



DOI: 10.2478/arlis-2025-0004

Research Article

Assessment of Farmers' Adoption of Released Drought-Tolerant Maize Varieties in Northern Nigeria

Aisha Simbiat Hussaini¹, Yusuf Usman Oladimeji¹, Tahirou Abdoulaye²,
Muhyideen Oyekunle³, Zakariya Saminu³

¹Ahmadu Bello University, Department of Agricultural Economics, Zaria, Nigeria

²International Institute of Tropical Agriculture, Bamako, Mali

³Ahmadu Bello University, Institute for Agricultural Research, Department of Plant Science, Zaria, Nigeria

Received May, 2025; Revised September, 2025; Accepted October, 2025

Abstract

Maize (*Zea mays* L.) ranks as the second most widely cultivated crop in Nigeria, valued for its adaptability to diverse agro-climatic conditions and its multifaceted role in food security, animal feed, and industrial uses. This study explores farmers' preferences for and adoption of drought-tolerant maize varieties (SAMMAZs), developed and issued by Ahmadu Bello University's Institute for Agricultural Research (IAR), and cultivated widely across Northern Nigeria, a region responsible for over 75% of the country's maize production. With reference to cross-sectional data gathered from 850 maize farmers (715 men and 135 women) during the 2019-2024 farming seasons and with aid of descriptive statistic and regression models, the study highlights notable differences in varietal preferences. Male farmers prioritized high grain yield (90.6%), drought tolerance (79%), and low fertilizer input (54.8%). Meanwhile, female farmers showed greater preference for uniform growth (85.3%), high grain yield (72.1%), and low fertilizer requirements (59.4%). Statistical t-test indicated a significant yield advantage for the SAMMAZ51 (4,987.02 kg/ha) compared to farmer varieties (1,718.27 kg/ha), at 1% level of probability. The multivariate Probit regression models using Maximum likelihood with complete information (FIML) and endogenous switching regression model (ESRM) established key socioeconomic and institutional variables that determined choice of SAMMAZs, and factors that influenced productivity and gross margin of these products. Tobit regression analysis identified primal factors that influenced intensity of adoption to encompass the availability of extension and research services, closeness to input centers, credit availability, and assistance from both public and private entities. These results highlight how crucial it is to match farmers' practical demands with crop breeding initiatives, particularly when it comes to qualities like market value, drought resilience, and yield potential.

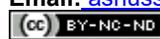
Keywords: SAMMAZ Varieties, Adoption Drivers, Gender Differences, Yield Performance, Tobit Model, Northern Nigeria.

Introduction

Maize (*Zea mays* L.) is a crucial crop in sSA, serving as one of the region's primary food crop and a key element in ensuring food security [1]. In Nigeria, virtually every household consumes maize products. It is widely used in the country as feed and industrial raw material with an estimated

annual demand of 15.5 million metric tonnes, while supply stands at 11 million tonnes, leaving a considerable gap supplemented by imports [2]. However, the productivity of maize farming is greatly influenced by improved maize seed technologies which are essential for enhancing agricultural productivity. For example, Ruzzante et al. (2021) [1] noted that, increased adoption of improved maize seed technologies is crucial for increasing agricultural output, bolstering small-scale farmers' income, and ensuring global food security in developing countries. Almekinders et al. (2019) [3], and Usman et al. (2022) [4], also

* Corresponding author: Aisha Simbiat Hussaini,
Email: ashussaini@abu.edu.ng

 © 2025 A.S. Hussaini et al., published by De Gruyter Open.
This work was licensed under the Creative Commons Attribution-NonCommercial-NoDerivs 3.0 License

argued that improving seed quality is essential to raising agricultural output and guaranteeing the world's food security. Improved seeds respond well to inorganic fertilizer and are drought- and disease-tolerant in addition to being high-yielding [4,5]. In contrast, traditional seeds typically yield less but are better suited to the local environment [6]. Nigeria is among the many developing nations that have recently made attempts to improve crop varieties, but the adoption rates have fallen short of projections [7].

Maize production and productivity, which are crucial for the food security of rural communities, remain significantly low. This may be due to the low adoption of improved maize technology. The average yield gap between local and improved maize varieties is about 2 tons per hectare, a significant difference for enhancing food security. Maize productivity in Nigeria has remained flat or decreased in comparison to a baseline two decades prior. Because of this, the Nigerian government is currently concentrating on increasing productivity [8]. In a bid to enhance productivity, improve farmers' welfare and achieve sustainable agricultural development, the agricultural sector in Nigeria is undergoing a transformational change driven by various technological initiatives. Among these initiatives is the seed technology improvement projects that include stress tolerance maize (STMA), drought tolerant maize varieties (DTMA), accelerate genetic gain (AGG) in maize, and wheat and accelerated varietal improvement and seed delivery of legumes and cereals in Africa (AVISA) Projects.

[9] noted that unless if better management practices, eco-friendly methods, and improved maize seed technologies are embraced and used in agricultural production in a sustainable manner, increasing productivity might remain a pipe dream.

One of the ways to transform agriculture in Nigerian is small-scale farmers are being introduced to contemporary agricultural techniques and enhanced maize seed technologies. For instance, the amount of cultivated land in the United States decreased from 945,080 to 916,990 acres between 2000 and 2011, according to a comparison of agricultural production patterns in the country.

Yet gross farm income in 2011 was \$425.0 billion as against the figure of \$225.0 billion in 2000 [10] which implies that gross farm income more than doubled. This indicates a rise in agricultural productivity. Changes in agricultural production techniques, including the adoption of novel, enhanced maize seed technologies like improved

seed types, are the primary cause of this growth being the most significant.

Despite the availability of various improved maize seed technologies, there is limited understanding regarding farmers' preference and adoption among maize farmers in Kaduna State, necessitating a detailed assessment of northern Nigerian farmers' adoption and varietal preferences of released drought-tolerant maize (SAMMAZs).

In operational terms, the specific objectives were to evaluate the determinants of adopter drivers of maize seed variety, and assess the impact of adoption of improved maize seed on yield and gross margin.

Material and methods

The study was carried out in northern Nigeria, which comprises 19 states. The Northern region of Nigeria is more suitable for maize production due to high incident solar radiation, moderate rainfall and the occurrence of biotic stresses and natural dryness at the time of harvest.

The maize producer survey used a four-stage sampling procedure. In each of the three geopolitical zones of northern Nigeria, one (01) of the top producing states for maize was specifically chosen. These were Kaduna from north west, Niger from north central and Gombe from north east. Four (04) Local Government Areas (LGAs) from each state were chosen at random as the second step in the sampling process considering the LGAs where improved maize technologies have been and are still being promoted by Institute for Agricultural Research and other research for development partners, including International Institute of Tropical Agriculture (IITA). This resulted in a total of twelve (12) LGAs. Thereafter, four communities each were randomly selected from the list of maize communities listed and registered with the state agricultural development project department, resulting in 48 communities. The last stage involved a proportional random sampling based on sample frame of each community gives a total of eight hundred and fifty (850) maize farmers comprising seven hundred and fifteen (715) males and one hundred and thirty-five (135) females. This sample size also comprises of 321 male and 53 female adopters and 394 male and 82 female non-adopters after classifying them during data analysis.

The data collection was achieved with the aid of structure questionnaire and interview schedule, which were used to gather primary data. During the course of the study, the ethical standards of secrecy, anonymity, and respect for respondents, beneficence, and the principle of fairness were all

observed. Throughout the survey, all respondents were treated fairly and equitably, regardless of their race or religious beliefs.

Econometric Analysis and Model Specification Specification of endogenous switching regression model (ESRM)

The Random Utility Theory (RUT) is used to predict the adoption of better seed. It implies that farmers will decide whether or not to embrace improved seed depending on the utility it provides [11]. It is assumed that farmers are risk neutral, and their decision to adopt improve seed is influenced by the utility (yield) they will derive from adopting the improved seed. Maize Therefore, it is presumed that farmers will select the management strategy that will yield the greatest advantages for them [12]. The utility (yield and gross margin) that farmers obtain from adopting improved yield is assumed to be Y_a , while the utility from non-adoption is Y_n .

The mathematical specifications of the two systems are as follows:

$$Y_{Ja} = X_j\beta_a + u_{ja} \quad (1)$$

and

$$Y_{Jn} = X_j\beta_n + u_{jn} \quad (2)$$

where X_j is a vector of independent variable factor prices (independent factors of farm production and household characteristics); β_a and β_n are the parameter estimates for adopters and non-adopters respectively; u_{ja} and u_{jn} are the error terms with zero mean and constant variance, which are assumed to be independently distributed. Every rational farmer will choose the technology with the highest utility and it is expressed as, $Y_{Ja} > Y_{Jn}$.

Econometric of Tobit Regression Model

The Tobit regression model was used in assessing the factors that influenced the probability of intensity of adoption of improved maize seed technology among farmers.

The model is expressed implicitly as follows:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + U_i \quad (3)$$

where:

Y = Adoption index which denote number of recommended good agricultural practices by each farmer divided by total number of GAPs by IAR procure. These include (i) seed treatment (apron star or apron plus, 40 g sachet per 15 kg of seed); (ii) selecting drought tolerant SAMMAZ variety; (iii) land preparation-ploughing, harrowing and ridging using tractor or animal drawn; (iv) seed rate 10-15 kg/ha; (v) sowing date (June); (vi) soil depth 2-3 cm; (vi) fertilizer requirement, 200-300 kg of NPK fertilizer and 100-150 kg of urea per ha depending on soil test; (vii) weed management include ridge moulding, glyphosate 3 litres/ha and nicosulfuron at 2 litres per ha; (viii) pest and disease management include Caterpillar at 200 g per ha; (ix) maturity-extra, medium and late and (x) yield 5-6 ha.

$X_1 - X_8$ were defined in the results β_0 = Constant term; $\beta_1 - \beta_8$ = Slope or coefficients (marginal effects of the regressors); U_i = Stochastic error term, assumed to be normal, homoscedastic with no serial correlation.

Results and discussion

Traits Preference for DTMV (SAMMAZs) by Improved Maize Adopters

Preference for a variety is *sine qua non* to liking one or two traits in that variety. This section presents the traits preferred by farmers. The result in Table 1 indicates the distribution of traits preferred by male and female farmers in northern Nigeria. Majority of male farmers (90.6%) prefer high yield, 79% prioritize drought tolerant and 54.8% favour low fertilizer application as the three most important traits for adopting maize variety. In contrast, the female farmers prefer to adopt maize varieties with traits such as uniform growth (85.3%), high yield (72.1%) and resistance to striga (46.4%). However, when pooled together, respondents most commonly prefer to adopt maize varieties with high yield, uniform growth and drought tolerant. Therefore, productivity, especially yield attributes, is crucial in determining farm households' choices for various types of maize and in creating suitable incentive-based strategies for breeding programs [13]. The result of the study is in tandem with [14], who found yield and drought tolerance, as the most preferred traits in sorghum production using choice probability and conditional Logit model for chosen sorghum varietal attributes in northern Nigeria.

Table 1. Descriptive statistics of preference for planting DTMVs (SAMMAZs)

Traits	High yield	Drought tolerant	Uniform growth	Fertilizer application	Early maturing	Big cobs	Uniform cobs	Marketability
Male (n=321)	90.6	79.0	46.3	54.8	43.9	42.8	39.7	39.1
Female (n=53)	72.1	45.9	85.3	59.4	42.4	42.7	42.0	36.9
Pooled adopter (n=374)	81.35	62.45	65.8	57.1	43.15	42.75	42.45	38.0

Multiple response allowed.

Source: Author's computation based on field survey data, 2024.

Effects of the Adoption of DTMV SAMMAZ

To examine the impact of adopting SAMMAZ on the yield of farmers in the study area using endogenous switching Probit model (ESPM). Table 2 presents the difference between actual and counterfactual maize yields. One of DTMVs' inherent features, yield stabilization, is examined using the yield variance from the ESR model. The treatment effects of DTMV adoption on the variance of yield are, however, only significant for adopters and non-adopters. From the results presented in Table 6, the estimated ATE and ATT are based on the endogenous switching probit estimates for every choice and type of engagement. The calculated ATE value of 9.412

indicates that the probability of a randomly chosen farmer being chosen would be about 9.41 percent greater of adopting a new variety if he or she is aware of the benefits of adopting a new variety. Additionally, the ATE's positive sign and high significance suggest that the decision to adopt a new variety would be significantly impacted by the DTMV. Also, the estimated ATT of 12.009 suggests a 12 percent higher likelihood of adopting an improved variety. As a result, treatment assignment usually resulted in a 12 percent increase in adoption probability. The finding is consistent and comparable with studies of [8,10,15,16,17].

Table 2. Treatment effects for the adoption of DTMV SAMMAZ using endogenous switching Probit and adjusted FIML robust models

Variable	ESRPM		FIML	
	Coefficient	Std error	Coefficient	Std error
Average treatment on the treated (ATT)	12.009***	1.0876	15.0002***	1.9543
Average treatment effect (ATE)	9.4212***	1.7076	11.9763***	1.8002
Potential-outcome mean (POM)	na	na	9.0027***	1.9227

Factors that Influence Intensity of adoption of DTMV

Factors estimating the intensity of DTMV adoption are extracted using the Tobit regression model and are displayed in Table 3. In this study, nine independent variables were assumed to be factors affecting farmers' intensity of adoption, of which seven (including years of farming experience, access to extension, social membership, credit utilized, farm size, distance to input centres, and government and non-governmental organisations (NGOs) support were positive and statistically significant, while the remaining variables did not significantly influence the intensity of adoption of DTMVs. We will

discuss briefly variables that were statistically significant.

Farming experience: The results show that the number of years spent farming was positive and statistically significant at 1%, suggesting that farmers gain one unit of experience for every unit of years of agricultural experience in adoption of maize varieties which implies that the more experience a farmer has, the more likely they are to adopt new varieties, as it helps the farmer to adjust to the changes required for each new agricultural technology.

Access to extension: Contact with extension agent was significant at 10% and showed a positive relationship with the intensity of adoption

of DTMV maize variety among maize farmers. This means that respondents that had previous contacts with extension agents were likely to have higher intensity of adoption. The marginal effect also indicates that contact with extension agents increases the intensity of adoption of DTMV by 6.23%. This may be attributed to the awareness of DTMV resulting from contact with extension

agents. Mahoussi et al. [18] discovered that the decision to increase the use of enhanced technology in Ethiopia and the Republic of Benin was significantly and favorably influenced by access to extension services, respectively and that awareness increases the likelihood of adoption among farmers.

Table 3. Tobit model estimates of intensity of adoption of DTMV (SAMMAZs) in Northern Nigeria

Variable	Dy/dx	Std error	P > (z)
Constant	0.05617*	0.00284	0.0619
Level of education	-1.47301	0.000582	0.210
Household size	-0.65415	0.00039	0.113
Farming experience	0.73204***	0.04007	0.000
Access to extension contacts	0.1065***	0.00623	0.000
Social membership	0.65043**	0.01142	0.018
Credit utilized for production	1.99044**	0.00542	0.027
Farm size	0.55210***	0.00432	0.000
Distance to input centres	-0.00843**	0.000621	0.030
Support from Govt & NGOs	0.00065*	0.00021	0.0800

***, **, * denote significant at 1, 5 and 10%, respectively, number of observation (374); Adjusted R² (0.422); Log of likelihood (-89.664); LR Chi² (-89.664); LR Chi² (127.008). Prob > Chi² (0.000)
Source: Author's computation based on field survey data, 2024.

Social membership: Social membership was found to have a positive (0.65043) effect at 5% on the level of adoption of DTMV. This implies that farmers who belong to groups can easily get information on new maize varieties from other group members who have already adopted the variety or through collective training by extension workers since most rural training programs tend to target groups rather than individual as noted by [19].

Credit utilized for maize production: Access to credit was positive and statistically significant at 1% level of probability. This is because credit is necessary to facilitate the adoption intensity for smallholder maize farmers. Whenever farmers have access to credit, they tend to invest in farm inputs that are perceived to significantly increase maize yields. This explains why it is important for farmers to have access to credit in order to enhance adoption; access to credit raises the intensity of use because it increases farmers' purchasing power. This finding lends support to that of Addison et al. [20] and [21] who found access to credit by farmers positively associated with the adoption of new agricultural technologies.

Farm size devoted for maize production: When it comes to the adoption of new technologies in agriculture, farm size is a crucial

factor. Numerous studies have demonstrated that the size of a farm significantly influences how quickly technology is adopted [22]. The farm size of the respondent was significant at 5% and positively influenced the area allocated to DTMV varieties. This result implies that the larger the size of the farm of the respondent, the more area is allocated to DTMV maize varieties. Hence, if the farm size of the adopter's increases with one unit it leads to an increase in the area planted with DTMV by 0.55210 units. Thus, as land size increases, it increases the household opportunity to utilize the DTMV, in line with studies by [23].

Distance to input centres: Costs of transportation could be a barrier, especially for farmers in rural areas. It was discovered that the distance from input centers determined the intensity of adoption since it was statistically significant at the 5% significance level and negatively (-0.0083) correlated with the probability of DTMV adoption choice. Consequently, a minute increase in the distance to the input center, the probability of adopting DTMV would decrease by 0.0083 units. The far remote the input centres from the homestead, the lesser would be the probability of agricultural input utilization.

Distance to input centres: Costs of transportation could be a barrier, especially for

farmers in rural areas. It was discovered that the distance from input centers determined the intensity of adoption since it was statistically significant at the 5% significance level and negatively (-0.0083) correlated with the probability of DTMV adoption choice. Consequently, a minute increase in the distance to the input center, the probability of adopting DTMV would decrease by 0.0083 units. The far remote the input centres from the homestead, the lesser would be the probability of agricultural input utilization. The finding is in line with the findings of Menale et al. [24] in Tanzania's rural areas, where farm revenue and input adoption decline with increasing plot distance. The likelihood of adopting DTMV therefore drops by 0.0082 units as the distance from the closest market grows by one kilometer, while all other factors remain unchanged, as a result of the on-time procurement and distribution issue.

Government and non-governmental organisations (NGOs) support: Government

and non-governmental organisations (NGOs) can promote adoption of a technology especially among farmers who are affiliated to social organisations, who are more likely to learn about the technology through social networks, thereby increasing their chances of adopting it. The variable was found to influence adoption of DTMV with marginal effect of 0.0065 at 10% statistical level of significance. Siziba et al. [25] found this variable to affect smallholder farmers in sub-Saharan Africa's involvement in the cereal market. Social network effects have a big influence on people's decisions, and this is particularly true for farmers who can gain from the expertise and experiences of their peers.

Profitability of DTMV (SAMMAZ) production in northern Nigeria

The profitability analysis of DTMV and farmers' varieties showcases the economic implications of adopting DTMV. The result of the cost-return analysis is presented in Table 4.

Table 4. Costs and return (profitability) of DTMV (SAMMAZ51) production in Northern Nigeria

Estimates per ha	SAMMAZ51		Farmers' variety	
	Value (USA Dollar)	%TVC	Value (USA Dollar)	%TVC
Variable Cost				
Seed	(\$57.38)	5.65	(\$30.09)	3.97
Labour	(\$330.09)	32.52	(\$299.69)	39.593
Fertilizer	(\$410.13)	40.40	(\$229)	30.293
Agrochemicals	(\$34.27)	3.37	(\$19.87)	2.62
Rent of farmland	(\$105.13)	10.35	(\$105.13)	13.89
Transportation	(\$27.68)	2.728	(\$31.90)	4.21
Bags and storage items	(\$50.27)	4.95	(\$49.93)	5.40
Total Variable Cost	(\$1014.98)	100	(\$756.93)	100
t-test	2.8004**			
Gross return				
Yield (kg/ha)	(\$800.5)		(\$2.758)	
Gross Revenue	(\$2801.78)		(\$1242.53)	
Gross margin	(\$1979.41)		(\$485.59)	
t-test	3.417**			
Net margin				
*Depreciation of fixed items	(\$287.24)		(\$4598.83)	
Net farm income	(\$1692.19)		(\$439.61)	
Return on investment	2.51		1.54	

* denote items such as hoe, cutlass, sprayer, rent on tractor and other machines.

** denote statistically significant at 1%, respectively. Dollar rate: ₦622.985 Nigeria Naira to Dollar.

Source: Author's computation.

The results reveal that, on average, DTMV (SAMMAZ51) yields 4,987.02 kg/ha while farmers' variety yields 1,718.27 kg/ha with the difference statistically significant at 1% probability level. It is implied that the production of maize that can withstand drought is more profitable. As a result, farmers that use drought-tolerant maize varieties see an increase in income, which may be related to the adoption of these particular varieties.

The findings presented in Table 4 indicate that gross revenue realised from the sales of SAMMAZ51 was ₦1,745,467.5 (\$2801.78) per hectare, while the farmers' variety yielded ₦774,080.635 (\$1242.53). Therefore, the gross margin for SAMMAZ51 was ₦1,233,146.45 (\$1979.41) higher than the farmers' variety that recorded a gross margin of ₦302,520.58 (\$485.59). The return on investment (ROI) of ₦1.54 for farmers' variety and ₦2.51 for improved SAMMAZ51. Based on this result, the improved variety generates the highest income, which should encourage the farmers to adopt SAMMAZ51 maize variety in subsequent cropping seasons.

Conclusions

The study concludes that technology has significantly impacted productivity, increase yield especially among high adopter farmers. The key factors influencing the adoption and intensity of adoption were socio-economic, institutional and socio-cultural characteristics. Hence, efforts should be made by government and NGOs to provide targeted support to low adopter of improved maize seed technologies. This could include tailored training programs, access to credit and DTMVs, and provision of other quality improve seeds and other agricultural inputs. Additionally, engaging more agricultural extension services and support groups can help increase adoption rates. Strengthening the improved maize seed supply chain and distribution networks will help farmers access the necessary inputs for successful cultivation of improved maize seed technologies. Addressing social and cultural barriers that hinder the adoption of new technologies is essential. Community-based awareness programs and sensitization campaigns can help change perceptions and attitudes toward improved maize seed technologies. Engaging local leaders and influencers in promoting the benefits of the technology can also facilitate its acceptance and adoption. Continuous monitoring and evaluation of the adoption and impact of improved maize seed technologies are necessary to identify challenges and areas for improvement.

Acknowledgements

Special appreciation goes to the International Maize and Wheat Improvement Center (CIMMYT) and the International Institute of Tropical Agriculture (IITA) for providing substantial part of the funding for data collection. Also, to the Institute for Agricultural Research (partnering in the project) by providing the logistic and manpower during the data collection exercise and to the enumerators including postgraduate, IAR technical personnel and ADP staff who helped in collecting the data.

References

1. Ruzzante, S., Labarta, R., & Bilton, A. (2021). Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. *World Development*, 146, 105599. <https://doi.org/10.1016/j.worlddev.2021.105599>.
2. Ameh, A., Oladimeji, Y.U. & Ugbabe, O.O. (2020). Assessment of Households' Food Security and Production Constraints of Maize Farmers in Kaduna State, Nigeria. *Journal of Agripreneurship and Sustainable Development*, 3(3), 1-12. <https://doi.org/10.59331/jasdv3i3.130>.
3. Almekinders, C.J., Beumer, K., Hauser, M., Misiko, M., Gatto, M., Nkurumwa, A.O. & Erenstein, O. (2019). Understanding the relations between farmers' seed demand and research methods: The challenge to do better. *Outlook on Agriculture*, 48(6), 1-6. <http://dx.doi.org/10.1177/0030727019827028>.
4. Usman, H.A., Oladimeji, Y.U., Egwuma, H. & Abdoulaye, T. (2022). Gender Gaps in Profitability of Drought Tolerant Maize Varieties (DMTVs) Production in Selected States of Northern Nigeria. In 10th International Conference on Social Science and Humanities, Theme: Agriculture, Animal Sciences and Rural Development in Ozdemir et al. 2022, Silvas University of Science and technology, 264-273.
5. Simtowe, F., Amondo, E., Marenja, P., Sonder, K. & Erenstein, O. (2019). Impacts of drought-tolerant maize varieties on productivity, risk, and resource use: Evidence from Uganda. *Land use policy*, 88, 104091. <https://doi.org/10.1016/j.landusepol.2019.104091>.
6. Anang, B.T. (2019). Are adopters of improved rice varieties more productive than non-adopters? Empirical evidence from northern Ghana. *Ghana Journal of Development Studies*, 16 (1), 92-107. <https://doi.org/10.4314/gjds.v16i1.5>.
7. Oladimeji, Y.U., Abdoulaye, T., Usman, H.A., Egwuma, H., Kadjo, K.D., Anyebe, Y.O., Oyekunle, M., Saminu, Z. & Mani, H. (2022). Differentials in adoption of maize seed varieties and impact on farmers' livelihood in northern Nigeria. *Nigerian Agricultural Journal*, 53(3), 22-31.
8. Adeniyi, S.T., Ojeleye, O.A., Oladimeji, Y.U. & Abubakar, A.D. (2024). Impact evaluation of babban gona franchise on productivity of smallholder maize farmers in Kaduna State, Nigeria. *FUOYE Journal of Agriculture and Human Ecology*, 7(1), 9-19. <https://doi.org/10.62923/fuojaha.v7i1.254>.
9. Oladimeji, Y.U., Abdulsalam, Z. & Ayandotun, B.W. (2016). Rural Household Fuel Consumption and

Energy Crisis: A Synopsis of Poverty Trend in North Central Nigeria. *Ethiopian Journal of Applied Science and Technology*, 7(1), 59-76.

10. **Vansteelandt, S., Rotnitzky, A. & Robins, J.** (2007). Estimation of regression models for the mean of repeated outcomes under nonignorable nonmonotone nonresponse. *Biometrika*, 94(4), 841-860, <https://doi.org/10.1093/biomet/asm070>.

11. **Ojo, T.O., Adetoro, A.A. Ogundeji, A.A. & Belle, J.A.** (2021). Quantifying the Determinants of Climate Change Adaptation Strategies and Farmers' Access to Credit in South Africa. *Science of the Total Environment*, 792, 148499.

12. **Bidzakin, J.K., Fialor, S.C., Awunyo-Vitor, D. & Yahay, I.** (2019). Impact of contract farming on rice farm performance: Endogenous switching regression. *Cogent Economics & Finance*, 7(1), 1-20, <http://dx.doi.org/10.1080/23322039.2019.1618229>.

13. **Asrat, S., Yesuf, M., Carlsson, F. & Wale, E.** (2010). Farmers' preferences for crop variety traits; lessons for on-farm conservation and technology adoption. *Ecological Economics*, 69(12), 2394-2401.

14. **Tijani, I., Abdulrahman, S., Oladimeji, Y.U., Vabi, M.B., Abdulsalam, Z., Yusuf, O., Hussaini, A.S. & Yisa, F.** (2024). Analysis of farm-level productivity and varietal preferences among sorghum farmers in Sahel, Sudan and Guinea Savannah of Nigeria. *J. Arid Agric.*, 25(3), 52-63.24.

15. **Gitonga, Z.M., Visser, M. & Mulwa, C.** (2020). Can climate information salvage livelihoods in arid and semiarid lands? An evaluation of access, use and impact in Namibia. *World Development Perspective*, 20, 100239, <https://doi.org/10.1016/j.wdp.2020.100239>.

16. **Kolapo, A., Muhammed, O.A., Kolapo, A.J., Olowolafe, E.O., Eludire A.I., Didunyemi, A.J. Falana, K. & Osungbure, I.D.** (2023). Adoption of drought tolerant maize varieties and farmers' access to credit in Nigeria: Implications on productivity. *Sustainable Futures*, 6, 100142, 1-13, <https://doi.org/10.1016/j.sfr.2023.100142>.

17. **Rosenbaum, S.M. & Rubin, D.B.** (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41-55, <https://doi.org/10.1093/biomet/70.1.41>.

18. **Mahoussi, F.E., Adegbola, P.Y., Aoudji, A.K.N., Kouton-Bognon, B. & Biaoou, G.** (2021). Modelling the adoption and use intensity of improved maize seeds in Benin West-Africa: Double-hurdle approach. *African Journal of Food, Agriculture, Nutrition and Development*, 21(4), 17931-17951.

19. **Okello, D.M., Aliro, T., Odongo, W., Ndyomugenyi, E.K. & Owiny, D.O.** (2022). Alone or a combination: Ascertaining factors associated with choice of pig health management strategies amongst smallholder farmers in northern Uganda. *Preventive Veterinary Medicine*, 199, 105562, <https://doi.org/10.1016/j.prevetmed.2021.105562>.

20. **Addison, M., Anyomi, B.K., Acheampong, P.P., Wongnaa, C.A. & Amaning T.K.** (2023). Key drivers of adoption intensity of selected improved rice technologies in rural Ghana. *Scientific African*, 19, 1-13 <https://doi.org/10.1016/j.sciaf.2023.e01544>.

21. **Sheikh, A.T., Mugera, A., Pandit, R., Burton, M. & Davies, S.** (2022). The adoption of laser land leveler technology and its impact on groundwater use by irrigated farmland in Punjab, Pakistan. *Land Degradation and Development*, 33(12), 2026-2038, <https://doi.org/10.1002/ldr.4290>.

22. **Lavison, R.** (2013). *Factors Influencing the Adoption of Organic Fertilizers in Vegetable Production in Accra*. Msc Thesis, Accra Ghana.

23. **Wanjiraa, K., John, I.N., Mburu, A, Felister, M., Nzuve, B., Stella Makokha, C., Rosemary, A.E. & Tarachada, C.** (2022). Modelling the Adoption and Intensity of Climate-smart Maize Varieties in Embu County, Kenya: Double Hurdle Approach John. *Asian Journal of Extension, Economics and Sociology*, 40(6), 116-128.

24. **Menale, K., Moti, J., Bekele, S., Mmbando, F. & Muricho, G.** (2012). Plot and Household-Level Determinants of Sustainable Agricultural Practices in Rural Tanzania. *Environment for Development Discussion Paper Series*. EFD DP 12-02.

25. **Siziba, S., Nyikahadzo, K., Diagne A., Fatunbi A.O. & Adekunle, A.A.** (2010). Determinants of cereal market participation by sub-Saharan Africa smallholder farmers. *Publics Journal of Agriculture and Environmental Studies*, 2(1), 180-193.