CEDS Journal of Entrepreneurship and Innovation Research
Vol. 3 No. 2, December, 2024

ADOPTION AND IMPACT OF AGRICULTURAL TECHNOLOGY INNOVATION ON FARMERS' AGRICULTURAL PRODUCTIVITY IN GOMBE METROPOLIS, GOMBE STATE, NIGERIA

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ABSTRACT

This paper assesses the impact and adoption of agricultural technology innovations on farmers' agricultural productivity in Gombe metropolis, Gombe state, Nigeria. The data used in this paper was primary data collected through questionnaire design. Out of Three Hundred and Eighty Four (384) questionnaire administered, a total of Three Hundred and Twenty (320) were returned filled and valid. The data was analyzed using descriptive statistics, Chi-square technique and binary logistics regression model. However, it is found that more than fifty percent (50%) of the respondents adopted agricultural innovations in their farmlands. The Chi-square results also reveal that adoption of agricultural technology increases farmers' productivity and income. However, the logistic regression results also show that out of the ten explanatory variables used in the model, only education level of the farmer determines the adoption of technology innovations. The remaining variables were not significant. Therefore, it is recommended based on the aforementioned findings, that educational level of the farmers should be encouraged and government should subsidize the cost of those technological inputs to enable low-income farmers to be able afford it.

Keywords*:* Agriculture, Innovations, Technology, Logistic Regression

1.0 Introduction

The adoption of improved agricultural technologies continues to be seen as an important route out of poverty in most of the developing world. Agriculture plays a significant role not only to the growth and development of a nation, but also in achieving a sustainable food security, poverty alleviation and rural development. Globally, more than 60% of the world's population depends on agriculture for their survival according to FAO data cited by Zavatta (2014). With variations at the continental level, this sector has contributed to a 2.9% increase in the growth of the global GDP. However, adoption of agricultural technology is crucial for increasing agricultural output in developing nations in order to reduce poverty and ensure food security (World Bank 2007). Another important factor propelling economic growth is the adoption of agricultural technology (Barrett et al. 2010; Foster & Rosenzweig, 2010). One of the most crucial elements that would help to boost agricultural productivity has long been the development of numerous new or enhanced agricultural technologies (Monu, 1995). As observed by Sharifi et al. (2010), numerous scholars are interested in this issue because of the significance of technology and the uptake of new agricultural technologies, particularly in developing nations. They believe that in those nations, agriculture continues to play a significant role.

Meanwhile, by 2050 the world population is expected to reach 9.7 billion, achieving food security of food supply will be at risk if countries continue to adopt traditional agricultural methods. Factors such as changes in environment, global warming and emerging diseases could negatively impact on the health of the farm. Thus, adoption of agricultural technological innovation is crucial for boosting agricultural outputs, creating jobs, generating income and alleviating poverty, and driving social development.

In Nigeria, agriculture remains the major sector that contributes to the growth and development of a country. For instance, according to the Federal Ministry of Agriculture, Water Resources and Rural Development (2022), the sector provides food for the teeming population, source of raw materials and employment and constituting a major source of foreign exchange earnings. According to National Bureau of Statistics (2021), agricultural sector had a contribution of 25.88% to the country's national GDP in 2021. However, the contribution of agriculture to Nigeria's economy simply points out the fact that the sector is one that has a lot of potential and can yield quite a number of benefits for the country in general.

However, agricultural development of any so called country or economy depends largely on innovations. As such, innovations is said to be the major source of productivity, competitiveness, and economic growth through advanced and emerging economies and plays an important role in creating jobs, generating income and alleviating poverty, and driving social development (Diagne & Demont, 2007). Nigeria is among the countries that are suffering from food crises. A country where more than fifty percent 50% of its population could not have access to food at all times. As pointed out by FAO (2021) and World Food program (2024) millions of Nigerians are in acute or severe food insecurity especially in the Northern part of the country. Considering the magnitude of food crises and poverty in the country there is need to adopt such agricultural innovations like improved varieties of crops, farming systems, post-harvest practices/activities, smart agricultural technologies and other agricultural innovations in order to boost high productivity and reduce poverty among people.

Unfortunately, in many cases the adoption rate of such agricultural technology or innovation is low. This means that the majority of the smallholder farmers continue to rely on their traditional cropping patterns or farming practices (Sedi et al. 2024). Against this backdrop this paper attempts to assess the adoption and impact of agricultural innovation on Farmers' agricultural productivity in Gombe metropolis, Gombe State, Nigeria.

Ho: Adoption of agricultural technology innovations does not significantly improve farmers' productivity in Gombe metropolis,

The paper is structured into five sections. Section one and two consist of the introduction and related literature; section three and four contain the research methodology and presentations of results and finally, section five concludes and provide the policy recommendations

2.0 Literature Review

2.1 Empirical literature

2.1.1 Concept of Agricultural Technology Innovation

The terms, "Innovation, Invention and Technology", are mostly confused with one another and they tend to have different definitions depending on the context they are applied. In the field of information and communication, Salazar-Acosta and Holbrook, (2008) observed that technology refers to "knowledge, artefact or skills". But in economics, technology deals with

the technical process applied in the transformation of inputs to outputs. Technology is also the relationship between inputs and outputs or it is rather viewed as production function (Tian, 2009 & Rhode, 2013).

Agricultural Technological Innovation deals with introduction and application of a new, or a substantially modified or improved product or process over a period of time. In connection to agriculture, technological innovation refers to the introduction of a new tested or a proven substantially improved commodity or technique in agricultural production with a view to improve its productivity (Sharifi et.al 2019). In other word, "Agricultural Technology Innovation " refers not only agricultural machinery but also new crops (e.g horticulture) and improved variety of crops (e.g hybrid seed, high-yielding variety), farming system (organic farming, sustainable agricultural practices-SAP), post –harvest practices/activities (e.g marketing channel choices, drying technology), smart agricultural technologies (e.g robot and sensors) and other agricultural innovations e.g information and communication technologies (Yuniarsih et al., 2024).

2.2 Empirical Review

There are available empirical studies on the adoption and impact of agricultural technology adoption in the literature. For example, Uaiene (2011) examines the determinants of agricultural technology adoption in Mozambique. The study used a unique rich panel data from TIA05, a national representative data set from rural Mozambique, covering the period from September 2004 to August 2005. The results of the Econometric analysis of new agricultural technology adoption in Mozambique, indicates that, holding other factors constant, households with access to agricultural advisory services, those with access to rural credit and members of agricultural associations are more likely to adopt new agricultural technologies. Changes in technology adoption are associated with changes in extension access and changes in credit access as well as initial status of farm household on access to credit and access to extension services. To increase the likelihood of adopting modern agricultural technologies by smallholder farmers, policy makers should put emphasis on overcoming credit market failures, access to advice via extension, organisation of farmers into associations and improved education.

Kassa et.al (2014) identified the determinants of agricultural technology adoption decision and examining the impact of adoption on farm income. Cross sectional data was collected through semi-structured questionnaire administered on 270 randomly selected smallholder farmers. Probit and Ordinary Least Square (OLS) regression models were employed. Consistent with the findings of previous studies, regression results showed that agricultural technology adoption decision of farm households has been determined by irrigation use, land ownership right security, credit access, and distance to the nearest market, plot distance from the home stead, off-farm participation and tropical livestock unit. The regression result also revealed that agricultural technology adoption has a positive and significant effect on farm income.

Ayanwale et.al (2014) examines the factors that affect the adoption of agricultural technologies and determined the profitability of cereals and legumes in Sudan Savannah of Nigeria. The data used in their study were obtained from the baseline study conducted in 2008 and other official data. Data collected were analyzed using descriptive statistics, budgetary and logit regression model. Findings reveal that educational level is very low only one third 1/3 of them up to six years formal education. Results of the logistic regression model show that location of the farmer, large farm size and awareness encouraged the adoption of new technologies. The gross margin reveals that, among the cereals crops, Maize has a highest yield and revenue. Thus, the study recommends that, farmers in the study area possess the

potentials to adopt agricultural technologies which could improve yield and enhanced income.

Rafael (2015) assesses the determinants of agricultural technology adoption in Mozambique, using a unique rich panel data set from rural Mozambique covering the period of 2004-2005. It is found that, households with access to agricultural advisory services, those with access to rural credit and members of agricultural associations are more likely to adopt new agricultural technologies. Thus, the study recommends that, in order to increase the adoption of agricultural technologies among farmers, policy makers should put emphasis on overcoming credit access failures, access to advice via extension, organization of Farmers into associations and improved Farmer's education.

Echetama et.al (2015) evaluates the determinants of adoption of improved agricultural technologies among Agricultural Development Programme (ADP) radio farmers' programme listeners in Imo State-Nigeria. The data was collected and through questionnaire and analyzed using descriptive statistics and likert scaling type multiple regression models. The results from the multiple regression models show that level of education, farming experience, farm size, farmer organization membership and ownership of radio were socioeconomic characteristics significant in determining the level of adoption. It was recommended among others that educated farmers as well as farmers being members of farmers' organizations be encouraged if the objectives of adequate food supply and improved standard of living can be achieved in Imo State through this laudable programme.

Saliem et.al (2020) reviewed some studies related to new technology adoption and to determine the influencing factors. The study revealed that farmers' decisions to adopt new technology depended on dynamic interaction between the technology's characteristics, conditions and circumstances. At least four aspects affect agricultural technology adoption they are; technology; economy and finance; society and institution, and farm business and farmer household aspects. However, there is no single determinant of agricultural technology adoption instead of combining some elements. Improving adoption rate should take into account the entire factors. Thus, a comprehensive approach is the best choice to disseminate new technology. The government could play as a facilitator for technology adoption and ensure that such technology creates farmers' benefits.

Oleh-Petani and Di-Negara (2021) evaluates the determinants of agricultural technology adoption by smallholder farmers in developing countries. This paper is a review and synthesis of the literature related to potential factors that may constrain or encourage smallholder farmer adoption of new agricultural technologies. The determinant factors influencing smallholder farmer adoption of new technologies in developing countries vary from study to study based on contextual applicability and specific local condition. There are four major typologies of determinant factors whichnare identified to help explain low adoption rates of particular agricultural technology in developing countries which are; technology attributes, farmer or farm household characteristics, farm characteristics and institutional factors.

Ngochembo et.al., (2022) investigated the determinants for adopting agricultural innovations by rice farmers in the North West Region of Cameroon. A multi-stage sampling technique was employed to identify and collect data from 800 rice farmers in Ngoketunjia division. Data was collected through a structured questionnaire and analyzed using descriptive statistics and binary logistic regression. The results showed that ten of the thirty-three variables tested in the regression analysis significantly influenced the adoption of innovations by rice farmers. Household size, farm size, level of motivation, number of extension visits, and the ongoing socio-political crisis had statistically significant and positive influence while, type of labour

use, qualified personnel or hired labour, innovation institutions, property rights, and social norms affected innovations adoption negatively.

Baiyegunhi (2023) examines the determinants of agricultural innovation activities of 35 emerging sugarcane growers in KwaZulu-Natal's North Coast, South Africa, this study employed the Nossal and Lim framework, which utilised the criteria and methodologies described in the Oslo Manual to measure the innovation activities of firms. The Ordered Probit Model (OPM) was utilized to estimate the factors impacting the innovation activities of the emerging sugarcane farmers. The study findings show that majority of farmers (57%) are highly innovative, with process innovation being the most popular type of innovation. Furthermore, the OPM results revealed that several socioeconomic, institutional, and farm level factors are statistically significant in explaining farmers' capacity for innovation.

Zubairu et.al., (2024) analyzed the factors affecting the adoption of improved varieties of maize among farm families of Ardo-kola local government area of Taraba State, Nigeria. Multi-stage random sampling techniques were used to select 80 respondents for the study. Descriptive statistics was used to analyze the data. The study revealed that, the levels of adoption of improved maize farming technologies in the area were generally low while majority of the farmers had no formal education. The study also found that majority of the maize farmers had no contact with agricultural extension agents which can negatively affect adoption of improved maize farming technologies in the study area. Factors such as cost of the technology, complex nature of the technology, lack of skills to adopt the technology, risk and uncertainty of the technology and lack of productive resources were identified as challenges inhibiting the adoption of improved maize farming technologies in the area.

Nkwuagba and Nkamnebe (2024) explore agricultural technology adoption behaviour among cassava farmers in North Central Nigeria, with a focus on elucidating the predictors of technology adoption within the region. Leveraging a quantitative survey research design, data was collected from 377 cassava farmers through structured questionnaires. Findings reveal significant relationships between various factors such as performance expectancy, effort expectancy, social influence, facilitating conditions, price value, hedonic motivation, prior experience, and the adoption of agricultural technology. Through multiple linear regression analyses, it was established that these factors exert substantial influences on technology adoption behaviour among cassava farmers. Studies on the impact of agricultural innovation technology on farmer's output were very few, particularly in North-Eastern Nigeria. Majority of the empirical studies reviewed in this paper with regards to Nigeria were mostly carried out in Western and North Central Nigeria with majority of them conducted outside Nigeria. In view of this, this study sets out to assess the adoption and impact of agricultural innovation on Farmers' agricultural productivity in Gombe metropolis, Gombe State, Nigeria.

3.0 Materials and Methods

The target population of this study constitutes of all Farmers in Gombe metropolis, Gombe state, Nigeria. However, there is data unavailability on the actual number of the farmers located in Gombe metropolis. In view of the above, the formula that is found to be statistically useful in drawing the sample size of the unknown population based on the investigation is given by Chochran (1963). Many researchers have applied this formula in their respective studies (see Ul-Haq, et al 2020; Ul-Haq, et al 2020; Shahzad et al 2021). Thus, the formula is given as:

$$n = \frac{Z^2 pq}{e^2} \tag{3.1}$$

where:

n = number of sample size
Z = standard normal deviation set at 95% confidence level=1.96
p = maximum variability of the population at 50% level i.e 0.5
e = sampling error at 5%
q = 1 – p

Solution

$$Z = 95\% = 1.96$$

$$e = 5\% = 0.05$$

$$q = 1 - 0.5 = 0.5$$

$$n = \frac{(1.96)^2(0.5)(0.5)}{0.05^2}$$

$$n = \frac{(3.8416)(0.25)}{0.0025}$$

$$n = 384.16$$

$$n \cong 384$$

The method used in collecting data was structured questionnaire and convenient sampling technique was used to select the target respondents. To estimate and analyze the data collected, Chi-square and logistic regression model were adopted. Binary logistic regression model has been widely used in several studies by different researchers (see Agidew et al 2018; Cordero-Ahiman, et al., 2020; Aboaba et al, 2020; Pakravan-Charvadeh et al 2021; Dung, 2020). Discrete choice binomial logit regression model has two categories, coded 0 and 1. The logistic binary specification is suitable for models when endogenous variables are dichotomous

The model of this paper is specified in a functional form in equation one below:

$$INV = f(gender, age, educ, religion, no.yrs\ farming, fsize, Ethnic\ group) \quad (1)$$

Equation one however, can be re-stated in logistic regression form as done by Baum and Trivedi (2006):

$$\log\left[\frac{\Pr(INV_i)}{1-\Pr(INV_i)}\right] = \alpha + \beta_1 X_n + \mu \quad (2)$$

Pr(INVi) is the probability of farmer adopting agricultural innovation, and 1- Pr(INVi) is the probability of farmer not adopting agricultural innovation. Xn is the vector of explanatory variables (Gender, Age, Education, Religion, Farm-size, ethnic group and Number of years in farming) and is a constant while μ1 is an error term.

The general formula used to calculate the chi-square as a way to accept/reject the hypothesis stated in chapter one is gives as:

$$X^2_{cal} = \sum (O-E)^2 / E$$

Where O = is the observed variables, E = is the expected variables, and Σ is the summation.

The condition is that, if $X^2_{cal} > X^2_{tab}$ then reject null hypothesis and accept alternative and vice-versa.

4.0 Result and Discussion

This section presents and discusses the results of the major findings. From the descriptive statistics results, it is found that 180 of the respondents representing 56.25% adopt agricultural technology innovations while 140 of the respondents accounting for 43.75% did not apply any of the agricultural innovations. Equally found from the descriptive statistics, majority of the farmers adopt chemicals with highest frequency of 50 and a percentage of 27.75%. This follows by the adoption of seedlings and irrigation facilities with frequency of 45 and 35 with a corresponding of 25.00% and 19.44% respectively. However, only 20 respondents out of 180 applied all the forms of agricultural innovations with a percentage of 11.11%.

Table 1: Chi-square:

Options	Observed values (O)	Expected Values (E)	O – E	$(O - E)^2$	$(O - E)^2 /E$
Strongly agreed	120	64	56	3136	49
Agreed	60	64	-4	16	0.25
Indifferent	90	64	26	676	10.56
Disagreed	40	64	-24	576	9
Strongly Disagreed	10	64	-54	2916	45.56
Total	320				$\sum (O-E)^2 / E =$ 114.37

Source: Researcher's Computation (2023)

At ten percent levels of significance (10%), K-1, degree of freedom (df)= 5-1 =4. As such, using statistical table, the tabulated value (X^2_{tab}) was found to be 7.779 and the calculated t value X^2_{cal} is 114.37. Therefore, since calculated value is greater than the tabulated value, this satisfies the rejection of null hypothesis which says agricultural innovations does not increase farmer's output and accept the alternative hypothesis which says that, agricultural innovations increase farmers' output. Therefore, the paper concludes that application of various agricultural innovations among farmers in Gombe metropolis boost their agricultural output and income. This result is in line with the findings of Kassa. Kassa, Abrha, and Aregawi (2014).

Table 2: Logistic Regression Model on the Determinants of Agricultural Technology Innovation among Farmers in Gombe Metropolis

VARIABLES	(1) Coefficient	(2) Odd Ration
Gender	-0.599	0.549
	(0.788)	(0.449)
Age	-0.0180	0.982
	(0.0358)	(0.341)

Education	1.259**	3.523**
	(0.554)	(1.764)
Religion	0.537	1.712
	(1.315)	(3.695)
No. of years in farming	0.173	1.189
	(0.383)	(0.444)
Farm size	0.0930	1.097
	(0.348)	(0.458)
Hausa	-1.232	0.292
	(1.487)	(0.653)
Fulani	-1.199	0.302
	(1.408)	(0.676)
Tera	-0.0302	0.970
	(1.656)	(2.478)
Bolawa	-1.795	0.166
	(1.367)	(0.382)
Constant	-1.347	0.260
	(1.278)	(0.381)
Pseudo R2	0.156	0.156
Observations	320	320

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Researcher's Computation (2023)

Table 2 reports the results of the binary logistics regression model on the determinants of the adoption of agricultural technology innovations among farmers in Gombe metropolis, Gombe state. The regression results show that only educational level of the farmer was found to be statistically significant at 5%. It is found to be significant since half its coefficient is greater than the standard error. The odds ratio also suggests that as farmers move from one educational level to another, the probability of adopting agricultural innovation increases by 3.52 times larger odds. While other variables such as gender, age, religion, number of years in farming and ethnic group were not significant since halves of their coefficients are less than their corresponding standard errors. Echetama et.al (2015) also found similar findings to this study. In view of the above findings, it can be clearly observed that the objective of the paper has been achieved using the two techniques of analysis.

5.0 Conclusion and policy Recommendations

This paper investigates the adoption and impact of agricultural technology innovations with reference to Gombe metropolis. Adoption of agricultural innovations has been observed to a way of boosting agricultural productivity and enhancing farmer's income. As found in the study area, more than fifty percent of the respondents apply different forms of agricultural innovations. The Chi-square results also depict that adoption of such agricultural technology innovations boost agricultural output and improve the income of the farmers. However, the logistic regression model consists of ten explanatory variables out of these only one variable (education of the farmers) was found to be statistically significant at 5%. Based on the above findings, the paper makes the following recommendations:

i. It is recommended that government and other stakeholders should organize training, workshops and seminars on the new technologies to enable farmers understand their full benefits before they can fully adopt them. This will foster a transition from subsistence to commercial farming, thereby increasing agricultural productivity and socio-economic development of the area.

ii. The government at all levels should subsidize the cost of those technological inputs to enable low-income farmers to afford it. Finally, it is recommended that educational level of the farmers should be encouraged.

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