S. Afr. J. Agric. Ext. Maziya, Nkonki-Mandleni & Van Niekerk
Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Smallholder Farmers' Choice of Climate Change Adaptation Strategies in the uMkhanyakude District in KwaZulu-Natal, South Africa

Maziya, M.[1], Nkonki-Mandleni, B.[2] and Van Niekerk, J.A.[3]

Corresponding Author: M. Maziya. Correspondence Email: Mbongeni.maziya@univen.ac.za

ABSTRACT

Climate change poses a considerable risk to sustaining smallholder farming in developing countries and hinders efforts to reduce poverty and food insecurity. One way to mitigate and counter the adverse effects of climate change is through adaptation. This study aimed to investigate the climate change adaptation strategies adopted by smallholder farmers in the uMkhanyakude district of KwaZulu-Natal, South Africa. A stratified random sampling procedure collected data from 400 smallholder farmers. Focus group discussions were used to gather in-depth knowledge about climate change adaptation. A multinomial regression model (MNL) was used to analyse the adaptation strategies and their determinants. The results of the MNL model revealed that factors such as access to extension services, Tropical Livestock Units, gender of the household head, age, land size and market access play an important role in farmers' adaptation to climate change. The study recommends that programmes and initiatives aimed at supporting smallholder farmers should facilitate their access to both formal and informal sources of credit. By addressing this key factor, policymakers can contribute to building the adaptive capacity of farmers and strengthening their ability to cope with climate change challenges.

Keywords: Climate Change; Smallholder farmers; Adaptation; uMkhayakude District

[1] Senior Lecturer : Institute for Rural Development, University of Venda, Thohoyandou, South Africa. Email: mbongeni.maziya@univen.ac.za. https://orcid.org/0000-0001-5374-3260

[2] Professor: Community Engagement and Development Directorate, Mangosuthu University of Technology, Durban, South Africa. Email: mandleni@mut.ac.za. https://orcid.org/0000-0001-9908-8504

[3] Associate Professor: Department of Sustainable Food Systems and Development, University of the Free State, 205 Nelson Mandela Avenue, vniekerkJA@ufs.ac.za. https://orcid.org/0000-0001-9842-0641

1. INTRODUCTION

Climate change and variability are among the biggest threats to agricultural production for current and future generations. Scenarios on the vulnerability of world agriculture suggest that smallholder farmers in developing countries are the most affected by the negative effects of climate change because of their overreliance on a rainfed agricultural system and limited adaptive capacity due to poor resource endowments (Hitayezu, Zegeye & Ortmann, 2014; Jiri, Mafongoya, Mubaya & Mafongoya, 2015; Kassie, Hengsdijk, Ro¨tter, Kahiluoto, Asseng & Ittersum, 2013). As the African populace strives to outstrip poverty and improve economic growth, the production risks associated with climate change will deepen vulnerabilities and seriously undermine the prospect of development (Ojo & Baiyegunhi, 2020). As a result, climate change will likely hinder global efforts to achieve the 2030 agenda on sustainable development, especially sustainable goals that aim to end poverty and hunger (SDG 1 and SDG 2).

Agriculture is important in sustaining the livelihoods of many smallholder farmers in South Africa. There are over 240 000 market-oriented smallholder farmers and an estimated two to four million subsistence-oriented farmers (Ncube & Fanadzo, 2017). Most of these farmers reside in communal areas where agriculture is dominant (Maziya, Mudhara & Chitja, 2017).

The adoption of agricultural innovations in the context of climate change is currently a prominent conversation among development economists and has become a primary focus of policymakers (Gebrehiwot & Van der Veen, 2013). Adaptation to climate change in the context of smallholder agriculture pertains to the capacity of farm households to devise and implement pragmatic strategies aimed at mitigating the adverse consequences of climate change-induced events, including but not limited to drought, floods, hailstorms, heat waves, and strong winds (Grothmann & Patt, 2005; Mugambiwa, 2018). Successful adaptation necessitates the confluence of the requisite skill and a willingness to engage in adaptive measures. Adaptation can be responsive (against current occurrences) or planned in anticipation of future climatic events.

Adaptation to climate change is a two-step process; the first step requires the individual to recognise that climate change is occurring, and the second step requires the individual to act, i.e., to implement adaptation strategies to reduce human or economic losses. The second step requires both the ability and willingness of the smallholder farmer. Mugambiwa (2018) asserts that the extent to which climate change's negative effects are felt depends on the extent of adaptation. As a result, the adverse effects of climate change tend to be severe where there is no adaptation. In addition, demographic, socio-cultural, and institutional variables influence the selection and implementation of adaptation strategies (Hitayezu, Wale & Ortmann, 2017).

There are a plethora of studies that have documented climate change adaptation in the African continent (Komba & Muchapondwa, 2018; Asfaw, Simane, Bantider & Hassen, 2019; Marie, Yirga, Haile & Tquabo, 2020) and area-specific studies that have focused on South Africa (Lottering, Mafongoya & Lottering, 2021; Shisanya & Mafongoya, 2016; Kom, Nethengwe, Mpandeli & Chikoore, 2020). The continental and local-level studies generally agree that local-level climate change adaptation can play an important role in improving the resilience of smallholder farmers (Abegunde, Sibanda & Obi, 2019; Awazi, Tchamba & Avana, 2019). Adaptation to climate change, for example, has been shown in studies to improve crop productivity in drought-prone areas (Abate, Cosmos, Amsal & Peter, 2015; Fisher et al., 2015; Lunduka, Mateva, Magorokosho & Manjeru, 2017). The common adaptation strategies in agriculture include planting drought-resistant crops, introducing livestock species adaptable to harsh climatic conditions, changing planting dates, mixed farming, irrigation and adopting mixed cropping systems (Wale, Nkoana & Mkuna, 2022; Asfaw *et al*., 2019; Marie *et al*., 2019; Lottering *et al*., 2021).

The study aimed to investigate smallholder farmers' adaptation strategies and their determinants. 'Farmers' adaptation strategies and determinants in the uMkhanyakude district are little known. Understanding farmer's choice of climate change adaptation and their determinants will facilitate a better understanding of how smallholder farmers adapt to climate change.

2. MATERIALS AND METHODS

2.1. Study Area

UMkhanyakude District municipality is in the northern part of the KwaZulu-Natal (KZN) province in South Africa (32, 014489; -27, 622242) (uMkhanyakude District Municipality, 2019). The district borders the Indian Ocean in the east, Mozambique to the north, the Kingdom of Eswatini in the northwest and King Cetshwayo and Zululand districts in the south and west. There are five local municipalities in the uMkhanyakude district: Jozini, uMhlabuyalingana, Hlabisa, Mtubatuba and Big Five False Bay. UMkhunyakude is a rural district with Mtubatuba and Jozini as major local towns. The district covers a surface area of 12 818 km^2 and has about 625 846 people with a population density of 46 per km^2 (uMkhanyakude District Municipality, 2019). In terms of size, uMkhanyakude is the second-largest district in KZN. Out of 11 districts in KZN, uMkhanyakude district was purposively chosen. UMkhanyakude district is one of the poorest municipalities in KZN, and the area is highly devastated by climate-induced changes (Ntsaluba, 2014).

2.2. Sampling

Israel (1992) provides guidelines for determining sample sizes based on population size, the margin of error and confidence levels. The selected local municipalities (LMs) have 84 198 households; based on the guidelines, population sizes of 10 000, 100 000 and 500 000 have corresponding sample sizes of 370, 383 and 388, where the margin of error is 5%, and the confidence level is 95%. A sample size of 400 households was considered adequate for this study. A multi-stage random sampling procedure was used to select participants. In the first stage, 50% of the wards in each local municipality were randomly selected. In the second stage, farming households were randomly selected within the wards. Jozini LM has 20 wards, while uMhlabuyalingana LM comprises 18 wards. Data was collected in two LMs, i.e., Jozini and uMhlabuyalingana. Jozini LM has a population of 198 215 and 44 584 households, while uMhlabuyalingana LM has a population of 172 077 and 39 614 households (Stats SA, 2020).

2.3. Data Collection

A structured questionnaire was used to collect quantitative data between November and December 2020. The survey questionnaire was designed to capture data on demographics, crop production, household assets, livestock ownership, support services and farmer training, land ownership, food security, climate change perception and adaptation. The study focused on smallholder farmers engaged in both crop and animal production. Enumerators visited the sampled households and interviewed the household head.

This study used focus group discussions to gather in-depth information on farmers' experiences of climate change, adaptation strategies and the perceived effect of climate change and variability on their livelihoods. Qualitative data obtained from the focus groups was used to supplement quantitative data in the questionnaires. As Tang and Davis (1995) recommended, each focus group consisted of a maximum of 12 farmers, which is considered appropriate for maximum participation.

2.4. Data Analytical Methods

The multinomial logit regression (MNL) model was employed to analyse the determinants of farmers' choice of adaptation strategies. The MNL model offers several advantages, such as analysing decisions involving multiple categories and estimating choice probabilities for each category (Madalla, 1983). The model has been widely used in studying crop and livestock choices for climate change adaptation (Ubisi *et al*., 2017; Hassan & Nhemachena, 2008).

Using an MNL model has the benefit of being computationally simple for determining analytically expressible decision probabilities (Tse, 1987). It provides a straightforward closed form for calculating choice probabilities without requiring multivariate integration, facilitating the assessment of choice scenarios with multiple alternatives (Tse, 1987). In addition, the likelihood function of the MNL model specification is globally concave, which reduces computational complexity (Hausman & McFadden, 1984). However, the MNL model has a weakness known as the Independence of Irrelevant Alternatives (IIA) property. This property assumes that the ratio of the probability of selecting any two choices is independent of any other attribute in the decision set (Hausman & McFadden, 1984).

During preliminary site visits, it was established that smallholder farmers were using four main distinct adaptation strategies. They included planting -resistant crops, shifting planting dates, practising mixed farming, and using irrigation. It was also established that some farmers did not adopt any climate change adaptation strategy. Consistent with previous climate change adaptation studies (Saguye, 2016; Debela, 2017), the dependent variables in this study are binary and were assigned a value of 1 if the farmer implemented the specific adaptation strategies and 0 if the farmer did not employ them. This approach was adopted to distinguish between farmers who successfully adapted to climate change and those who did not. For this study, a farmer is considered to have adapted to climate change if they implemented at least one of the following adaptation strategies: planting drought-resistant crops, adjusting planting dates, practising mixed farming methods, or utilising irrigation. The MNL logit model is expressed as follows:

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

The dependent variable is the adaptation strategy adopted by the farmer (1= Drought-resistant crops; 2= Shifting planting dates; 3= Mixed farming; 4= Irrigation; 5= No adaptation). Let A_j= (j= 1, 2, 3, 4, 5) be the probability of each smallholder farmer being in each adaptation strategy and j=5 being the base category (no adaptation). According to Greene (2003), the MNL model for choice of adaptation strategies expresses the relationship between the probability of a farmer being in a particular adaptation option and a set of explanatory variables. The model is expressed as follows:

$A_j = I_n (A_j / A_5) = \beta_0 + \beta_1 X_1 + \ldots\ldots \beta_{12} X_{12} + ei$

where:

A_j = adaptation strategy (1= Drought resistant crops; 2= Shifting planting dates; 3= Mixed farming; 4= Irrigation)

In= the natural logarithm

A_5= base category (no adaptation)

β_0 = constant term;

$\beta_1, \beta_2 \ldots \beta_{12}$ = regression coefficients of the explanatory variables;

X_1 , X_2 ……. X_{12} = explanatory variables;

$e_{i=}$ error term.

According to Deressa *et al.* (2009), the parameter estimates derived from the MNL model indicate only the direction of the influence of independent variables on the dependent variable. These estimates do not quantify the actual magnitude of change or probabilities. Marginal effects are used to analyse the impact of the explanatory variables on probabilities. The marginal effects are calculated as follows:

$$\partial_j = \frac{\partial A_j}{\partial X_i} = A_j\left[\beta_j - \sum_{k=0}^{j} A_j\, \beta_k\right] = A_j\left(\beta_j - \beta^{-}\right)$$

According to Greene (2000), marginal effects measure the anticipated change in the probability of a specific adaptation strategy being chosen in response to a unit change in an explanatory variable. Some statistical concerns, such as multicollinearity, were assessed for the hypothesised independent variables. The variance inflation factor (VIF) was employed to detect multicollinearity among continuous explanatory variables. The correlation matrix approach was used to determine the degree of relationship between dummy explanatory variables. Variables are considered collinear if the coefficient correlation matrix exceeds 0.4.

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Multicollinearity is also present when the correlation coefficient exceeds 0.4 (Long & Freese, 2006).

The model incorporates a range of explanatory variables hypothesised to influence farmers' choice of adaptation strategies. These variables include various factors, such as demographic, socio-economic and institutional characteristics that shape the farming landscape. Table 1 provides details of the variable names, descriptions, and anticipated signs within the model.

TABLE 1: Variables Used in the Multinomial Logit Regression Model

Variable code	Variable name	Variable descriptionand measurement	Expected sign
AGE	Age	Age of household head in years (continuous)	+/-
GENDER	Gender	1= male and 0 otherwise (dummy)	+/-
EDUCAT	Education	Years of schooling (continuous)	+
LAND_SIZE	Land size	Land size in hectares (continuous)	+
TOTAL_INCOME	Farm and off-farm income	Total amount of money received by the household in the previous year (continuous)	+
H_HADULTS	Number of adult equivalents	Number of people above 18 years who reside in the household and assist in farming (continuous)	+
EXTENSION	Access to extension	1 if the farmer has access to extension services and otherwise (dummy)	+
TLU	Tropical Livestock Units	Livestock size per household (TLUs) (continuous)	+
MARKET_ACCESS		1 if the farmer has access to markets and 0 otherwise (dummy)	+
CREDIT	Access to credit	1 if the farmer received credit in the previous year and 0 otherwise (dummy)	+

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

3. RESULTS AND DISCUSSION

3.1. Socio-Economic Characteristics of the Sampled Farmers

Data was analysed using STATA version 15. Descriptive statistics were employed to analyse the variables used in the model and the barriers to adaptation. Table 2 presents the variables included in the MNL model and their respective means and proportions. The findings indicate that 32% of the sampled farmers were males, whereas 68% were females. These results align with previous studies conducted in the KwaZulu-Natal province (Lottering *et al*., 2021) and Limpopo province (Kom *et al*., 2020) of South Africa. These findings imply that women constitute the majority of smallholder farmers in South Africa, suggesting that they are particularly susceptible to the adverse impacts of climate change.

The average age of smallholder farmers is 55.77 years, indicating that the study area predominantly consists of older individuals engaged in smallholder farming. This demographic composition raises concerns about the sustainability of smallholder farming in the uMkhanyakude district. Nevertheless, the reliability of the results is bolstered by the fact that the average age of smallholder farmers is 55.77, as this study focused on a 20-year reference period. Moreover, in Nigeria, Obayelu *et al*. (2014) found that older people were more active in farming compared to younger people. On average, households in the uMkhanyakude district had approximately five adults during the study. These results conform to earlier findings about the composition of agricultural households in KwaZulu-Natal (Hitayezu *et al*., 2017).

On average, smallholder farmers had attained 7.14 years of schooling, implying that most farmers in the local area did not go beyond primary education. The low levels of education (EDUCAT) in the study area may potentially hinder the adoption of agricultural innovations. Studies (Muzangwa *et al*., 2017; Marenya et *al*., 2017) have shown that education is critical in enhancing understanding and facilitating the uptake of adaptation strategies.

The findings indicate inadequate levels of institutional support provided by the government. Approximately 19% of smallholder farmers received extension services between November 2019 and November 2020. The limited access to extension services (EXTENSION) has broader implications for their ability to adopt innovative climate change adaptation strategies that could mitigate the adverse effects of climate change. These results align with previous studies that reported only 13.6% of agriculturally active black households in the KZN province received agricultural support in 2017 (Stats SA, 2018).

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

More than half (53%) of the sampled smallholder farmers reported having access to some form of credit (CREDIT). However, previous studies conducted in South Africa (Myeni *et al*., 2019; Khapayi & Celliers, 2016) have highlighted the limited access to credit among households due to low income, advanced age and low levels of education. Focus group discussions revealed that most farmers in the uMkhanyakude district had access to informal credit sources such as stokvels, friends and family members. These findings emphasise the significant role of social networks as essential sources of credit, providing much-needed funding for smallholder farmers.

The average land size (LAND_SIZE) controlled by farmers was 1.31 hectares. This result aligns with previous studies that reported that most smallholder farmers in South Africa own less than 2 hectares of land (DAFF, 2012; Mpandeli & Maponya, 2014; Von Loeper *et al*., 2016). The study results indicate that market access (MARKET_ACCESS) was not a problem in the uMkhanyakude district. Those involved in the two irrigation schemes in the Jozini local municipality sold their produce to bakkie traders who were mainly from Richards Bay and the port city of Durban. However, farmers lamented in the focus groups that they mostly get orders in winter since they can plant summer crops in winter because of the warm temperatures.

TABLE 2: Variables Used in the MNL Model

Variable code	Variable name	Mean	SD
AGE	Age of household head in years	55.77	12.36
GENDER	Gender of the household head	0.32	-
EDUCAT	Years of schooling	7.14	4.74
LAND_SIZE	Land size in hectares (ha)	1.31	1.20
MARKET_ACCESS	Access to output markets	0.62	-
H_HADULTS	Number of adult equivalents	4.25	3.76
TLU	Tropical Livestock Units	8.13	12.23
CREDIT	Access to credit	0.53	-
TOTAL_INCOME	Total annual income (Rands)	55674.49	32568.76
EXTENSION	Access to extension services	0.19	-

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Smallholder farmers in the uMkhanyakude district implemented various climate change adaptation strategies to mitigate climate risk. Figure 1 depicts the prevalent adaptation strategies employed by smallholder farmers. Mixed farming was the most widely used adaptation strategy. About 37.25% of the sampled farmers practised mixed farming. Figure 1 shows that 16.5% of the surveyed farmers were adjusting planting dates as an adaptation strategy against the adverse impacts of climate change. Similar findings have been reported in South Africa (Taruvinga *et al*., 2016; Ubisi *et al*., 2017) and Togo (Gadédjisso-Tossou, 2015). Approximately 17.25% of the smallholder farmers planted drought-resistant crops to adapt to climate change. Previous studies (Kom *et al*., 2020; Vilakazi *et al*., 2019) conducted in South Africa have shown that farmers living in harsh climatic conditions are shifting to drought-resistant crops. In the focus group discussions, farmers indicated they were also planting crops such as cassava and sweet potatoes since they have minimal water requirements. Irrigation is one way of enhancing crop production by reducing dependency on rainfed agriculture. A small proportion (4.5%) of the smallholder farmers used irrigation to adapt. Extension officers in the area echoed this result. They agreed that irrigation is not well developed and the support received by smallholder farmers regarding irrigation infrastructure was limited and insufficient to adequately support irrigation as a widely used adaptation strategy.

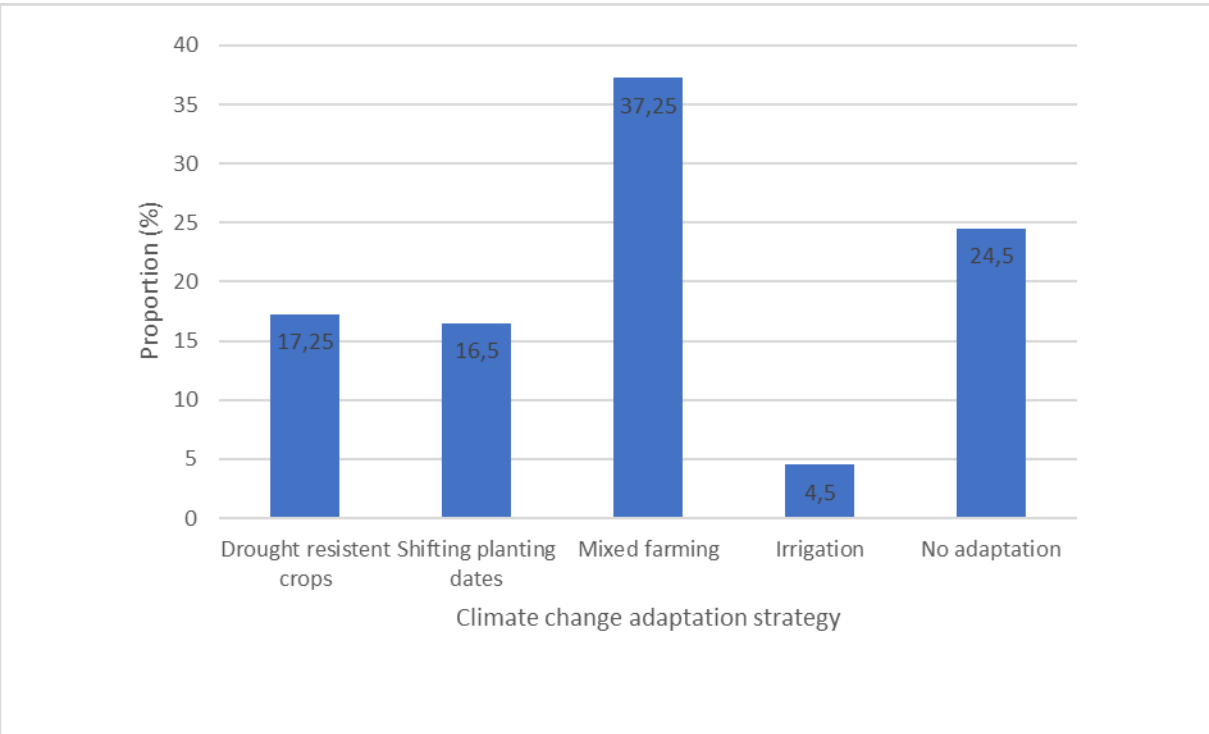

FIGURE 1: Climate Change Adaptation Strategies

The study further explored the barriers hindering climate change adaptation. Figure 2 shows that farmers identified lack of information, insufficient financial resources, scarcity of labour and limited availability of land as the barriers to climate change adaptation. Among the surveyed farmers, a significant proportion (70%) cited a lack of information as a significant barrier to climate change adaptation. Around 60% of the farmers identified a lack of financial resources as a constraint impacting their ability to adapt to climate change. In addition, 23% of the sampled farmers reported labour shortages, while 20% mentioned limited land as a limiting factor. These findings align with the results of Wale *et al*. (2022), who reported that lack of information, financial constraints, and labour shortages were the main factors impeding climate change adaptation in the KwaZulu-Natal province of South Africa. In the focus groups, some farmers echoed the sentiment that they had not interacted with extension agents between November 2019 and November 2020. This explains the high proportion (70%) of farmers who indicated a lack of information as a barrier to climate change adaptation.

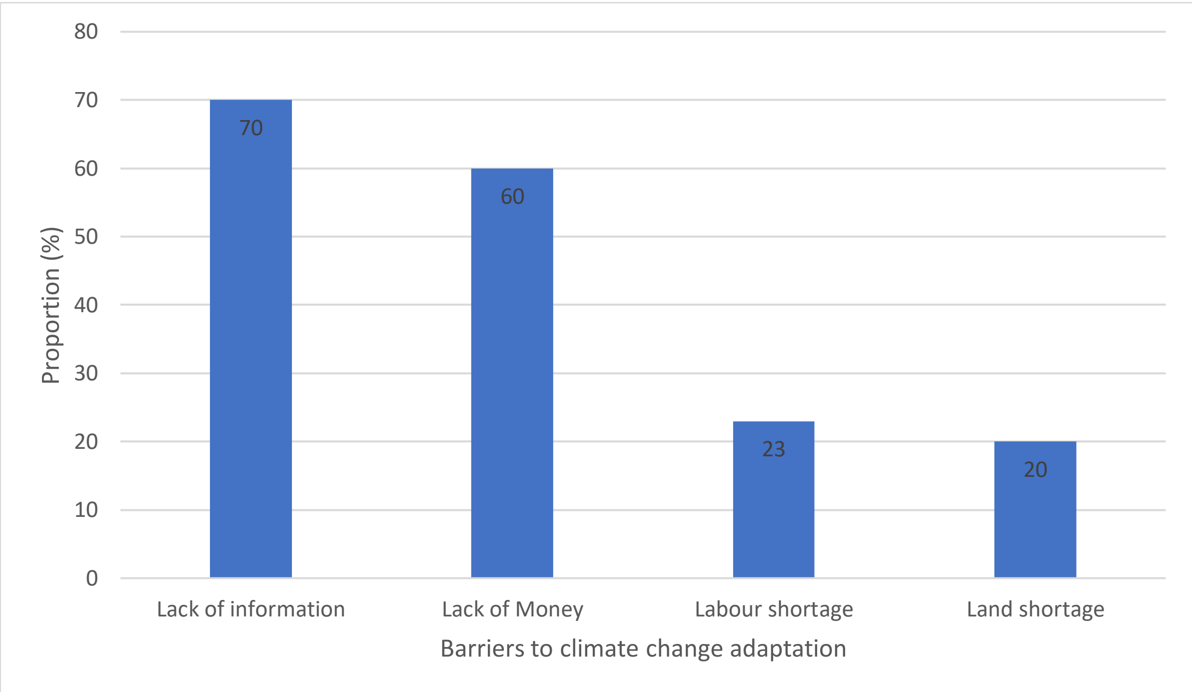

FIGURE 2: Barriers to Climate Change Adaptation

3.2. Determinants of Farmers' Choice of Adaptation Methods

The MNL model was used to analyse the factors influencing farmers' adaptation strategies. The MNL model in this study was employed by normalising one category, also called the base or the reference category. In addition, the Ordinary Least Squares (OLS) model was applied to

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

assess multicollinearity using the Variance Inflation Factor (VIF) and highly correlated variables were removed from the regression model. Appendix 1 presents the VIF values for the variables included in the MNL model. With a mean VIF of 1.10, multicollinearity was not a problem, and the remaining variables were considered appropriate for the model. Correlations were also performed, and the remaining variables had coefficients of less than 0.4, which is regarded as appropriate.

Table 3 displays the parameter estimates of the MNL climate change adaptation model, while Table 4 presents the corresponding marginal effects and their significance levels. The parameter estimates indicate the direction of the independent variables' effect on the dependent variable without providing the exact magnitudes of change. Instead, the marginal effects are reported, representing the expected change in the probability of selecting a specific adaptation strategy. The coefficients are compared to the base category of no adaptation.

To assess the assumption of independence of irrelevant alternatives (IIA) in the MNL model, a nested Logit model, an extension of the MNL, was employed (Hausman & McFadden, 1984). A standard method involving a restricted choice set (shifting planting dates or irrigation alternatives) was used. The model exhibited no significant changes, and the results were further validated through the Hausman test (Long & Freese, 2006), which confirmed that the null hypothesis of IIA could not be rejected. Consequently, using the MNL model to estimate the determinants of climate change adaptation choice is deemed appropriate and justified.

3.2.1. Planting Drought Resistant Crops

The results show a positive and statistically significant relationship ($p<0.1$) between access to extension services (EXTENSION) and the adoption of drought-resistant crops as a climate change adaptation strategy. This result is in line with the *a priori* expectation. The findings indicate that access to extension services increases the likelihood of farmers adopting drought-resistant crops by a factor of 0.046. This underscores the importance of extension officers as a valuable source of agricultural information for smallholder farmers. By accessing extension services, farmers can enhance their understanding of climate change and learn about suitable drought-resistant crop options that are specifically suited to their region. These results are consistent with previous studies that found a positive relationship between access to extension services and adopting drought-resistant crops as a climate change adaptation strategy (Carlisle, 2016; Myeni *et al*., 2019).

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Consistent with the *a priori* expectation, the results revealed a positive and significant relationship ($p<0.01$) between access to credit (CREDIT) and the adoption of drought-resistant crops. The results indicate that having access to credit increases the likelihood of smallholder farmers adopting drought-resistant crops by a factor of 0.128. This implies that farmers who can access informal credit sources such as stokvels and formal credit from financial institutions are more likely to afford and cultivate drought-resistant crops. Given the capital-intensive nature of acquiring drought-resistant crops (i.e., improved crop cultivars), farmers with limited resources may face difficulty purchasing such crops without credit assistance. This finding highlights the critical role of credit in facilitating climate change adaptation. These results align with previous studies (Ojo & Baiyegunhi, 2020; Chipfupa *et al*., 2021).

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TABLE 3: Parameter Estimates of the MNL Climate Change Adaptation Model

Variable code	**Planting drought resistant crops**		**Shifting planting dates**		**Mixed farming**		**Irrigation**	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
AGE	0.012	0.014	-0.000	0.015	-0.014	0.011	0.023	0.025
GENDER	-0.473	0.372	-1.305***	0.436	-0.440	0.308	-0.401	0.585
EDUCAT	0.080*	0.046	0.050	0.045	0.030	0.035	0.188**	0.094
LAND_SIZE	-0.128	0.183	0.024	0.176	0.181	0.147	0.030	0.259
MARKET_ACCESS	0.522	0.361	1.151***	0.390	1.046***	0.306	0.507	0.581
H_HADULTS	0.024	0.056	0.060	0.055	0.063	0.046	0.031	0.090
TLU	0.036*	0.018	0.035*	0.019	0.047***	0.016	0.021	0.028
CREDIT	1.548***	0.369	1.188***	0.371	0.427	0.292	1.940***	0.683

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TOTAL_INCOME	5.61e-07	2.53e-06	6.24e-07	2.48e-06	1.57e-06	2.28e-06	1.75e-06	2.48e-06
EXTENSION	0.606	0.386	0.638*	0.386	0.243	0.391	0.158	0.677
Base category		No adaptation						
Number of observations		400						
LR Chi-square		124.80***						
Log likelihood		-517.58624						
Pseudo-R^2		0.1076						

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TABLE 4: Marginal Effects from the MNL Climate Change Adaptation Model

Variable code	Planting drought-resistant crops		Shifting planting dates		Mixed farming		Irrigation	
	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE
AGE	0.002	0.001	0.000	0.002	-0.004**	0.002	0.001	0.001
GENDER	0.006	0.041	-0.124**	0.048	0.019	0.052	0.005	0.022
EDUCAT	0.006	0.006	0.001	0.005	-0.004	0.006	0.006	0.004
LAND_SIZE	-0.029	0.019	-0.004	0.016	0.044**	0.020	-0.000	0.009
MARKET_ACCESS	-0.031	0.039	0.064	0.042	0.114**	0.051	-0.009	0.022
H_HADULTS	-0.002	0.005	0.003	0.005	0.008	0.007	-0.000	0.003
TLU	0.001	0.002	0.000	0.002	0.005***	0.002	-0.000	0.001
CREDIT	0.128***	0.041	0.064*	0.039	-0.100**	0.047	0.050*	0.028

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TOTAL_INCOME	-5.24e-08	2.00e-07	-4.63e-08	1.72e-07	2.37e-07	2.38e-07	3.92e-08	5.22e-08
EXTENSION	0.046*	0.026	0.047**	0.024	-0.025	0.054	-0.008	0.025

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

3.2.2. Shifting Planting Dates

Approximately 17.25% of the smallholder farmers in the sample implemented shifting planting dates as a climate change adaptation strategy. The analysis reveals a positive and statistically significant ($p<0.05$) relationship between access to extension services (EXTENSION) and shifting planting dates. This finding aligns with the *a priori* expectation, as extension officers play a crucial role in advising smallholder farmers on the appropriate months for cultivation based on predicted or prevailing climatic conditions in the area. Access to extension services increases the probability of adopting shifting planting dates by a factor of 0.047. This result can be attributed to access to extension services enhancing smallholder farmers' access to climate-related information.

Consequently, farmers become more knowledgeable about the adverse impacts of climate change (Dinku *et al*., 2014) and the potential adaptation strategies that can be employed. Access to information enables farmers to make informed decisions regarding shifting planting dates to mitigate the adverse effects of climate change. These findings are consistent with the study conducted by Kibue *et al.* (2015), which found that farmers' willingness to adapt to climate change increases with improved access to extension services.

The analysis reveals a negative and statistically significant ($p<0.05$) relationship between gender (GENDER) and the adoption of shifting planting dates as a climate change adaptation strategy. This result suggests that female farmers are likelier to shift planting dates than their male counterparts. The probability of adopting shifting planting dates increases by a factor of 0.124 for female farmers. This finding is consistent with previous studies conducted in Kenya (Pello *et al*., 2021) and South Africa (Thinda *et al*., 2020). The higher adaptive capability of female smallholder farmers may be attributed to their heightened vulnerability to climate change, arising from factors such as limited off-farm activities, lower levels of education, and weaker social networks (Djoudi *et al.*, 2016). The observed gender disparity in adopting shifting planting dates highlights the need for targeted interventions and support for female farmers to enhance their resilience to climate change.

Access to credit (CREDIT) has a positive and statistically significant ($p<0.1$) relationship with the adoption of shifting planting dates as a climate change adaptation strategy. The probability of shifting planting dates increases by 0.064 when farmers can access credit. Due to unpredictable climatic changes, farmers often plant summer crops later than usual, outside their

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

region's optimum planting time. As a result, farmers might require financial resources to purchase early maturing crops. This finding underscores the importance of financial support mechanisms in promoting climate change adaptation in the agricultural sector.

3.2.3. Mixed Farming

The variable for the age of the household head (AGE) has a negative and statistically significant ($p<0.05$) relationship with the adoption of mixed farming as a climate change adaptation strategy. This suggests that older farmers are less likely to adopt mixed farming as an adaptation strategy. The adoption of mixed farming decreases by 0.004 with increasing age. The negative impact of age on adopting mixed farming may stem from older farmers having limited knowledge about the benefits and practices associated with mixed farming, potentially due to lower levels of education. This finding implies that older farmers may be less aware of the available options and strategies suitable for their farms in the context of climate change. These findings align with the results from Ojo *et al*. (2021), where they identified a negative and significant relationship between age and adopting climate change adaptation strategies in South Africa. Similarly, in Ghana, Zakaria *et al*. (2020) reported a negative and significant relationship between age and adopting climate change adaptation strategies. Overall, the results suggest that age can be an important factor influencing the adoption of specific climate change adaptation strategies, highlighting the need for targeted interventions and education programmes to increase the awareness and knowledge of older farmers regarding suitable adaptation practices.

The variable for land size (LAND_SIZE) has a positive and statistically significant ($p<0.05$) relationship with the adoption of mixed farming as a climate change adaptation strategy. This implies that as the land under cultivation increases by a hectare, the likelihood of adopting mixed farming as an adaptation strategy increases by 0.044. The positive relationship between land size and the adoption of mixed farming can be attributed to the advantages that larger farm sizes offer. Farmers with larger land sizes can explore and integrate various agricultural enterprises, such as livestock, alongside their crop production. This diversification reduces the risks associated with climate change, as different enterprises can provide a buffer against the potential impacts of unpredictable weather patterns. The results suggest that farmers with larger land sizes have the flexibility and resources to implement mixed farming practices, which can enhance their resilience to climate change. These findings align with previous studies that have

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

also demonstrated a positive relationship between land size and adopting climate change adaptation strategies (Ojo & Baiyegunhi, 2020; Bryan *et al*., 2013). Overall, the positive association between land size and the adoption of mixed farming highlights the importance of land resources in facilitating adaptive strategies. It emphasises the potential benefits of promoting larger land holdings or supporting farmers in utilising their available land more effectively to enhance climate resilience in agricultural systems.

The coefficient for market access (MARKET_ACCESS) has a positive and statistically significant ($P<0.05$) relationship with the adoption of mixed farming as a climate change adaptation strategy. The findings indicate that farmers with access to markets are more likely to adopt mixed farming practices to respond to climate change. The probability of adopting mixed farming increases by 0.114 with improved market access. The positive relationship between market access and adopting mixed farming can be attributed to several factors. Firstly, market access allows farmers to procure necessary farm inputs, such as improved seeds or livestock, enabling them to expand and diversify their agricultural activities. Secondly, farmers with market access can easily sell their cash crops or livestock, enhancing their income and financial capacity to invest in mixed farming. This income can contribute to the necessary resources and flexibility for implementing mixed farming practices. These results align with previous studies that have identified a positive association between market access and climate change adaptation (Alemayehu & Bewket, 2017; Adimassu & Kessler, 2016). Improving market connectivity and ensuring farmers access reliable markets can enhance their capacity to diversify their agricultural activities and resilience to climate variability. Access to markets can empower farmers to make informed decisions, access necessary resources, and capitalise on market opportunities, ultimately improving their adaptive capacity in the face of climate change.

The results show that there is a positive and statistically significant ($p<0.01$) relationship between livestock ownership (TLU) and the adoption of mixed farming as a climate change adaptation strategy. An increase in livestock ownership increases the probability of adopting mixed farming by a factor of 0.005. The observed positive relationship can be attributed to the benefits of livestock ownership in diversifying smallholder farmers' agricultural activities. Livestock is an additional enterprise alongside crop farming, enabling farmers to mitigate risks associated with unfavourable climatic conditions and potential crop failures. Farmers can spread their risks by incorporating livestock into their farming systems and enhancing their

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

resilience to climate change impacts. This finding is consistent with other empirical studies highlighting the positive association between livestock ownership and climate change adaptation (Amare & Simane, 2017; Regmi *et al*., 2017). These studies have emphasised the role of livestock in providing alternative sources of income, nutrient-rich manure for soil fertility and potential insurance against crop losses, all of which contribute to farmers' ability to adapt to changing climatic conditions. In addition, the positive relationship between livestock ownership and adopting mixed farming underscores the importance of integrating livestock in climate change adaptation strategies.

Contrary to the *a priori* expectation, access to credit (CREDIT) has a negative and statistically significant ($p<0.05$) relationship with the adoption of mixed farming as a climate change adaptation strategy. This finding suggests that farmers with credit access are less likely to diversify their farming enterprises. With all other variables held constant, access to credit decreases the probability of adopting mixed farming by a factor of 0.1. The unexpected negative effect of credit on mixed farming adoption could be attributed to specific circumstances surrounding credit availability and utilisation in the study area. Focus group discussions revealed that the credit sources for farmers practising mixed farming predominantly stem from informal lending institutions, which tend to impose high interest rates. These exorbitant interest rates may discourage farmers from investing in diverse farming enterprises like mixed farming, as the financial burden becomes a disincentive for pursuing such practices. The findings underscore the significance of considering the presence of credit and its accessibility and affordability. While access to credit is generally perceived as a facilitator of agricultural activities, the specific terms and conditions associated with credit sources can significantly influence farmers' decisions and behaviours. In this context, the high interest rates charged by informal lending institutions appear to hinder farmers' inclination towards adopting mixed farming. Creating favourable credit environments that offer reasonable interest rates and flexible repayment terms could encourage farmers to embrace diverse farming enterprises, contributing to their resilience in climate change.

3.2.4. Irrigation

The results indicate that access to credit (CREDIT) has a positive and statistically significant ($p<0.1$) effect on the adoption of irrigation as a climate change adaptation strategy. Access to credit increases the probability of adopting irrigation by a factor of 0.05. This finding highlights

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

the importance of credit in facilitating the adoption of irrigation, considering its capital-intensive nature. Implementing irrigation systems, which involves acquiring infrastructure such as tanks and pipes, requires substantial financial resources that may not be readily available to smallholder farmers. Farmers gain additional financial resources to purchase the necessary irrigation infrastructure by providing access to credit. This financial support is crucial in overcoming the financial barriers associated with implementing irrigation as a climate change adaptation strategy. Even if farmers possess the necessary information and knowledge about climate change and its impacts, their ability to acquire the required equipment may be constrained if they lack access to credit. These findings align with previous empirical studies (Ojo and Baiyegunhi, 2020), further emphasising the significance of credit in facilitating the adoption of climate change adaptation strategies, specifically in irrigation. Access to credit provides farmers with the means to invest in necessary infrastructure and empowers them to manage water resources better and enhance their agricultural productivity and resilience.

4. CONCLUSION AND RECOMMENDATIONS

The study assessed farmers' choice of climate change adaptation strategies and their determinants in the uMkhanyakude district of KwaZulu-Natal province of South Africa. The study results revealed that smallholder farmers adapted to climate change by employing different adaptation strategies/methods. Indeed, descriptive statistics showed that farmers were employing mixed farming, shifting planting dates, planting drought-resistant crops and irrigation to adapt to climate change. Lack of information, financial resources, and land and labour shortages were the major barriers hindering smallholder farmers from adapting to climate change. Access to credit was not a problem in the study area; smallholder farmers use informal sources of credit to support agricultural activities.

Most of the smallholder farmers in the study area were females and, by implication, were the most affected by the adverse effects of climate change. Access to extension services was low, which has implications for the transfer of agricultural information and innovative practices that mitigate the adverse effects of climate change. Therefore, it is unsurprising that farmers mentioned lack of information as a barrier to adaptation. Farmers in the area owned less than 1.5 ha of agricultural land. With climate change, farmers will need more land to spread climate risk by diversifying farm activities.

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

The results from the MNL marginal analysis indicate that access to credit, access to extension services, gender of the household head (female headship), market access, tropical livestock units, and land size were the factors that influenced farmers' choice of adaptation strategies. Thus, overcoming financial constraints, broadening extension services and supporting mixed farming (livestock systems in addition to cropping systems) methods in rural areas can be underlined as a policy option to reduce the negative impacts of climate change. Access to credit has emerged as a dominant factor affecting the adoption of most adaptation strategies. The study recommends that programmes and initiatives aimed at supporting smallholder farmers should facilitate their access to both formal and informal sources of credit. By addressing this key factor, policymakers can contribute to building the adaptive capacity of farmers and strengthening their ability to cope with climate change challenges.

REFERENCES

ABATE, T., COSMOS, M., AMSAL, T. & PETER, S., 2015. *Maize variety options for Africa*. Zimbabwe: CIMMYT Institutional Multimedia Publications Repository.

ABEGUNDE, V.O., SIBANDA, M. & OBI, A., 2019. The dynamics of climate change adaptation in Sub-Saharan Africa: A review of climate-smart agriculture among small-scale farmers. *Climate.,* 7(7): 132.

ADIMASSU, Z. & KESSLER, A., 2016. Factors affecting farmers' coping and adaptation strategies to perceived trends of declining rainfall and crop productivity in the central Rift Valley of Ethiopia. *Environ. Syst. Res.,* 5: 13.

ALEMAYEHU, A. & BEWKET, W., 2017. Determinants of smallholder farmers' choice of coping and adaptation strategies to climate change and variability in the central highlands of Ethiopia. *Environ. Develop.,* 24: 77-85.

AMARE, A. & SIMANE, B., 2017. Determinants of smallholder farmers' decision to adopt adaptation options to climate change and variability in the Muger Sub-basin of the Upper Blue Nile basin of Ethiopia. *Agric. Food Sec.,* 6: 1-20.

ASFAW, A., SIMANE, B., BANTIDER, A. & HASSEN, A., 2019. Determinants in the adoption of climate change adaptation strategies: evidence from rainfed-dependent smallholder farmers in north-central Ethiopia (Woleka sub-basin). *Environ Dev Sustain.*, 21: 2535–2565.

AWAZI, N.P., TCHAMBA, M.N. & AVANA, T.M., 2019. Climate change resiliency choices of small-scale farmers in Cameroon: determinants and policy implications. *J Environ Manage.*, 250: 109560.

BRYAN, E., RINGLER, C., OKOBA, B., RONCOLI, C., SILVESTRI, S. & HERRERO, M., 2013. Adapting agriculture to climate change in Kenya: household strategies and determinants. *J Environ Manage.*, 114: 26–35.

CARLISLE, L., 2016. Factors influencing farmer adoption of soil health practices in the United States: A narrative review. *Agroecol Sust Food Sys.*, 40(6): 583-613.

DEBELA, B., 2017. Gender and climate change: determinants of female farmer's adaptation strategies to climate change; A survey study in Atsbi Womberta, Ethiopia. *Citizenship and Morality.*, 1(1): 14–40.

DEPARTMENT OF AGRICULTURE, FORESTRY AND FISHERIES (DAFF)., 2012. *A Framework for the development of smallholder farmers through cooperatives development*. Pretoria, South Africa: Department of Agriculture, Forestry and Fisheries. Available from: http://Www.Nda.Agric.Za/Doadev/Sidemenu/Cooperativeandenterprisedevelopment/Docs/Framework-%20of%20small%20farmers%20(2).Pdf

DERESSA, T.T., HASSAN, R.M., RINGLER, C., ALEMU, T. & YESUF, M., 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Glob. Environ. Change.*, 19: 248-255.

DINKU, T., BLOCK, P., SHAROFF, J., HAILEMARIAM, K., OSGOOD, D., DEL CORRAL, J., COUSIN, R. & THOMSON, M.C., 2014. Bridging critical gaps in climate services and applications in Africa. *Earth Perspect.*, 1(15): 1-13.

DJOUDI, H., LOCATELLI, B., VAAST, C., ASHER, K., BROCKHAUS, M. & SIJAPATI, B.B., 2016. Beyond dichotomies: gender and intersecting inequalities in climate change studies. *Ambio.*, 45(3): 248-262.

FISHER, M., ABATE, T., LUNDUKA, R.W., ASNAKE, W., ALEMAYEHU, Y. & MADULU, R.B., 2015. Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: determinants of adoption in eastern and southern Africa. *Clim. Change.*, 133: 283–299.

GADÉDJISSO-TOSSOU, A., 2015. Understanding farmers' perceptions of and adaptations to climate change and variability: The case of the maritime, plateau and Savannah Regions of Togo. *Agric. Sci.,* 6: 1441-1454.

GEBREHIWOT, T. & VAN DER VEEN, A., 2013. Farm level adaptation to climate change: the case of farmer's in the Ethiopian Highlands. *Environ. Manage.*, 52: 29–44.

GREENE, W.H., 2003. *Econometric analysis*. 5th edn. New Jersey: Prentice Hall.

GREENE, W.H., 2000. Econometric analysis. 4th edn. New Jersey: Prentice Hall.

GROTHMANN, T. & PATT, A., 2005. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Glob. Environ. Change.*, 15(3): 199-213.

HAUSMAN, J. & MCFADDEN, D., 1984. Specification tests for the multinomial logit model. *Econometrica.*, 52(5): 1219–1240.

HITAYEZU, P., WALE, E. & ORTMANN, G., 2017. Assessing farmers' perceptions about climate change: A double-hurdle approach. *Clim. Risk Manag.,* 17: 123-138.

ISRAEL, G.D., 1992. *Determining sample size*. Florida: University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, EDIS.

JIRI, O., MAFONGOYA, P., MUBAYA, C. & MAFONGOYA, O., 2015. Seasonal climate prediction and adaptation using indigenous knowledge systems in agriculture systems in Southern Africa: A review. *J. Agric. Sci.,* 8(5): 156-172.

KASSIE, B.T., HENGSDIJK, H., RO¨TTER, R., KAHILUOTO, H., ASSENG, S. & ITTERSUM, M.V., 2013. Adapting to climate variability and change: Experiences from cereal-based farming in the Central Rift and Kobo Valleys, Ethiopia. *Environ. Manage.,* 52(5): 1115-1131.

KHAPAYI, M. & CELLIERS, P. 2016. Factors limiting and preventing emerging farmers to progress to commercial agricultural farming in the King William's Town area of the Eastern Cape province, South Africa. *S. Afr. J. Agric. Ext.,* 44(1): 25-41.

KIBUE, G.W., PAN, G., JOSEPH, S., LIU, X., JUFENG, Z., ZHANG, X. & LI, L., 2015. More than two decades of climate change alarm: farmers' knowledge, attitudes and perceptions. *Afr. J. Agric. Res.,* 10(27): 2617-2625.

KOM, Z., NETHENGWE, N.S., MPANDELI, N.S. & CHIKOORE, H., 2022. Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. *GeoJournal.,* 7: 1-12.

KOMBA, C. & MUCHAPONDWA, E., 2018. Adaptation to climate change by smallholder farmers in Tanzania. *Agric. Adapt. Climate Chang. Africa.,* 129(168): 129–168.

LONG, J.S. & FREESE, J., 2006. *Regression Models for Categorical Dependent Variables Using Stata*. Stata Press.

LOTTERING, S.J., MAFONGOYA, P. & LOTTERING, P., 2021. The impacts of drought and the adaptive strategies of small-scale farmers in uMsinga, KwaZulu-Natal, South Africa. *J. Asian Afr. Stud.,* 56(2): 267–289.

LUNDUKA, R.W., MATEVA, K.I., MAGOROKOSHO, C. & MANJERU, P., 2017. Impact of adoption of drought-tolerant maize varieties on total maize production in south Eastern Zimbabwe. *Clim. Dev.,* 11(1): 35-46.

MADALLA, G., 1983. *Limited dependent and qualitative variables in econometrics*. Cambridge: Cambridge University Press.

MARENYA, P.P., KASSIE, M., JALETA, M. & ERENSTEIN, O., 2017. Predicting minimum tillage adoption among smallholder farmers using micro-level and policy variables. *Agric. Food Econ.,* 5: 12.

MARIE, M., YIRGA, F., HAILE, M. & TQUABO, F., 2020. Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from north-western Ethiopia. *Heliyon.,* 6: e03867.

MAZIYA, M., MUDHARA, M. & CHITJA, J., 2017. What factors determine household food security among smallholder farmers? Insights from Msinga, KwaZulu-Natal, South Africa. *Agrekon.*, 56(1): 40-52.

MPANDELI, S. & MAPONYA, P., 2014. Constraints and challenges facing the small-scale farmers in Limpopo Province, South Africa. *J. Agric. Sci.*, 6(4): 135-143.

MUGAMBIWA, S.S., 2018. Adaptation measures to sustain indigenous practices and the use of indigenous knowledge systems to adapt to climate change in Mutoko rural district of Zimbabwe. *Jàmbá: J. Disaster Risk Stud.*, 10(1): 388.

MUZANGWA, L., MNKENI, P.N.S. & CHIDUZA, C., 2017. Assessment Of conservation agriculture practices by smallholder farmers in the Eastern Cape province of South Africa. *Agronomy.*, 7(3): 46.

MYENI, L., MOELETSI, M., THAVHANA, M., RANDELA, M. & MOKOENA, L., 2019. Barriers Affecting Sustainable Agricultural Productivity of Smallholder Farmers in the Eastern Free State of South Africa. *Sustainability.*, 11: 3003.

NCUBE, B. & FANADZO, M., 2017. Improving smallholder farmer livelihoods through developing strategies to cope and adapt during drought periods in South Africa. Report on the Literature review on the current knowledge of smallholder farming in South Africa. Water Research Commission Project No. K4/2716/4.

NTSALUBA, G., 2014. *KwaZulu-Natal water crisis: Too little too late*. Corruption Watch. Available from: https://www.corruptionwatch.org.za/kzn-water-crisis-too-little-too-late/

OBAYELU, O.A., ADEPOJU, A.O. & IDOWU, T., 2014. Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria. *J. Agric. Environ. Int. Dev.*, 108(1): 3-16.

OJO, T.O. & BAIYEGUNHI, L.J.S., 2020. Determinants of climate change adaptation strategies and its impact on the net farm income of rice farmers in south-west Nigeria. *Land Use Policy.*, 95: 103946.

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. *Sci. Total Environ.,* 792: 148499.

PELLO, K., OKINDA, C., LIU, A. & NJAGI, T., 2021. Factors Affecting Adaptation to Climate Change through Agroforestry in Kenya. *Land.,* 10: 371.

REGMI, N., DHAKAL, D. & GHIMIRE, B., 2017. Determinants of farmers' adaptation to climate change: A case from Syangja district of Nepal. *Agric. Econ. Ext. Rural Dev.,* 5: 658-663.

SAGUYE, T.S., 2016. Determinants of Smallholder Farmers' Adoption of Climate Change and Variability Adaptation Strategies: Evidence from Geze Gofa District, Gamo Gofa Zone, Southern Ethiopia. *J. Environ Earth Sci.,* 6(9): 147-161.

SHISANYA, S.O. & MAFONGOYA, P., 2016. Adaptation to climate change and the impacts on household food security among rural farmers in uMzinyathi District of Kwazulu-Natal, South Africa. *Food Secur.,* 8(3): 597-603.

STATISTICS SOUTH AFRICA (STATS SA)., 2018. *General Household Survey 2015*. Pretoria: Statistics South Africa.

STATISTICS SOUTH AFRICA (STATS SA)., 2020. *Mid-year population estimates*. Pretoria: Statistics South Africa.

TANG, K.C. & DAVIS, A., 1995. Critical factors in the determination of focus group size. *Fam. Pract.,* 12(4): 474-475.

TARUVINGA, A., VISSER, M. & ZHOU, L., 2016. Determinants of rural farmers' adoption of climate change adaptation strategies: Evidence from the Amathole District Municipality, Eastern Cape Province, South Africa. *Int. J. Environ. Sci. Dev., 7*(9): 687-692.

THINDA, K.T., OGUNDEJI, A.A., BELLE, J.A. & OJO, T.O., 2020. Understanding the adoption of climate change adaptation strategies among smallholder farmers: Evidence from land reform beneficiaries in South Africa. *Land Use Policy.,* 99: 104858.

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TSE, Y.K., 1987. A diagnostic test for the multinomial logit model. *J. Bus. Econ. Stat.,* 5(2): 283-86.

UBISI, N.R., MAFONGOYA, P.L., KOLANISI, U. & JIRI, O., 2017. livelihoods in rural Limpopo province, South Africa change on crop production and household Smallholder farmer's perceived effects of climate. *Change Adapt. Socio-Ecol. Syst.,* 3: 27-38.

UMKHANYAKUDE DISTRICT MUNICIPALITY., 2019. *Integrated development plan review: 4th Generation 2019/2020.*

VILAKAZI, B.S., ZENGENI, R. & MAFONGOYA, P., 2018. Indigenous strategies used by selected farming communities in KwaZulu Natal, South Africa, to manage soil, water, and climate extremes and to make weather predictions. *Land Degrad Dev.,* 30(2): 1-10.

VON LOEPER, W., MUSANGO, J., BRENT, A. & DRIMIE, S., 2016. Analysing challenges facing smallholder farmers and conservation agriculture in South Africa: A system dynamics approach. *S. Afr. J. Econ. Manag. Sci.,* 19: 747-773.

WALE, E., NKOANA, M.A. & MKUNA, E., 2022. Climate change-induced livelihood adaptive strategies and perceptions of forest-dependent communities: The case of Inanda, KwaZulu-Natal, South Africa. *Trees, Forests and People.,* 8: 100250.

ZAKARIA, Z., ALHASSAN, S.I., KUWORNU, J.K.M., AZUMAH, S.B. & DERKYI, M.K.K., 2020. Factors influencing the adoption of climate-smart agricultural technologies among rice farmers in Northern Ghana. *Earth Syst. Environ.,* 4(1): 257-271.

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Appendix 1

Multicollinearity test between independent variables

Variable code	Variance Inflation Factor (VIF)	Multicollinearity Tolerance
AGE	1.03	0.967
GENDER	1.09	0.916
EDUCAT	1.03	0.973
LAND_SIZE	1.17	0.856
MARKET_ACCESS	1.11	0.900
H_HADULTS	1.15	0.870
TLU	1.23	0.811
CREDIT	1.09	0.915
TOTAL_INCOME	1.10	0.905

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

EXTENSION	1.01	0.990
MEAN VIF	1.10	