability and resilience of agricultural systems by allowing farmers to expand their operations, diversify income sources, and reduce vulnerability to market fluctuations and environmental shocks. This financial flexibility encourages farmers to take calculated risks in adopting new technologies, reinforcing the role of credit as a key driver in the adoption of GAPs. Policymakers should focus on improving access to credit through tailored financial services that cater to smallholder farmers' specific needs, ensuring that credit mechanisms are accessible, affordable, and supportive of sustainable agricultural practices.

Summary

The study explored the adoption and factors influencing the implementation of GAPs among arable crop farmers in Borno State. A total of 390 respondents were surveyed, with 90.26% adopting GAPs, 75.28% of whom demonstrated a high adoption level. Fertiliser use (80.97%), seed treatment (65.91%), and intra-row spacing (64.77%) were among the most adopted practices. Regression results identified farm size, cooperative membership, and credit access as significant determinants. However, poor extension service access and limited credit availability were significant challenges.

Conclusion

The results revealed a generally high level of GAP adoption among respondents, despite the study region being adversely affected by persistent insurgency. This outcome may be attributed to intensified NGOs and donor interventions in the form of training, awareness campaigns, and the provision of agricultural inputs aimed at building resilience and food security in conflict-affected areas.

Notably, the regression analysis indicated that while certain socio-economic factors had statistically significant effects on GAP adoption, the direction of these relationships was not uniformly positive. Specifically, farm size, membership in cooperatives, and access to credit were all found to have significant but negative associations with the level of adoption. This suggests that larger farms may not necessarily translate into higher GAP uptake, possibly due to the complexities and costs of implementing GAP across expansive areas. Similarly, cooperative membership and access to credit—typically expected to facilitate adoption—may be hindered by issues such as weak institutional structures, poor group coordination, or misallocation of credit.

Recommendations

1. Facilitate Credit Access: Implement financial schemes to enable farmers to invest in GAPs. Loans provided for GAPs should be subsidised, and measures should be taken to ensure credit is channelled to GAP adoption.
2. Promote Cooperative Membership: Restructure cooperative organisations and provide training to encourage GAPs adoption among members.
3. Target Farm-Specific Support: Develop programs tailored to farm sizes to ensure equitable adoption of GAPs. Special GAPs training program on effective large farm management and labour-saving techniques should be established.
4. Enhance Resilience-Based Interventions: Given the high level of adoption in an insurgency-prone region, continued investment in resilience-building initiatives, such as farmer training, subsidised inputs, and adaptive technologies, should be sustained and expanded.
5. Further Research: Additional studies should investigate the underlying causes of the negative associations observed, with a focus on understanding the structural and behavioural dynamics within cooperatives and credit access systems.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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