Vol. 52 No. 4, 2024: 185-206
https://doi.org/10.17159/2413-3221/2024/v52n4a18423

Institutional Factors Affecting Smallholder Farmers' Decision to Adopt Climate Change Adaptation Strategies: Evidence from Raymond Mhlaba Local Municipality Eastern Cape, South Africa

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ABSTRACT

In recent years, adaptation to climate change has become a global focus; therefore, the present study was conducted in Raymond Mhlaba Local Municipality to understand the adaptation strategies employed by smallholder farmers to the adverse impact of climate change and to examine the extent to which institutional factors play a role in farmers' decisions to adapt to climate change. Using a multistage research design, data were collected from 120 smallholder farmers by administering a pre-tested questionnaire with both open- and closed-ended questions. The collected data were analysed using descriptive statistics and a binary logistic regression model. The results revealed that farmers employed crop diversification, crop rotation, calendar redefinition, resilient crop varieties, and tree planting as adaptation strategies in response to climate change. The binary logistic regression model results indicated that access to extension services, climate change information, and farmers' organisations influenced farmers' decisions to

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adopt climate change adaptation strategies. Policymakers should focus on enhancing rural institutional services and increasing climate change education to improve smallholder farmers' capacity in a changing climate.

Keywords: Climate Change, Institutional Factors, Binary Logistics, Smallholder Farmers

1. INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) (2014) has widely recognised climate change as one of the biggest challenges in modern society. Scientific evidence indicates climate change is a global phenomenon characterised by increased temperature because of the increasing greenhouse gas emissions (Landicho *et al*., 2023; Belay *et al*., 2017; Pachauri *et al*., 2014). According to IPCC (2014), the global mean surface temperature changes for the period 2016 to 2035 is similar to the period of 1986 to 2005, will likely be in the range of 0.3 to 0.7 degrees Celsius but is projected to likely exceed 1.5 degrees Celsius by the end of the twenty-first century (IPCC, 2013). A study by Pereira *et al*. (2014) noted that climate change results in low agricultural production and increased food insecurity, while Nwachuku and Shisanya (2017) predicted climate change could significantly decrease agricultural productivity in Africa. Furthermore, the literature points out the vulnerability of the agricultural sector, particularly the smallholder farmers, to climate change impacts (Landicho *et al*., 2016; Evangelista *et al*., 2013; Morton, 2007). These impacts include a decline in crop yield, increased use of farm inputs, a decline in farm income (Landicho *et al*., 2015), and food security after extreme weather events (Harvey *et al*., 2018). Jha and Gupta (2016) noted the importance of adaptation as a critical and practical strategy for climate change impact, and it becomes imperative for all stakeholders involved in food production to understand the various factors that shape farmers' decisions to adapt to climate change. Support provided by national and international institutions to reduce the impacts of climate change has been found to positively influence farmers' adaptation (Comoé & Siegristet, 2015). A study conducted by Bryan *et al*. (2009) on climate change in South Africa and Ethiopia revealed that factors influencing farmers' decision to adapt to climate change were access to climate information, extension services, and credit. Nguyen *et al*. (2016) stated that to achieve climate change

Vol. 52 No. 4, 2024: 185-206
https://doi.org/10.17159/2413-3221/2024/v52n4a18423

adaptation, there is a need to have an in-depth understanding of different factors that shape farmers' agricultural practices and their adaptive responses to stimuli.

Climate change has been proven to negatively impact agricultural productivity, and agricultural production is highly sensitive to climate change due to its high reliance on climate variables such as rainfall, humidity, temperature, and wind speed (Belay *et al*., 2017). Moreover, climate change continues to threaten global economic development and may impact different aspects of domestic life, such as agricultural productivity and food security. Additionally, Sub-Saharan African countries, such as South Africa, have suffered seasonal and yearly unpredictability in rainfall and temperature in recent years, resulting in several adverse effects on the agricultural sector's sustainability (Sousa *et al*., 2018). Sustaining rural households' food security in the face of climate change becomes a critical challenge, as climate change poses a terrible danger to rural areas where agricultural production is primarily practised by smallholder farmers who heavily depend on rainfall for water (Ogundeji 2022; Shisanya & Mafongoya, 2016). Dependence on rainwater is difficult for smallholder farmers because South Africa is viewed as a water-scarce country, reducing agricultural production and contributing to food security (Adetoro *et al*., 2020).

Agriculture is one of the most climate-sensitive sectors directly affected by physical and chemical changes (Mitter *et al*., 2019). In South Africa, agriculture remains an important economic sector, provides employment, especially in rural areas, and is a primary source of foreign exchange. However, climate change and variability have negatively affected agricultural production, especially for smallholder farmers. According to Tomlinson and Rhiney (2018), smallholder farmers face numerous challenges, such as drought, temperature increase, pasture deterioration, increased parasites and diseases, and low production. In the face of climate change, smallholder farmers in developing countries like South Africa are particularly vulnerable due to their reliance on agriculture.

Furthermore, smallholder farmers are particularly vulnerable to climate change due to their reliance on rain-fed agriculture, insufficient access to land, high poverty and poor education levels, limited access to extension training, and lack of financial support to adopt adaptive measures (Harvey *et al*., 2018; Morton, 2007). Climate change poses a significant threat to the sustainability of agriculture production among smallholder farmers in South Africa. To reduce the adverse impact of climate change, smallholder farmers have sought to adopt different adaptation strategies. Fadina and Barjolle (2018) noted that farmers should respond to climate change through various adaptation measures to boost agricultural productivity and improve their livelihoods. Silici *et al*. (2021) highlighted the crucial role of agriculture in the economy and its vulnerability to climate change impacts, with the need to invest in measures that would build and enhance smallholder farmers' adaptive capacity and resilience. To mitigate these challenges, farmers are expected to modify their agricultural practices to align their production methods with the increasing challenges of climate change, which directly affects agricultural activities (FAO, 2010).

Additionally, involvement in non-farm income activities has significantly increased the adoption of climate change adaptation strategies among smallholder farmers (Ojo & Baiyegunhi, 2020). Furthermore, studies have highlighted the importance of smallholder farmers' awareness of climate change impact and their ability to identify relevant coping and adaptation strategies (Yahaya, 2024; Addis & Abirdew, 2021; Kom *et al*., 2019). Recognising climate change and implementing appropriate adaptation interventions are essential for smallholder farmers to effectively cope with climate change challenges (Mekonnen & Kassa, 2019).

Moreover, the availability of easily accessible and reliable climate change information, often acquired through indigenous and local knowledge, plays a significant role in smallholder farmers' decision-making process for climate adaptation (Zvobgo *et al*., 2023). Several institutional factors can influence smallholder farmers' decision to adopt climate change adaptation strategies (Amenuvor, 2019). Furthermore, institutional factors influence smallholder farmers' decisions to adopt climate change adaptation strategies. In Sub-Saharan Africa, climate change decreased yield, caused crop failures, diminished quality, and heightened diseases and pests, rendering vegetable production financially unviable (Abewoy, 2018). According to Partey *et al*. (2018), limited attention is given to issues relating to adopting concepts or agricultural practices that tackle climate change, specifically in small-scale agriculture. It is against this background that this study attempts to fill the gap by investigating the institutional factors that influence smallholder farmers' decision to adopt climate change adaptation strategies and what are the climate change adaptation strategies

Vol. 52 No. 4, 2024: 185-206
https://doi.org/10.17159/2413-3221/2024/v52n4a18423

used by smallholder farmers in Raymond Mhlaba Local Municipality (RMLM) in the Eastern Cape Province of South Africa.

2. METHODOLOGY

2.1. Study Area

The study was conducted in Raymond Mhlaba Local Municipality (RMLM) (see Figure 1); the municipality is located in Amathole District Municipality in Eastern Cape Province of South Africa and is the largest local municipality in Amathole District with a total area of 6 357 km2 (Municipalities of South Africa, 2021). The RMLM is a rural municipality whose economy is primarily driven by the agricultural sector (Mtyelwa *et al*., 2022). The study area was chosen because it is predominantly rural, with most households farming. It is one of the areas most affected by climate change due to low rainfall and high temperatures (Household Community Survey, 2016). Moreover, insufficient literature analyses institutional factors influencing smallholder farmers to adapt to climate change strategies.

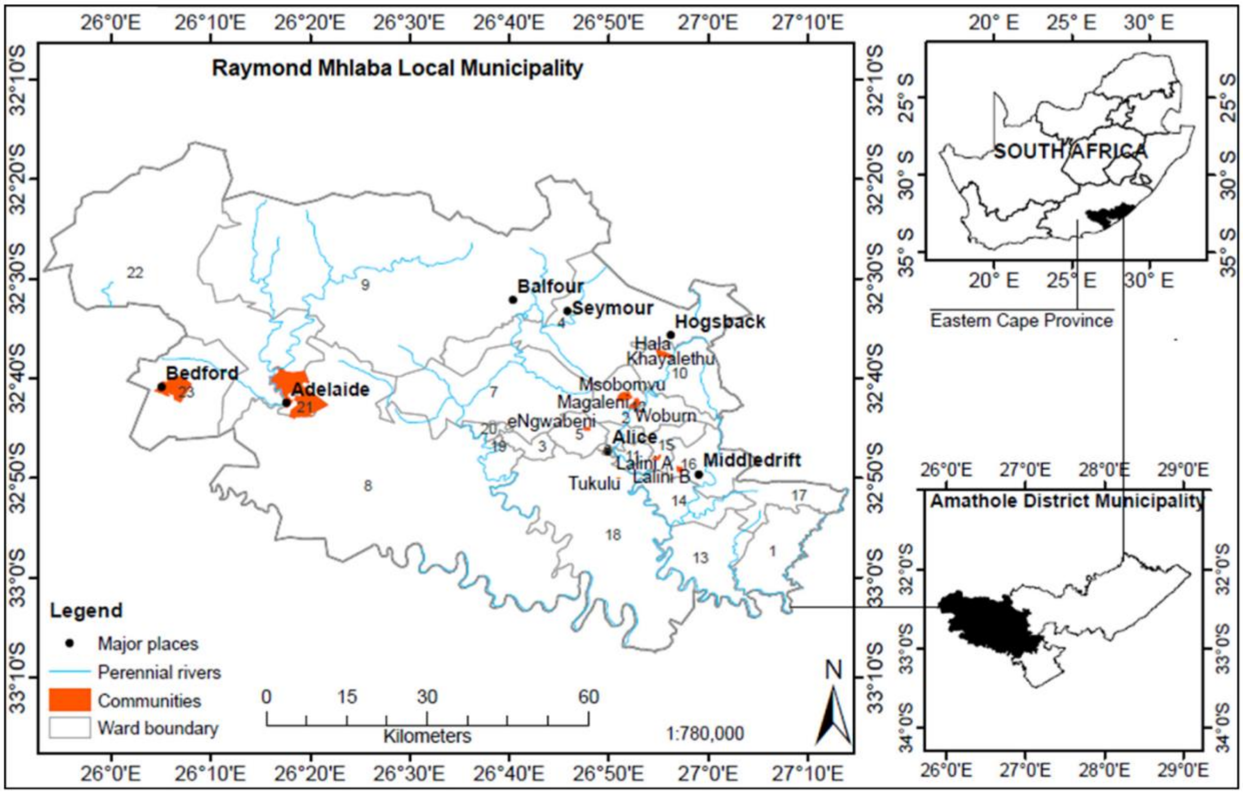

FIGURE 1: Raymond Mhlaba Local Municipality (Source: Mdiya *et al*., 2023)

2.2. Sampling Procedure and Data Collection

The study used a multistage stratified random sampling procedure, where a combination of purposive and random sampling procedures was used to identify and select smallholder farmers in the study area. A semi-structured pre-coded questionnaire was used to collect data from one hundred and twenty smallholder farmers in Raymond Mhlaba Local Municipality (RMLM). This was done to explore the adaptation strategies used by smallholder farmers for the effects of climate change and the institutional factors that influence the selection of those strategies in the study area. To estimate the appropriate sample size for analysis, the study used the Yamane formula (1967) as shown below:

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

where *n*: sample size, *N*: total population (1836 households), *e*: marginal error (10%) was used to determine the study sample size $n = \frac{1836}{1+(1836*0.01)2}$ = 120. Therefore, 120 smallholder farmers were sampled.

The local language, isiXhosa, was used for effective communication for the survey, focus group discussions, and informative interviews. Enumerators fluent in the local language and knowledgeable of the local tradition were recruited and trained before conducting the survey. The study employed qualitative and quantitative data collection methods, as Neuuma (2015) recommended. The data was coded on Microsoft Excel and analysed using descriptive statistics such as frequencies, figures, and tables. The Binary Logistic Regression Model (BLRM) was employed in the STATA 14.2 version. According to Muzamhindo (2015), the binary logit model is appropriate because it considers the nexus between a binary dependent variable and a set of explanatory variables.

2.3. Analytical Framework

To identify the institutional variables that affect farmers' decisions to adapt to climate change strategies, the Binary Logistic Regression Model (BLRM) was used. When predicting the presence or absence of a characteristic or outcome based on the values of a group of predictor variables is necessary, BLRM is thought to be helpful (Norusis, 2004). Like a linear regression model, the BLRM is appropriate for models with dichotomous dependent variables, such as the one used in this study. For each model's independent variable, odd ratios were estimated using BLRM coefficients. According to Norusis (2004), the following link function describes how the dependent variable Z and the likelihood of the relevant event are related in the BLRM:

$$\pi_i = \frac{e^{Zi}}{1+e^{Zi}} = \frac{1}{1+e^{Zi}} = \frac{1}{1+e^{-Zi}} \quad (1)$$

or,

$$\mathcal{Z}_i = log\left(\frac{\pi_i}{1-\pi_i}\right) \quad (2)$$

Where, π_i = probability of the i^{th} case; $\mathcal{Z}_i$ = value of the independent variable for the i^{th} case. The model assumes that Z is linearly related to the predictors. Thus,

$$\mathcal{Z}_i = b_0 + b_1X_{i1} + b_2X_{i2} + \ldots + b_pX_{ip} \quad (3)$$

Where, X_{ij} = predictor for the j^{th} case; b_j = j^{th} coefficient and p = number of predictors. Since Z is unobservable, the predictors are related to the probability of interest by substituting Z in Equation 1.

$$\pi_i = \frac{e^{Zi}}{1+e^{Zi}} = \frac{1}{1+e^{Zi}} = \frac{1}{1+e^{-(b_0 + b_1 X_{i1} + b_2 X_{i2} + \ldots + b_p X_{ip})}} \quad (4)$$

In the regression context, it is assumed that there is a set of predictor variables, $X_1, \ldots X_n$ that are related to Y and, therefore, provide additional information for predicting Y (Greene, 2003).

$$Logit\ (P_i) = ln\ (P_i/1 - P_i) = \alpha + \beta_1 X_1 + \ldots + \beta_n X_n + u_i \quad (5)$$

Where, *ln* $(P_i/1 - P_i)$ = logit for farmers' decision to adapt to climate change adoption strategies *(Yes or No);* P_i = *Yes; 1 –* P_i*) = No*; β = coefficient; X_1 = covariates; u_i = error term.

When the variables are fitted into the model in Equation 5, the model is presented as:

$$ln\ (P_i/1 - P_i) = \alpha + \beta_1 X_1 + \ldots \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots\ldots \beta_n X_n + u_i \quad (6)$$

The estimated model was adapted from Tshikororo *et al*., (2020) and is specified as follows:

$$Y = \alpha + \beta_1 ACCI + \beta_2 CCC + \beta_3 ATMM + \beta_4 SS + \beta_5 FO + \beta_6 AES + \beta_7 ATC + \beta_8 ATM + \beta_9 LTS + \beta_{10} KES + \beta_{11} TSR + \beta_{12} EOV \quad (7)$$

TABLE 1: Description of Dependent and Independent Variables

Variable	Name Description	Type of measure	Expected sign
D	The decision to adopt strategies	Yes = 0, No = 1	
ACCI	Access to climate change information	Dummy; Yes = 0, No =1	+
CCC	Climate change campaign	Dummy; Yes = 0, No = 1	+
ATMM	Access to mass media	Dummy; Yes = 0, No = 1	+
SS	Support source	Dummy; Government = 0, Private institution = 1	-/+

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

FO	Member of farmers' organisation	Dummy; Yes = 0, No = 1	-/+
AES	Access to extension services	Dummy; Yes = 0, No = 1	+
ATC	Access to credit	Dummy; Yes = 0, No = 1	-/+
ATM	Access to market	Dummy; Yes = 0, No = 1	+
LTS	Land tenure security	Dummy; Yes = 0, No = 1	-/+
KES	Kind of extension services	Advice on production = 0, Climate change = 1, Advice on marketing = 2, Other = 3	-/+
TSR	Type of support received	Input provision = 0, Training = 1. Formal credit = 2, Financial assistance = 3	-/+
EOV	Extension officials' visits	Weekly= 0, Monthly =1, Quarterly =2, Yearly = 3	-/+

3. RESULTS AND DISCUSSION

The hypothesised independent variables were evaluated for some statistical issues like multi-collinearity. The Variance Inflation Factor (VIF) test in STATA detected the multi-collinearity issue among the continuous explanatory variables. The VIF was found to be 3.4, less than the conventional threshold of 10 (variables are not significantly correlated).

3.1. Sources of Weather Information on Climate Change

According to Yahaya *et al*. (2024), for effective implementation of informed adaptation strategies, agricultural extension officers need to improve their outreach and training programmes through innovative communication methods that will reach most farmers. Providing useful information, such as weather and flood forecasts and the best agricultural practices, can help reduce climate change's impact on smallholder farmers (Yahaya *et al*., 2024).

The results in Figure 2 show that most respondents (48%) became aware of climate change and its impact through radio station(s). About 20% of the respondents use television as their source of weather information, while 14% use other farmers, 11% use the internet, and 7% use social media, respectively, in the study areas. Smallholder farmers must have accessibility and availability of relevant and reliable information about climate change to make informed decisions on which adaptation strategies to use. These findings are similar to those of Atuber *et al*. (2021), who revealed that receiving weather information is key for farmers to adapt climate change strategies.

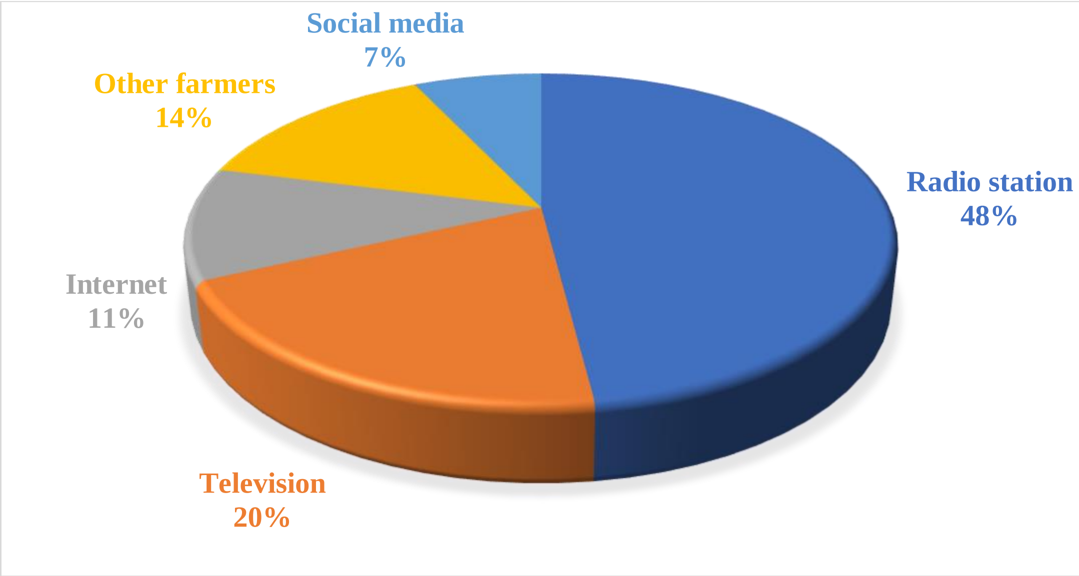

FIGURE 2: Percentage Source of Weather Information

3.2. Impact of Climate Change on Smallholder Farmers

Climate change is having an impact on agriculture and the livelihood of the smallholder farmers in the study area. The results presented in Figure 3 revealed that about 24.17% of the respondents indicated that loss of income was the primary indicator of climate change. The findings also showed that 20.83% of the farmers reported that climate change is responsible for crop yield reduction. The decline in agricultural output (crop yield reduction and crop failure) leads to increased food insecurity and decreased income generation from farming (Makamane *et al*., 2023). About 18.33% reported that climate change led to crop failure. Furthermore, the results indicate that the shift in climate results in about 15.83% water shortage, 10.83% results in the occurrence of pests and disease, and 10% results in seasonal flooding in the study, respectively. Similar results were reported by Atube *et al*. (2021), Marie *et al*. (2020), and Belay *et al*. (2017), who revealed loss of income, crop failure, and yield reduction, shortage of water as indicators of climate change.

Vol. 52 No. 4, 2024: 185-206
https://doi.org/10.17159/2413-3221/2024/v52n4a18423

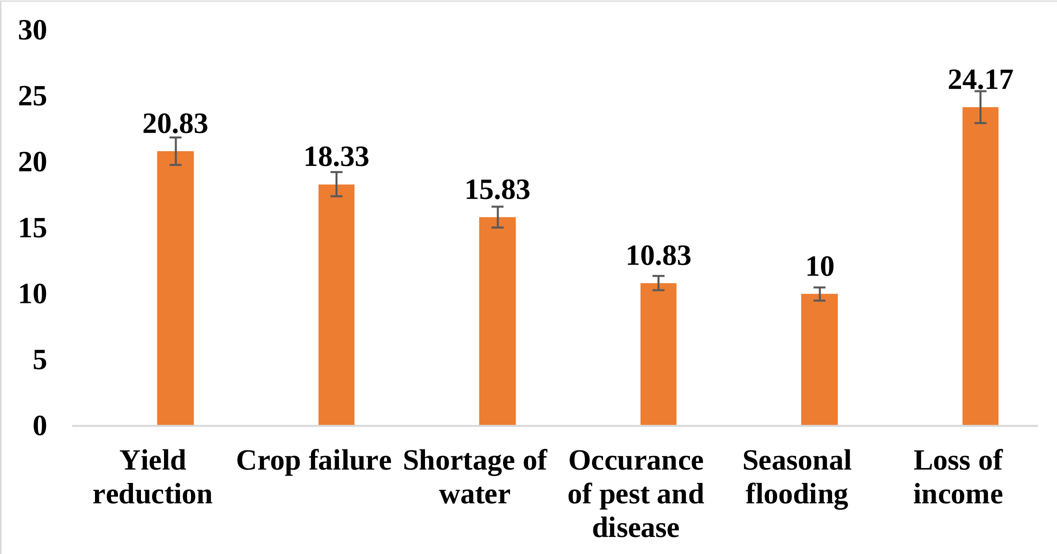

FIGURE 3: Impact of Climate Change on Smallholder Farmers in the Study Area

3.3. Adaptation Strategies to Climate Change Implemented by Smallholder Farmers

The smallholder farmers in the study area have adopted different strategies to adapt to the changing climate, and adaptation is critical to mitigating the impact of climate change on smallholder farming. As illustrated in Figure 4, to alleviate the adverse impact of climate change on agricultural production, some adaptation strategies are implemented by smallholder farmers. The most popular adaptation strategies were crop diversification, crop rotation, calendar redefinition, resilient crop varieties, and tree planting.

Crop diversification is the most common adaptation strategy applied by 32% of the study population. The second most widespread adaptation strategy is crop rotation, which accounts for 29%. About 24% of the farmers use resilient crop varieties as an adaptation strategy to reduce the adverse impact of climate change. These results are consistent with those of Nouri *et al.* (2017), who found that using drought-resistant varieties increased maize productivity under different climate change conditions. Thus, 20% of the farmers use calendar redefinition as an adaptation strategy to cope with the impact of climate change. Also, tree planting (15%) is used as an adaptation strategy to reduce the adverse effects of climate change. This is in line with a previous study by Fagariba (2018), who reported that most smallholder farmers had adopted at least one strategy to cope with the impact of climate change. Crop diversification is perceived as one of the most ecologically feasible, cost-effective, and rational ways of reducing uncertainties in agriculture, especially for smallholder farmers (Makate *et al*., 2016).

Furthermore, crop diversification improves soil fertility, controls pests and diseases, and brings about yield stability, nutrition diversity, and health (Makate *et al*., 2016; Lin, 2011). The findings indicate that many smallholder farmers use this strategy to cope with climate change.

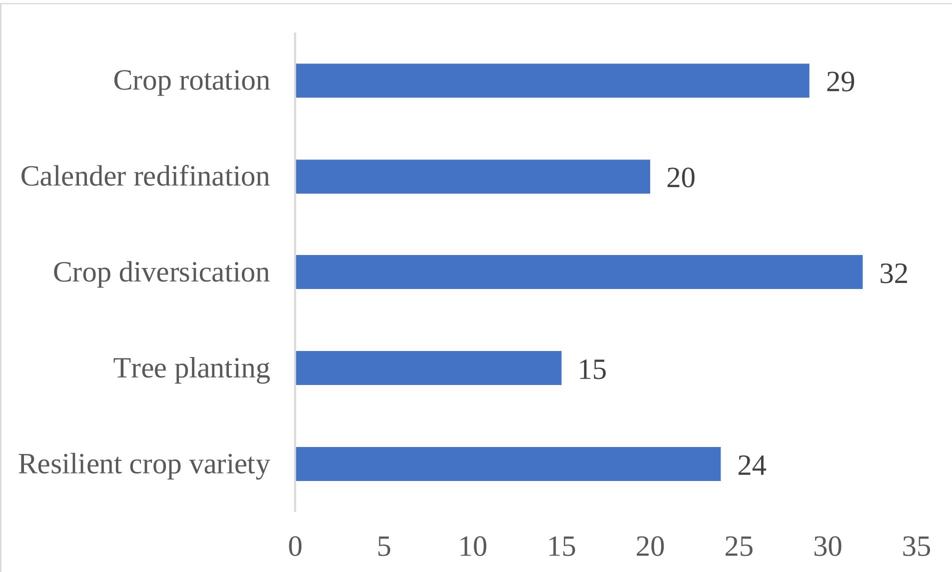

FIGURE 4: Percentage of Adaptation Strategies Used by Smallholder Farmers

3.4. Barriers to Adaptation Strategies

While farmers respond to climate change by adopting various adaptation strategies, they are challenged by different barriers that make adaptation difficult. The result presented in Figure 5 reveals that the most critical obstacles were lack of access to climate change information, shortage of farmland, shortage of farm inputs, lack of access to extension services, lack of credit, and lack of inadequate irrigation. The results in Figure 4 indicate that although diverse climate change adaptation strategies were used in the study area, the farmers did not apply them to their full capabilities due to barriers, as mentioned above. Most respondents (24%) reported that lack of access to climate change information was one of the main barriers hindering farmers' adoption of climate change adaptation measures. This result is supported by Abid *et al*. (2015), who showed that a lack of climate information hinders smallholder farmers' willingness to adopt climate change adaptation strategies.

Moreover, 21% of the farmers mentioned that the shortage of farmland was one of the barriers that hinder farmers' adoption of climate change measures. The results revealed a lack of access to extension services (18%), shortage of farm inputs (13%), lack of access to credit (15%), and lack of adequate irrigation (9%) among barriers that limit farmers' adoption. The results are in agreement with the findings of Anzum *et al*. (2023), Destaw and Fenta (2020), Nega *et al*. (2019) and Belay *et al*. (2017), who indicated a lack of information and inadequate irrigation as significant barriers to adaptation measures.

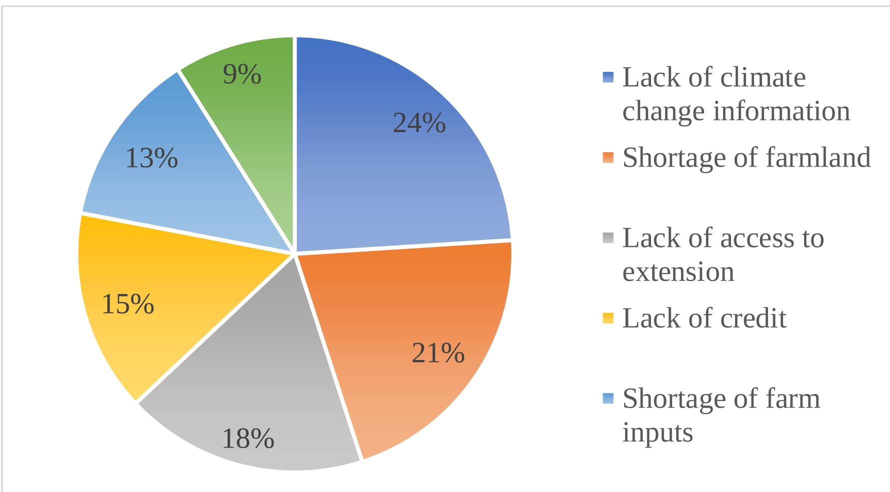

FIGURE 5: Barriers to Climate Change Adaptation in the Study Area

3.5. Institutional Factors Affecting Climate Change Adaptation Strategies

A binary logistic model was used to analyse the institutional factors influencing smallholder farmers' adaptation to climate change strategies. Table 2 indicates that, out of the 12 variables used, five independent variables influencing farmers' decisions to adapt to climate change strategies are statistically significant. These variables were as follows: access to climate change information, access to mass media, access to extension officers, source of support, farmers' organisation, land tenure security, and how to receive extension services. Access to variables such as weather information positively and significantly influences farmers' adaptation to climate change. A unit increase in accessing climate change information would increase the chances of farmers adapting to climate change strategies by 1.10 chances. Similar results were reported by

Tshikororo *et al*. (2020), who revealed that farmers who frequently receive information on climate change are more inclined towards adaptation strategies than those who do not. This result aligns with the findings of Mugagga *et al*. (2019), who also noted that access to climate change information through extension agents enhanced farmers' adaptation decisions.

The results further show that access to mass media positively influences farmers' adaptation to climate change strategies by 1.93. These results agree with the findings of Mulwa *et al*. (2017), who observed that access to climate change information is a significant driver of adaptation among farmers. Access to support sources significantly influences smallholder farmers' adaptation to climate change strategies in that a percentage increase in access to support sources increases farmers' adaptation to climate change strategies by 0.95 percent.

This finding is consistent with that of Come *et al*. (2015), who stated that providing farmers' support by national, private, and international organisations to reduce the impacts of climate change positively influences their adaptation strategies. Additionally, access to extension services positively and significantly influences farmers' adaptation to climate change strategies. An increase in the unit of access to extension officers by farmers increases their chances of adapting to climate change strategies by 0.41 chances. Destaw and Fenta (2021) indicated that extension services are critical in enhancing farmers' knowledge and skills to increase the adoption of improved agricultural technology. According to Bryan *et al*. (2013), farmers who do not have access to extension services are more likely to either not perceive climate change or incorrectly perceive it.

This implies that farmers' adaptation to climate change increases when they access different types of extension services. These results agree with the findings of Khanal *et al*. (2018), who revealed that accessibility of extension services is critical to farmers' willingness to adapt to climate change strategies. Similarly, Abid *et al*. (2019) indicated that farmers who receive advisory services from published extension officials adapt to different climate change adaptation strategies. The results showed that farmers' adaptation strategies to climate change are also significantly affected by being a member of the farmers' organisation. Being a member increases the chance of adopting climate change adaptation strategies by 0.95%. The results are supported by Makamane *et al*. (2023) and

Vol. 52 No. 4, 2024: 185-206
https://doi.org/10.17159/2413-3221/2024/v52n4a18423

Issahaku and Abdulai (2021), who revealed a positive and significant association between being a member of a farmer's organisation and adopting climate change adaptation strategies. Farm organisations provide farmers with new agricultural practices and information relevant to increasing agricultural output.

Furthermore, land tenure security positively and significantly influences the probability of adopting options to adapt to climate change. This implies that farmers who own land have 0.623 % more chances to adopt climate change adaptation strategies than their counterparts. This result agrees with the findings of Makamane *et al.* (2023), who revealed that land rights through land ownership are important in improving agricultural productivity, as they motivate farmers to invest more in their land and use improved agricultural practices.

TABLE 2: Parameter Estimates of the Binary Logistic Model of Institutional Factors

Variables	**Coefficients**	**Std. Err.**	**P>|z|**
ACCI	1.108	0.659	0.093*
CCC	0.302	0.313	0.335
ATMM	1.935	0.685	0.005***
SS	-1.008	0.586	0.085*
FO	0.958	0.565	0.090*
AES	-1.283	0.594	0.031**
ATC	0.301	0.623	0.629
ATM	0.842	0.611	0.168
LTS	-0.623	0.250	0.013**
KES	0.415	0.217	0.057*
TSR	0.125	0.321	0.696
EOV	0.147	0.345	0.668
cons	-3.504	1.268	0.006
		Wald chi2(12)	23.07
		Prob > chi2	0.027
		Log pseudolikelihood	-44.112

	Pseudo R2	0.207
	Number of observations	120

Note: Dependent variable = Decision to adopt; Yes = 0; No = 1. ***, **, * Significant at 1%, 5%, and 10% probability level, respectively.

4. CONCLUSION AND RECOMMENDATIONS

This study assessed institutional factors influencing smallholder farmers' climate change adaptation strategies. Using primary data from one hundred and twenty smallholder farmers in the study area, as the study sample size, the results indicate that the five most used adaptation strategies to climate change impact were crop diversification, crop rotation, calendar redefinition, resilient crop varieties, and tree planting, respectively.

The results further revealed constraints that limit smallholder farmers from adopting climate change adaptation strategies, such as lack of access to climate change information, shortage of farmland, shortage of farm inputs, lack of access to extension services, lack of credit, and lack of adequate irrigation. Furthermore, the study findings indicated that having access to climate change information, mass media, institutions, extension services, farm member organisations, and land tenure security determined farmers' choice of adaptation strategies to climate change. In addition, access to extension services influenced smallholder farmers towards adaptation strategies. Therefore, this study recommends developing climate change adaptation strategies by providing institutional support to different stakeholders.

This study further suggests that timely weather information should be distributed to farmers to sustain their adaptive levels and assist farmers in making informed decisions. There is also a need to provide access to the market, credit, and training to enhance their adoption of climate change adaptation strategies. In addition, policymakers should focus on strengthening rural institutional services and increasing climate change education to improve smallholder farmers' capacity for the changing climate. In South Africa, the agricultural sector is more vulnerable to climate change, and the variability in temperature and rainfall often results in poor quantity and quality of produce, even at times complete crop failure. Climate change and variability have adverse effects on agricultural productivity, which is vital for the existence of mankind. To overcome the adverse impacts of climate change, climate-resilient agriculture practices should be implemented.

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Vol. 52 No. 4, 2024: 185-206
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Vol. 52 No. 4, 2024: 185-206
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