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Does the Adoption of Genetically Modified Seeds Improve the Technical Efficiency of Family-Owned Maize Farms? A Case of Alfred Nzo in the Eastern Cape

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ABSTRACT

This study mainly focused on measuring maize farmers' technical efficiency and impact on maize production in Eastern Cape province. This research has employed a formal survey conducted on a sample size of 164 farmers. Data was collected using a semi-structured questionnaire. Mean, standard deviation, frequencies and percentages were used for descriptive statistics to examine the socioeconomic characteristics of family-owned maize farms. The stochastic frontier model was also used to estimate the technical efficiency of family-owned maize farms under present conditions. The results have shown that the socioeconomic characteristics of farmers largely influence accessibility and awareness to these kinds of technologies. The adoption is delayed due to limited farmer support, lack of awareness, scepticism about these technologies within rural households, and poor perceptions and attitudes. Furthermore, the results have revealed that socio-demographic characteristics influence farmers' decisions on whether or not to adopt the technology. Most farmers are old and still believe in what works for them, which limits and elongates the adoption process. The empirical analysis shows that adopting genetically modified seeds enhances the productivity of family-owned farms. Furthermore, this study finds that the technical efficiency of adopters is higher compared to non-adopters. Therefore, this study recommends that strategic alliance is an important and necessary condition for farmers to adopt genetically modified technologies.

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1. INTRODUCTION

In South Africa, maize is a significant food crop grown primarily for human and animal consumption. It is also the largest locally produced agronomic crop. The agricultural sector significantly depends on agricultural production to sustain their standard of life in South [4]Africa and other African nations (Mabaya *et al.,* 2015). However, Yokamo (2020) and Zanu *et al.* (2012) asserted that smallholder farmers only grow maize to feed themselves and the livestock they are raising, and they solely produce maize primarily to improve their household's standard of living and to maintain their household's livelihood.

The district's primary economic activity is agriculture; however, it has little potential for growth because most farming methods are strictly traditional subsistence farming (Fadeyi *et al.,* 2022). Having that confirmed, some common obstacles smallholder maize farmers face include access to production inputs, advanced technology, limited access to technology and resistant maize seeds, extension and advisory services, and stable markets (Tarus, 2019).

Insufficient agricultural value chain operations are closely related to maize producers in the Eastern Cape (Dos *et al.,* 2003). Small-scale farmers are primarily involved in the primary production of agricultural products and are increasingly distancing themselves from all activities involved in agricultural product value addition. As a result of inadequate farm technology use, it is challenging to satisfy domestic or local market demands. Adoption of genetically modified seeds can benefit family-owned farmers' maize production by increasing their yields and sustaining their maize production, which reduces poverty and fosters economic growth and development in the district and at the provincial level.

2. DEFINITION OF THE PROBLEM

Household food production is argued to remain crucial for sustainable food security and poverty alleviation strategy for many households in many developing countries. Parts of South Africa are evidence of that stabilised food production strategy, but a need to adopt genetically modified seeds by these family-owned maize farmers challenges its success. However, to overcome challenges nullifying the idea of adopting genetically modified seeds by family-owned maize farmers, collective action is necessary as the formation of cooperatives to such an extent that acquiring resources can easily be attained by these farmers. The main goal of encouraging maize farmers to form groups for cooperative farming is to recognise the value of working together to increase farm productivity and profitability.

In addition to being the main economic activity and a sector that feeds the world, agriculture supports many households, which helps ensure household food security. Fresh evolution is kicking in more strongly within the agricultural sector, with maize crops being a widely produced agricultural product in various locations and corners of South Africa. Securing farming supplies, machinery, inputs, and resources is a component. However, some issues prevent farmers from expanding agricultural output because of limited or improper technology adoption and use. Issues like inadequate infrastructure development and a lack of funding destroy the idea of household food sustainability. These elements contribute to low farm profitability, resulting in inadequate income generation and hinder farmer growth. By bringing new farming knowledge that links farmers to innovation and technology, nations worldwide are competing to modernise agriculture (Sahgal, 2021). However, several regions of South Africa continue to produce the least quantity of maize, especially in the province of the Eastern Cape (Statista, 2022).

Hence, conducting this study is of paramount importance, with that being the case this study seeks to improve and encourage family-owned maize farmers to adopt genetically modified seeds in the study area.

3. LITERATURE REVIEW

3.1. Overview of Maize Production in South Africa

The agricultural sector worldwide is the most viable sector with the potential to feed its population. Maize is a staple crop, primarily produced in many parts of the world, that conforms to adaptability to weather conditions. According to Benz (2001), maize or corn is a cereal grain first domesticated by indigenous people in Southern Mexico about 10000 years ago. Maize has become a staple food massively produced worldwide, consumed directly by humans, and used as animal feed. Other countries preferably and broadly use maize products to produce other by-products through undergoing value chain processes such as corn ethanol. Varieties of maize are produced at an international level and undergo different stages of agricultural value chain activities whereby production, processing and other value chain activities occur. In other countries, maize is not only consumed by people and animals; as far as maize is concerned, it also produces environmentally friendly maize products such as ethanol and other biofuels. However, maize production was strictly traditional back then in most African countries and other international countries. Nowadays, industrialisation and evolution are taking place; new information is inventing new ways of production, including advanced technology usage.

Moreover, the cultivation of maize is relatively supported by massive investment in technology, and farmers are called upon to adopt new technologies and innovations. Back then, maize cultivation was achieved through simple and traditional knowledge of indigenous knowledge systems that do not require technology. Hence, the government and other policy structuring bodies ve developed policy intervention strategies that will improve maize production for economic growth in a manner that will improve poor rural farmers by generating income through acting as an employer.

3.1.1. Attributes of Family-Owned Farms in the Eastern Cape

Formation of agricultural cooperatives has been widely promoted as an agricultural development policy initiative to assist farmers in coping with the challenges that arise in the production process, such as access to proper technology, proper storage facilities, availability of resources, limited access to production inputs, output markets, availability of credit facilities, and inadequate extension services. According to Wossen et al. (2017), there is well-documented empirical evidence on the roles of agricultural cooperatives in enhancing the adoption of improved agricultural technologies and involvement in agribusiness practices. Abebaw and Haile (2013) have asserted that if cooperative or group farmers are not supported by the provision of adequate extension services, resource availability, accessibility to reliable markets, investment in technology, and improved infrastructure, the idea of forming a cooperative is most likely to go into the drain with no desired objectives that are met.

3.1.2. Lack of Farming Resources

Acquiring farming resources has become the constraint limiting maize cooperative farmers from outperforming; hence, that is the priority that government institutions and other non-governmental organisations are focusing on, which is trying to put equitable measures in helping farmers acquire the required farming resources on their respective farms. A sudden decline in agricultural production contributes to poverty and food insecurity; hence, the government has introduced an Economic Recovery Plan (ERP) to enhance the agricultural sectors and its players. One of the critical factors in achieving and bridging the gap of poor accessibility to farming resources is to make it environmentally suitable.

3.1.3. Incompetent Family Members

According to the National Development Plan (NDP), agricultural cooperatives can effectively handle rural farmers' challenges by addressing concerns like food insecurity, poverty, and easy access to resources. According to Sabir et al. (2012), cooperatives can address all the concerns at once by obtaining economies of scale, adopting innovations and technology, and involving communities in agricultural development. Incompetent cooperative members sabotage the entire concept of group farming and the easy acquisition of farming resources such as land, equipment, and machinery and access to agricultural consultancy services. Because the costs are regulated and shared among the members, all the above benefits are readily available when farmers pool their resources.

3.1.4. Lack of Agricultural Capital

Inadequate agricultural capital remains one of the challenges tempering the farming progress of many farmers; availability of capital can positively contribute to increased economic growth, rural development, and improved farm income. According to the study conducted by Huger (2016), lack of capital poses a major barrier to technology adoption by cooperative members.

3.1.5. Aging Population

According to Hu and Zlong (2012), the agricultural sector is predominantly controlled by elderly people. Several obstacles, such as hampering farming activities and an ageing workforce, have a detrimental influence on the sector. According to Bates et al. (202)), older workers are less productive on average, and labour force ageing negatively influences output productivity. According to a study conducted by Li and Zhao (2009), the ageing of the agricultural labour force is detrimental to the total development of agricultural productivity. Youth are said to be distancing themselves from farming activities because of this literature; farming is becoming more commercialised due to this new information and dissemination of advanced farming techniques and technologies, and older people are finding it difficult to adapt

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to this new change. As a result, the need for rural youth to be included in the farming sector is critical and can be helpful to the overall industry.

3.2. Determinants of Technology Adoption by Smallholder Farmers

Smallholder farming is essential for enhancing food security and reducing hunger, although smallholder farmers tend to use technology sparingly. Farm household characteristics and institutional features are two elements that affect how smallholder farmers adopt new technologies. Technology adoption is governed by several factors, with farmer choice being the primary one, according to Mwangi and Kariuki (2015). Introducing a particular technology does not ensure acceptance of the technology (Mwangi & Kariuki, 2015). Farmers can take their time adopting a specific technology, which is hampered by their ability to do so. As a result, affordability or the farmers' economic standing impacts their acceptance, and farmer perception of new technology is a key requirement for adoption.

However, other variables linked to agricultural technology adoption include institutional, technological, and human-specific economic variables (Fadeyi et al., 2022). A large farm size may favour adopting a particular technology, according to Anang (2018), who identified the farm as one of the factors determining technology adoption. Most research has used a farmer's degree of education, age, gender, and household size to evaluate their use of technology (Anang, 2018).

3.3. The Impact of Technology Adoption on Technical Efficiency of Family-Owned Maize Farms

The fundamental goal of technology adoption is to increase farm earnings while also meeting the needs of customers who sustainably consume agricultural products. Farming practices are key in ensuring long-term agricultural output by boosting global crop yields to fulfil increased demand for agricultural food due to rising income and alarming population growth. Modern technology is critical to the development of the farming industry, improving food production, and providing farmers with new tools to raise crop yield. In addition, technology is utilised to preserve crops and identify diseases that threaten crops. According to Singh (2014), the employment of modern technology in agriculture has resulted in significant improvements and has had a favourable impact on how people farm and raise food or agricultural products. As a result, agriculture positively impacts a country's GDP and GNP by creating and conserving foreign exchange, reducing import costs, increasing agricultural productivity, and improving farmers' living conditions (Rambe & Khaola, 2021).

4. MATERIAL AND METHODOLOGY

4.1. The Study Area's Description

This study was undertaken in the Eastern Cape's Alfred Nzo District. Umzimvubu and Ntabankulu local municipalities have been chosen to host the study. Alfred Nzo district is one of the nine districts in the Eastern Cape situated on the north-eastern side of the Province of the Eastern Cape and stretches from the Drakensberg Mountains, borders Lesotho in the North, Sisonke District Municipality in the East and O.R. Tambo District Municipality in the South. Agriculture is the main economic activity in the Alfred Nzo district; it has been elucidated that the district has a limited base for financial expansion and agricultural growth since most of the farming is traditional subsistence farming. Commercial agriculture is confined to the area of Cedarville in the northeast of the district. The district contains favourable and conducive weather conditions for the aggressive development of the agricultural sector, and it is very critical to evaluate the potential of agriculture and devise methods of exploiting the untapped agricultural potential. With that information, the district has also been selected as one of the regions to undertake the implementation of Agri park initiatives, as one of the 27 poorest district municipalities in the country (IDP, 2017-2022). Furthermore, all such initiatives were directly in line with the agricultural policy plan and the district grain production master plan, which aimed to increase production levels within the agricultural sector. Hence, the study has developed an interest within the district to call for an urgent agriculture strategy to unlock the sector's hidden potential, particularly in maize production, to revive agriculture and improve farm profitability through a sustainable agricultural value chain supported by technology use.

4.2. Research Approach, Sampling Techniques and Research Design

The main aim of this study is to measure the adoption of genetically modified seeds on the technical efficiency of family-owned maize farmers in the Alfred Nzo district. This study will adopt a mixed-method research approach using both quantitative and qualitative methods to understand better the research problem than using one method. Using mixed research methods is appropriate to address the purposes of the study (Tashakkori & Teddlie, 2021). According to Creswell (1994), the weakness of one research method is nullified by the strength of another research method. Quantitative data will be obtained by administering semi-structured questionnaires, and qualitative data will be obtained through focus group discussions, the internet, and structured interviews.

4.3. Sample Size

According to Dell (2002), sampling is a technique used to select units in each population of interest, and the results obtained can be used to generalise the sampled population. The population in this study is heterogeneous; hence, the sample size will be determined using a suggested formula by Krejcie and Morgan (1970). For a mixed research method, Bell et al. (2010) suggested a rule of thumb, whereas other scholars opined that a sample size between 30 and 500 is suitable for quantitative and qualitative research. Furthermore, a sample size will be obtained from maize farmers in the Alfred Nzo district. This population sampling method is to categorise the two selected municipalities into strata, in which random sampling is applied to select respondents from each stratum. The following formula is used in sampling the size of the respondents:

Where:

n = sample size

X

2= Chi-square value at 95 percent confidence level with 1 degree of freedom (3.84)

N = Population size

P = Population proportion (0.96 percent)

$$n = \frac{X^2 * N * P\ (1-P)}{ME^2 * (N-1) + (X^2 P * (1-P))}$$

Where:

n = sample size

X^2= Chi-square value at 95 percent confidence level with 1 degree of freedom is 3.84

N = Population size

P = Population proportion (0.96 percent)

ME = desired margin of error express as a proportion (0,05)

Taken from the formular above:

$$n = \frac{3{,}84 * 210 * 0{,}96\ (1-0{,}05)}{0{,}05^2 * (210-1) + (3{,}84 * 0{,}96 * (1-0{,}5))}$$

n = 164

4.4. Research Design

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This study will use a descriptive research design, which is used for collecting and describing data, examining the relationships between variables, and producing models that are appropriate for the study objectives (Creswell, 1994). This study will use surveys, semi-structured questionnaires, and focus group discussions to gather quantitative and qualitative data on the estimation of technology adoption and technical efficiency on family-owned maize farms in the Eastern Cape.

TABLE 1: Table Depicting the Research Design Strategies Being Used

Research strategy	The type of research questions	Requires behavioural events to be under control	Focuses on contemporary events
Experimental research	Who, What, Where, How many	No	Yes/No
Case study	How, why	No	Yes
Interview and Archival analysis	Are, why	No	No

Source: Adopted from Yin (2014)

4.5. Method of Data Collection

To fulfill this study, a structured questionnaire was designed and administered within the area under study. The study questionnaire mainly contained open-ended and closed-ended questions written in English. This study allowed participants to elaborate and support their answers without fear, as it employed explanatory research. Even though the questions were written in English, interpretation occurred where necessary in IsiXhosa and Isimpondo as the local languages.

This study relied on both primary data and secondary data. This study ensured that the sampling techniques were followed and that the data collection process was successfully and lawfully processed, ensuring that the information of participants complied with the Protection of

Personal Information Act. The presidency has asserted the POPI Act. Personal information must be processed and acquired.

- Lawfully, and
- In a reasonable manner that does not infringe on the data subject's privacy.

4.6. Method of Data Analysis

Primary data collected from family-owned maize farmers was coded, edited and verified accordingly. Field data was edited to examine those minor mistakes. Data editing and cleaning were done to ensure data accuracy and consistency with other facts gathered, uniformly entered as completely as possible, and arranged in an orderly manner to facilitate coding and tabulation (Kenny, 1998).

The data collected was analysed using different software suitable for data analysis. Therefore, after collecting and gathering data, it was coded and captured in a spreadsheet in Microsoft Excel and exported to SPSS software using various statistical tests and econometric models.

4.6.1. Socioeconomic Characteristics

This study has employed descriptive statistics as an analytical tool for the socioeconomic characteristics of family-owned maize farmers. Descriptive statistics summarise a given data set, representing a sampled population for this study. Descriptive statistics, such as frequencies and percentages, were used to describe the data from the participants.

4.6.2. Stochastic Frontier Model

Measurement of technical efficiency compares the actual performance to the optimum performance or the true frontier. Empirically, the true frontier is unknown; hence, the best practice farmer is used mostly as a proxy for the true frontier. This study will employ the stochastic frontier approach to estimate the technical efficiency of family-owned maize farms under present conditions. The selection of the stochastic frontier approach is based on its ability to account for stochastic noise and the producer's inefficiency simultaneously.

The stochastic frontier production model that Battese and Coelli (1995) propounded in line with the original model by Aligner, Lovell, and Schmidt (1977) is implicitly defined as:

Y_i = f (X_i, β_i) exp ($V_1 - U_1$), I = 1,2,3,n……………………………………………..

Where:

Y_i = output of the maize farms

X_i = vector of input quantities used by the maize farms

β_i = vector of the unknown parameters to be estimated

f_i = represents an appropriate function

V_i = is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer.

U_i = is a non-negative random variable representing inefficiency in production relative to the stochastic frontier.

Specifically, the production (technical efficiency) of a family-owned maize farms will be estimated using Cobb-Douglas production functional form of the stochastic frontier production function model defined as follows:

$L_nY_i = \beta_0 + \beta_1 L_nX_1 + \beta_2 L_nX_2 + \beta_3 L_nX_3 + \beta_4 L_nX_4 + \beta_5 L_nX_5 + \ldots \ldots \beta_n L_nX_n + (V_i - U_i)$

Where:

Y_i = maize output (kilograms/tons)

X_1 = farm size (hectares)

X_2 = labour input (workdays)

X_3 = Maize seeds (kilograms)

X_4 = Fertiliser used (kilograms)

X_5 =Capital input (Rands), measured in terms of depreciation of farm tools or inputs, equipment, interest on borrowed capital, repairs and rent on land.

$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_n$ are the regression parameters to be estimated, and V_1 and U_1 are defined.

It is also assumed that U_i are to be non-negative random variables, independently distributed and arising from the truncation at zero of the normal distribution with variance σ^2 and mean $Z_i\delta_i$ where Z_i is the vector variables which are assumed to explain technical inefficiency, and δ is a vector of the coefficients to be estimated.

TE = Y^*

Y^* = f (X,B) exp (V_i-U_i)

But f (X,B) exp (V_i) = exp (-U_i)

Where:

Y_i is the observed output

Y^* is the frontier output

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TE = $\partial_0 + \partial_1 Z_1 + \partial_2 Z_2 + \partial_3 Z_3 + \partial_4 Z_4 + \partial_5 Z_5 + \ldots\ldots\ldots \partial_n Z_n$

Where:

TE = is the technical efficiency of the farmer

Z_1 = Household/family income

Z_2 = Household/family size

Z_3 = Cooperative membership

Z_4 = Extension-contact

Z_5 = Farm experience

Z_6 = Educational level

Z_7 = Credit access

Z_8 = Gender of farmer

Z_9 = Market access

Z_{10} = Use of fertiliser and seeds

Z_{11} = Usage of manure

Z_{12} = Use of pesticides

Z_{13} = Cooperative membership

Z_{14} = access to new maize implements

∂_0 = unit of intercept

$\partial_1 \ldots\ldots\ldots\ldots\ldots \partial_{12}$ = Parameters to be estimated

5. RESULTS AND DISCUSSIONS

5.1. Demographics and Socioeconomic Characteristics of the Sampled Maize Farmers

The demographic characteristics of farmers are indispensable when analysing economic data because such factors influence farmers' or homesteads' economic behaviour. Demographic characteristics and socio-cultural contexts are important variables as they illustrate the key factors in the socioeconomic analysis of smallholder systems. Table 2 below illustrates the farmer's profile and characteristics in the study area.

5.1.1. Demographic and Socioeconomic Characteristics of Farmers

TABLE 1: Descriptive Statistics

Variable	Mean	Standard deviation
Age	60.702	12.336

Level of education	7.322	4.685
Farming experience	11.049	10.997
Household size	4.602	2.460
Capital investment	602	72.53
Variable	**Frequency**	**Percentage**
Gender:		
Male	105	64
Female	59	36

The results showed that most farming households were headed by men, with a share of 64%, compared to 36% of females. These results are consistent with Kibirige *et al. (2016), who state* that men dominate farming in the province, as women care for the family and household chores. Additionally, the average age of the household head amongst smallholder farmers was 60 years, which implies that elderly persons in the study area dominate farming.

The evidence above shows that the level of education also contributes as a cofactor to farmer's ability and in decision-making in whether to adopt or not adopt genetically modified maize seeds; the results showed that the level of education of these farmers has a mean of 7.322, which is a true reflection that most farmers are not literate and being aware alone does not guarantee adoption of technologies of this nature. The level of education attained by a farmer is crucial in understanding the farming dynamics and changes over time within the farming sector; all these play a crucial role in adopting new technologies. Also, the level of education is expected to enhance efficiency. Education contributes to the knowledge farmers acquire, which they can effectively use in their farming operations. Furthermore, the farmer experience has a mean of 11.049, which indicates that these farmers have more experience in farming and know what works best for them. However, innovation to them threatens what they already know, and no one can convince them better than what they know.

In this study, household size was also considered as the number of persons residing with the participants or respondents; the mean household size between the respondents was 4.602. The household size does not indicate the quantity of labour available for households to rely on because it involves every household member. Capital investment also plays a fundamental role in the adoption of new technologies; the results shown in Table 2 have revealed a mean of 602

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for capital invested, which indicates little investment by these farmers in farming as their income status is not stable due to most of the farmers who rely on old age grant.

5.2. Technical Efficiencies of Adopters and Non-Adopters

TABLE 2: Stochastic Frontier Model Results

SPF model	Pooled		Adopters		Non-adopters		Test of means
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Unmatched							
Conventional SPF (pooled)	0.561	0.153	0.572	0.132	0.553	0.152	1.043
Conventional SPF (separate)			0.665	0.122	0.558	0.152	10.780***
Selectivity-corrected SPF			0.738	0.082	0.602	0.116	15.082***
Matched							
Conventional SPF (pooled)	0.577	0.155	0.586	0.137	0.570	0.172	0.874
Conventional SPF (separate)			0.665	0.122	0.547	0.170	8.580***
Selectivity-corrected SPF			0.702	0.112	0.556	0.148	9.823***

The table above compares technical efficiency levels generated through the SPF model. The mean difference of TE levels is not statistically significant in the estimation with pooled samples for both the matched and unmatched. Since it has been observed that the production frontier for each group is different through the likelihood ratio test, the comparison of separate estimations between the two groups is more reliable.

The results of all separate estimations suggest that adopters' average TE is higher than that of non-adopters. In the case where unmatched samples are used, the average TE of adopters is 0.665 in the conventional SPF model, higher by 24% than non-adopters.

5.3. Factors Influencing the Adoption

Numerous factors influence rates of technological adoption; these factors are the ones that determine whether a farmer can act decisively upon the innovation or technology being introduced to them. With all that being said, a particular technology's diffusion and adoption processes depend on the effectiveness of extension work and how information spreads and reaches the farmers. Even so, appropriate extension methods are the ones that speed up the process of adoption, as farmers are known to adopt technologies and innovations at different levels.

5.3.1. Socioeconomic Characteristics of Farmers

Any adopter incurs a cost in enquiring about a new technology or innovation, and the socioeconomic status of a farmer determines whether a farmer can afford and attain a particular technology. Financial stability in as much as gives hope that a farmer can acquire technology, but it does not guarantee adoption.

5.3.2. Social System

A social system can assist the diffusion of new technology or innovation, but only if the social system is open and when that particular technology does not conflict with the norms and beliefs of the society. Results have shown that the average age of farmers was 60 years and above, which implies that cultural and traditional beliefs bond these farmers; hence, the adoption rate is more likely to be slowed down and delayed due to the nature of these farmers.

5.3.3. Farmer's View on the Nature of the New Farming Technology

As indicated by the demographical characteristics of these farmers, farmers' views about the nature of the technology or innovation play a role in farmers' decisions to adopt or reject a particular technology. In this case, farmers are old, and most are laggards; they believe in what they believe in, and information dissemination and diffusion to them is regarded as a way of spreading information that the farmer considers unhelpful. Sampled farmers believed in what worked best for them.

6. CONCLUSION AND RECOMMENDATION

Therefore, discovering that accessibility and awareness are primarily influenced by the socioeconomic characteristics of farmers, and the adoption of technologies of this nature is being delayed due to issues of limited farmer support, lack of awareness, scepticism about these technologies within the rural households, perception, and attitudes towards these technologies. Furthermore, the results have revealed that socio-demographic characteristics influence farmers' decisions on whether or not to adopt the technology. Most farmers are old and still believe in what works for them, which limits and elongates the adoption process. However, considering all these factors, appropriate extension services and sustainable and improved maize production practices can significantly increase the adoption rate of genetically modified seeds and other technologies to improve farmer's decisions and change perspectives towards these technologies in improving maize yields.

This study recommends that the adoption of specific technology must be accompanied by support; many factors must be considered when introducing a certain technology to farmers. For instance, the gap between smallholders and commercial farmers will always exist. In cases of peasant farmers or disadvantaged farmers, proper evaluation and assessment are needed in a manner that if there is a need for certain farmers to acquire or adopt an introduced technology, the farmer needs to be evaluated and considered as a special case.

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8. CONFLICT OF INTEREST

The authors have no conflict of interest.

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