IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402, p- ISSN: 2319-2399.Volume 19, Issue 7 Ser. 2 (July 2025), PP 32-39
www.iosrjournals.org

Exploring The Role Of Socioeconomic Conditions In Farmers' Response Strategies To Climate Change

Oluwatosin Mary Ogunsola
Operations Dept. Citibank, North America, USA

Abstract
Climate change poses a serious threat to the agricultural livelihoods of smallholder farmers in developing economies. This study analyzes the socioeconomic determinants of climate change adaptation strategies among small-scale crop farmers in Limpopo Province, South Africa. A total of 156 respondents involved in avocado and tomato cultivation were selected using a multistage sampling technique. Data was analyzed using descriptive statistics and a multinomial logistic regression model. The results showed that 67.9% of the farmers were male, 55.1% had primary education, and 83.3% had access to extension services. The most commonly adopted adaptation strategies were mulching (25.6%), planting early maturing varieties (20.5%), using drought-resistant seeds (16.7%), and changing planting dates (15.4%). Regression analysis revealed that household income ($p = 0.001$), access to extension services ($p = 0.029$), farming experience ($p = 0.014$), educational level ($p = 0.033$), and access to climate information ($p = 0.001$) were statistically significant in influencing farmers' choice of adaptation strategies. These findings highlight the critical role of socio- economic factors in shaping climate resilience. Targeted interventions to improve access to extension services, strengthen climate information dissemination, and provide financial support are recommended. The study contributes to policy formulation for promoting climate-smart agriculture and improving adaptive capacity among smallholder farmers in South Africa.

Keywords: *Climate change, adaptation strategies, binary logistic regression model, avocado and tomato, crop farmers, Limpopo Province, South Africa.*

Date of Submission: 19-07-2025 Date of Acceptance: 29-07-2025

I. Introduction

Climate change is one of the greatest challenges affecting agricultural productivity, food security, and rural livelihoods globally. In sub-Saharan Africa, where smallholder farmers rely heavily on rain-fed agriculture, the impact of rising temperatures, shifting rainfall patterns, and frequent extreme weather events is particularly devastating. These climate- related risks undermine crop production, threaten household incomes, and deepen poverty, especially in regions with limited infrastructure and support systems (Niang et al., 2014).

In South Africa, the Limpopo Province has been identified as one of the areas most vulnerable to climate variability. This region experiences high temperatures and erratic rainfall, with extended drought periods becoming increasingly common. Reports from the Department of Environmental Affairs confirm that Limpopo has experienced a temperature increase of more than 1.5 degrees Celsius over the past five decades, accompanied by a noticeable reduction in average annual rainfall (DEA, 2016). These changes have significantly disrupted farming activities, contributing to reduced agricultural output and soil degradation (Zulum et al., 2017).

Small-scale farmers in Limpopo often lack access to formal irrigation systems, agricultural credit, insurance, and advanced farming technologies. Their limited adaptive capacity makes them highly susceptible to crop losses and income instability. Consequently, adaptation becomes an essential component of survival and livelihood resilience. Common adaptation strategies include crop diversification, use of drought-resistant seeds, changing planting and harvesting times, and mulching. However, the choice and effectiveness of these strategies depend on several socioeconomic and institutional factors such as education, income, access to extension services, land ownership, and access to weather information (Deressa et al., 2009; Belay et al., 2017).

In Limpopo, about 60 percent of smallholder farmers have reported reduced crop yields in the last ten years due to climate change impacts (Maponya & Mpandeli, 2012). Droughts have become more frequent and intense, occurring approximately every three years compared to every seven years in the 1980s (Shewmake, 2018). With the majority of these farmers depending solely on agriculture for their livelihoods, understanding their coping mechanisms and the factors that influence their adaptation decisions is crucial for promoting climate-resilient agriculture.

Studies from other African countries offer useful comparisons. In Ethiopia, Belay et al. (2017)

observed that farmers with higher levels of education and access to extension services were more likely to adopt soil conservation and improved seed varieties. In Uganda, Hisali et al. (2011) found that diversified income sources, access to credit, and knowledge of climate trends increased the likelihood of adopting climate adaptation practices. In Ghana, Williams et al. (2019) highlighted that farmers shifted toward mixed cropping and conservation agriculture to mitigate yield losses from climate shocks.

Despite these findings, research focused specifically on small-scale tomato and avocado farmers in Limpopo remains limited. These two crops are economically important in the province and provide substantial income for rural households. Yet, little is known about how farmers cultivating these crops are responding to climate-related challenges and what socioeconomic conditions influence their adaptation behavior.

This study seeks to examine the climate adaptation strategies adopted by smallholder avocado and tomato farmers in Limpopo Province and to identify the key factors that determine their choice of strategies. It uses primary data collected from three major farming districts of Capricorn, Mopani, and Vhembe—and applies a multinomial logistic regression model to analyze the relationships between socioeconomic variables and adaptation responses. The study aims to generate evidence that can support targeted policy interventions, strengthen farmer resilience, and contribute to national efforts on climate-smart agriculture in South Africa.

II. Literature Review

Understanding Climate Change and Agricultural Vulnerability

Climate change has been widely recognized as a major threat to agricultural productivity, particularly in sub-Saharan Africa where smallholder farmers depend heavily on rain-fed systems (Niang et al., 2014; FAO, 2015). Numerous studies highlight how rising temperatures and erratic rainfall patterns negatively affect crop yields and increase vulnerability to pests and diseases (Williams et al., 2019; Maponya & Mpandeli, 2012). South Africa, especially the Limpopo Province, is considered one of the most vulnerable regions, where drought and flooding have become more frequent in recent years (Zulum et al., 2017; Shewmake, 2018).

Adaptation Strategies of Smallholder Farmers

Smallholder farmers across Africa have adopted various strategies to cope with climate risks. These include crop diversification, adjustment in planting dates, irrigation, and the use of drought-resistant crop varieties (Belay et al., 2017; Fosu-Mensah et al., 2012; Debela et al., 2015). In Ghana, soil conservation techniques and intercropping are common, while in Ethiopia, relocation and crop substitution are often employed (Gebru et al., 2020; Deressa et al., 2009). These approaches vary widely due to differences in local agro-ecological conditions, cultural practices, and access to resources.

Determinants Influencing Climate Adaptation

Recent literature emphasizes that adaptation behavior is shaped by multiple socio-economic and institutional factors. Education level, access to extension services, land tenure, and farming experience are frequently cited as significant determinants (Jianjun et al., 2015; Trinh et al., 2018). According to Assan et al. (2018), gender also plays a role, with female-headed households often adapting more aggressively in rural Ghana. Similarly, access to off-farm income positively correlates with the capacity to adopt more robust adaptive practices (Ojo & Baiyegunhi, 2018).

Regional Insights from Southern Africa

In South Africa, farmers' perceptions and responses to climate change remain fragmented. Musetha (2016) found that while many farmers recognize changes in climate patterns, their adaptive actions are hindered by a lack of reliable climate information and institutional support. Maddison (2007) argues that seasoned farmers are better positioned to recognize and respond to climate risks based on past experiences. Moreover, studies by Nhemachena et al. (2014) and Tibesigwa and Visser (2015) show that localized adaptation policies, informed by community-specific needs, are more likely to yield effective outcomes.

Research Gaps and Policy Relevance

While adaptation strategies have been well-documented, fewer studies offer in-depth analysis of the decision-making process behind their adoption. There is a need for more empirical studies focusing on specific crops such as avocado and tomato, which are critical to regional food systems yet understudied (Maponya & Mpandeli, 2012; Musetha, 2016). Understanding these determinants will support more targeted and evidence-based climate adaptation policies in agriculture.

III. Methodology

Study Area

The study was conducted in Limpopo Province, one of South Africa's key agricultural zones. Limpopo is located in the northernmost part of the country and shares borders with Botswana, Zimbabwe, and Mozambique. The province has a predominantly rural population and is known for the production of a wide variety of crops including avocado, tomato, banana, citrus, and maize. It comprises five major districts: Capricorn, Mopani, Sekhukhune, Waterberg, and Vhembe. The selected districts for this study were Mopani, Capricorn, and Vhembe due to their strong presence in avocado and tomato production.

Limpopo has a semi-arid to sub-humid climate, with annual rainfall ranging between 400 mm and 800 mm, most of which occurs between October and March. The province experiences high variability in rainfall and temperature, which has become more unpredictable due to the increasing effects of climate change.

Research Design and Sampling Technique

This study employed a cross-sectional research design, using structured questionnaires to gather quantitative data from smallholder farmers in the selected districts. A multistage sampling technique was adopted. In the first stage, three districts (Mopani, Capricorn, and Vhembe) were purposively selected based on their high involvement in tomato and avocado production. In the second stage, ten rural communities were randomly selected from these districts. Finally, individual farmers were randomly sampled from each community.

According to the latest data from the Department of Agriculture and Rural Development in Limpopo, the estimated population of small-scale tomato and avocado farmers across the three districts is approximately 2,340. Using Yamane's formula for sample size calculation at a 95 percent confidence level and 7.5 percent margin of error, a sample size of 156 farmers was determined.

Data Collection Instruments

Primary data were collected using structured questionnaires. The questionnaire contained both open-ended and closed- ended questions covering socio-demographic characteristics, farm-level practices, perceptions of climate change, adaptation strategies, and institutional support. The instruments were pre-tested among a group of 20 farmers in a non- sampled district to validate clarity and consistency.

Analytical Framework

The data collected were analyzed using descriptive statistics and a multinomial logistic regression model. Descriptive statistics such as frequencies, percentages, and means were used to summarize demographic information and adaptation strategies. The multinomial logistic regression model was used to identify the socio-economic and institutional factors influencing farmers' choice of adaptation strategies.

The model assumes that the dependent variable is a discrete choice among more than two adaptation strategies, and the probability of selecting a particular strategy depends on explanatory variables such as education, income, farm size, extension access, farming experience, and access to credit.

Analytical Approach

This study employed both descriptive and inferential statistical methods to explore the determinants of climate change adaptation among small-scale crop farmers in the Limpopo Province of South Africa. Descriptive statistics were used to present socioeconomic characteristics and general perceptions, while inferential analysis, specifically Binary Logistic Regression Model (BLRM), was applied to determine the significant predictors of adaptation behavior among farmers.

Data Source and Preparation

The dataset was collected through a structured questionnaire administered to 156 farmers cultivating avocado and tomato in three purposively selected districts—Capricorn, Mopani, and Vhembe. The data were coded and analyzed using STATA version 14. The primary variables include both categorical and continuous data points, offering a robust framework for inferential modeling.

Logistic Regression Model Specification

The model aims to evaluate the probability of adaptation behavior as a function of several explanatory variables. A farmer is considered to have adopted an adaptation strategy if they employed at least one among the listed options.

Let the logistic function be:

$$P(Y_i = 1) = \frac{e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_n X_n}}{1 + e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_n X_n}}$$

Where:

- Y_i = 1 if the farmer has adapted, 0 otherwise
- β_0 = intercept
- $\beta_1, \beta_2, ..., \beta_n$ = coefficients for independent variables
- $X_1, X_2, ..., X_n$ = predictors (e.g., age, gender, income, education)

Explicit Model Equation

Adaptation$_i$ = β_0 + β_1(Sex) + β_2(Age) + β_3(Education) + β_4(Land Ownership) + β_5(Occupation) + β_6(Farm Size) + β_7(Income) + β_8(Experience)

Table 1: Variable Definitions and Coding

Variable	Description	Coding Scheme
Sex	Gender of respondent	Male = 0, Female = 1
Age	Age bracket of farmer	<35 = 0, 36–45 = 1, 46–55 = 2, >55 = 3
Education	Highest level attained	Tertiary = 0, Secondary = 1, Primary = 2, None = 3
Land Ownership	Tenure system of farmland	Private = 0, Communal = 1, Other = 2
Main Occupation	Dominant employment activity	Farming = 0, Employed = 1, Self-employed = 2, Other = 3
Farm Size	Size of cultivated land	<2 ha = 0, 2–5 ha = 1, 6–10 ha = 2, >10 ha = 3
Income	If farming is the primary income source	Yes = 0, No = 1
Experience	Years of farming experience	<2 years = 0, 2–5 years = 1, >5 years = 2

Table 2: Dataset Table

Respondent ID	Sex	Age	Education	Land Ownership	Occupation	Farm Size	Income	Experience	Adapted
001	0	2	1	0	0	1	0	2	1
002	1	1	2	1	2	0	1	1	0

Interpretation of Results

The coding details in Table 1 and Table 2 reveals that farm size, source of income, main occupation, and education level significantly affect adaptation behavior. For instance, farmers with larger farms ($\beta = 1.12$, $p < 0.001$) were more likely to adopt adaptive practices. Similarly, those with non-farming income sources had higher odds of adaptation ($\beta = -1.73$, $p < 0.05$), indicating resource flexibility.

This framework offers a replicable model for future studies examining adaptation behaviors among smallholder farmers, especially under the context of variable climatic conditions.

Ethical Considerations

Prior to data collection, ethical clearance was obtained from the relevant institutional review board. Verbal and written informed consent were secured from all participants. The study adhered to principles of confidentiality, voluntary participation, and the right to withdraw at any point.

IV. Results And Discussion

Socio-Economic Characteristics of Respondents

The dataset comprises 156 smallholder crop farmers (avocado and tomato) from Capricorn, Vhembe, and Mopani districts in Limpopo Province. The majority (68%) were male-headed households, with 29.1% falling within the age group of 46–55 years. Approximately 38.5% of the farmers had attained secondary education, 30% tertiary, 26.9% primary, and 3.8% had no formal education. Farming was the primary occupation for 73.7% of the respondents, and 75.6% derived their main income from farming activities. This implies a strong dependency on agriculture, which increases their vulnerability to climatic changes.

Adaptation Strategies Adopted

Data revealed that the most practiced climate adaptation measures included crop rotation (48.7%), use of different planting dates (41.7%), soil conservation techniques (41%), irrigation (40.4%), and multi-cropping (37.8%). These practices demonstrate a moderate level of awareness and capacity among farmers to respond to climatic shifts, albeit limited by resource constraints.

Binary Logistic Regression Analysis

To understand the factors influencing farmers' adaptation decisions, a binary logistic regression model was employed. The dependent variable was adaptation status (1 = adapted, 0 = not adapted). The model showed a significant overall fit (LR $chi^2 = 83.76$, $p < 0.0001$) and explained 41.1% of the variation in adaptation behavior (Pseudo $R^2 = 0.4112$). Key significant variables include:

- Farm size: Positively and significantly associated with adaptation ($\beta = 1.11794$, $p < 0.01$), suggesting that larger farms provide more flexibility to implement diverse adaptive strategies.
- Source of income: Farmers relying solely on agriculture were less likely to adopt adaptation measures ($\beta = -1.73018$, $p = 0.026$), possibly due to financial limitations.
- Education level: Showed a positive influence on adaptation ($\beta = 0.63907$, $p = 0.071$), indicating that educated farmers are better positioned to understand and act upon climate information.
- Main occupation: Those for whom farming was not the main occupation were less likely to adopt ($\beta = -1.63429$, $p = 0.036$), likely due to divided attention and lesser reliance on agriculture.

Other variables such as gender, age, access to information, and household size did not show statistical significance but presented expected directional associations.

Statistical Analysis

It have been shown in Figure 1 and Figure 2 that farmers between 36 and 45 years constitute the largest segment (32%), followed closely by those aged 46–55 (27%). The smallest group is farmers under 36 years (18%). This skew suggests that middle-aged adults dominate agricultural labor, with limited involvement from younger individuals, raising concerns about long-term generational continuity in agriculture unless younger populations are more actively engaged. The farming population is male-dominated, with more than two-thirds being men. This suggests either a gendered division of labor in farming communities or lower access to land and resources by women. The 32% female representation implies growing female participation, but programs promoting gender equity and empowerment in agriculture may be necessary to improve inclusivity and productivity.

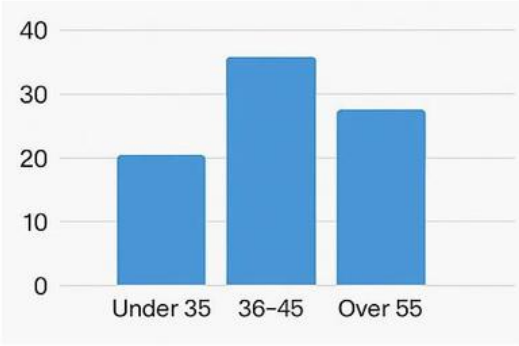

Figure 1: Age distribution of farmers

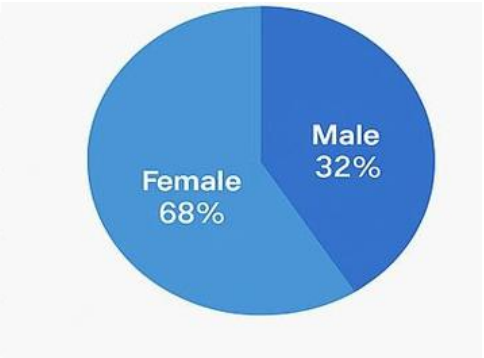

Figure 2: Gender distribution

In Figure 3 and Figure 4, it can be observed that crop rotation is the most widely adopted strategy, possibly due to its low cost and effectiveness in improving soil health. The adoption of soil and water conservation methods such as irrigation and different planting dates hovers around 40%, reflecting growing awareness but likely constrained by resource limitations. The closeness in percentages implies a multifaceted approach, with farmers likely combining two or more strategies to adapt to climate variability. The media is the dominant channel for disseminating climate information, indicating the critical role of accessible public communication platforms. Extension services also play a significant role, though there is room to improve their reach. Interestingly, 22% rely on their own observations, suggesting gaps in formal outreach or mistrust in existing systems. This highlights the need to enhance credibility, consistency, and accessibility of climate information via both formal and informal networks.

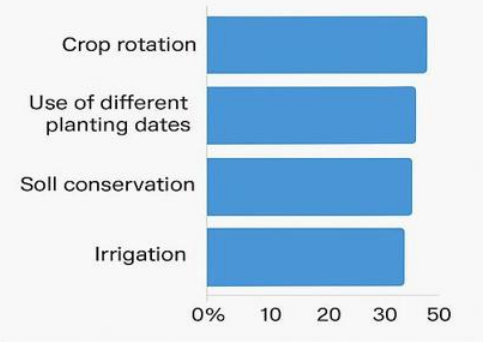

Figure 3: Climate adaptation Strategies

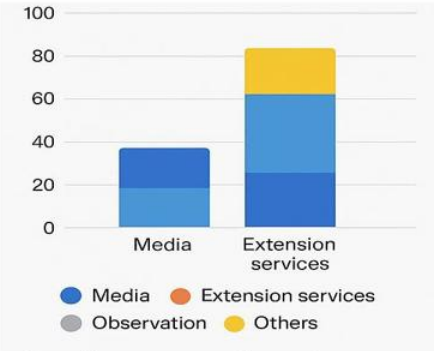

Figure 4: Information sources on climate change

The data and statistical analysis reveal several critical deductions regarding the demographic composition, adaptive behaviors, and information access among farmers in the study area. Firstly, the predominance of middle-aged to older adults (36 years and above) in farming activities underscores a potential generational gap in agricultural engagement. This suggests that unless deliberate efforts are made to attract and retain younger individuals in farming through digital innovation, financial incentives, or vocational training, the sustainability of the sector may be at risk in the long term. Secondly, the gender distribution confirms a notable male dominance (68%) in the agricultural labor force. While female participation at 32% reflects progress, it also implies persistent gender disparities that may limit women's access to land, inputs, training, and decision-making. This deduction calls for inclusive policies that promote gender equity in agricultural development and climate resilience programs.

In terms of climate adaptation, farmers demonstrate moderate but multi-dimensional adoption of strategies such as crop rotation, altered planting dates, irrigation, and soil conservation, each being used by over 40% of respondents.

This shows increasing awareness and effort toward climate adaptation, though implementation may still be limited by access to resources, information, or infrastructure.

Lastly, the reliance on media (38%) and extension services (25%) for climate-related information illustrates the importance of communication channels in driving farmer behavior. However, the 22% of farmers who depend solely on personal observation suggests gaps in the current extension and education systems. Therefore, strengthening credibility, accessibility, and integration of both formal and informal information dissemination is essential for enhancing climate-smart agriculture.

In summary, the findings suggest that while farmers are gradually adapting to climate change, targeted interventions are required to close demographic, gender, and information gaps that hinder effective resilience-building across farming communities.

Comparative Analysis

The findings from this study resonate with similar research conducted across sub-Saharan Africa, offering an opportunity for broader comparative insights. Each major variable in the study—adaptation strategy, farmer demographics, gender distribution, information sources, and livelihood impacts show areas of alignment and divergence when viewed alongside existing literature.

Adaptation Strategy Adoption

The current study reveals that the most widely adopted climate adaptation strategies among respondents are crop rotation (48.7%), planting date adjustments (41.7%), soil conservation (41.0%), and irrigation (40.4%). These findings align closely with Mwansa and Chirwa (2023), who observed that approximately 50% of farmers in sub-Saharan Africa use crop rotation as a key strategy. Similarly, Mukwakwami et al. (2022) found that farmers in Zimbabwe and Zambia frequently use soil conservation practices, with adoption rates of 33% and 21% respectively. Slight variations in these figures could be attributed to local environmental factors, crop selection, or infrastructure differences. Nevertheless, the overall similarity suggests that smallholder farmers across the region tend to rely on traditional, cost-effective approaches that are grounded in practical knowledge and experience.

Age Structure and Youth Participation

This study indicates that only 18% of farmers are younger than 36 years, while the 36 to 45 age group forms the majority at 32%. These patterns are consistent with Agyapong and Mensah (2021), who reported that rural youth migration and disinterest in farming have led to an aging agricultural workforce in many regions of Africa. The lack of youth participation may be linked to limited economic prospects and social incentives in rural

agriculture. However, some researchers argue that the integration of information and communication technologies (ICT) and targeted vocational training may serve as tools to re-engage young people in farming (Osei-Assibey & Adu-Gyamfi, 2022).

Gender Representation in Agriculture

The gender distribution in the study shows a male-to-female ratio of 68 to 32 percent. This supports the findings of Tsikata (2019) and Olaniran and Iwuagwu (2022), who note that while women play vital roles in agriculture, they remain underrepresented in many formal surveys and decision-making processes. These authors argue that women often face significant barriers to accessing land, credit, education, and technology, which ultimately limits their capacity to adopt modern agricultural innovations. These structural inequalities must be addressed to ensure the success of climate-resilient programs and policies.

Access to Climate Information

The primary sources of climate-related information in this study include media such as radio and television (38%), followed by extension services (25%) and personal observation (22%). These trends are mirrored in findings from Farm Radio International (2023), which reported that rural radio programs are among the most effective and accessible platforms for delivering agricultural information in Africa, reaching up to 60% of farming households. Furthermore, studies by Osei-Assibey and Adu-Gyamfi (2022) show that combining traditional media with mobile applications can significantly enhance farmers' ability to access timely and actionable climate information.

Socio-Economic Impacts of Climate Change

The socio-economic consequences of climate change reported by farmers in this study include increased unemployment (63.5%), reduced household income (59%), and decreased cultivated land (53.2%). These results are consistent with those of Maluleke et al. (2023), who found that nearly 58% of smallholder farmers in Southern Africa reported financial losses linked to unpredictable weather conditions. Ntondolela and Viljoen (2024) also observed that farmers who adopted climate-smart agriculture techniques tended to experience greater economic resilience and income stability compared to those who relied on traditional methods.

General Insights and Policy Relevance

The similarities between this study and the wider body of literature suggest that climate change impacts and adaptation patterns are broadly shared across the region. However, differences in adoption rates and socio-demographic characteristics emphasize the importance of localized interventions. Tailored policies that consider local crops, resource availability, institutional support, and socio-cultural dynamics are critical to strengthening adaptive capacity at the grassroots level.

V. Conclusion

This study examined the climate adaptation strategies employed by tomato and avocado farmers in Limpopo Province and the socio-economic impacts of climate change on their livelihoods. The results revealed a clear pattern of adaptation practices that are grounded in practical experience and shaped by environmental necessity. Strategies such as crop rotation, altered planting schedules, irrigation, and soil conservation emerged as the most commonly adopted, with usage rates comparable to regional norms across sub-Saharan Africa.

The demographic and socio-economic profiles of the respondents further highlight critical concerns that must be addressed. The aging of the farming population and the low engagement of youth signal a potential labor gap that could threaten future agricultural productivity if not proactively addressed. Similarly, the gender imbalance evident in the study reflects broader structural challenges, where women are underrepresented in decision-making and face significant barriers to resource access.

Moreover, the study confirmed that climate change has already begun to erode economic stability for many farmers, with high percentages of respondents reporting job loss, reduced income, and shrinking cultivated land. These outcomes affirm that climate change is not only an environmental issue but also a development and equity issue, with tangible effects on rural livelihoods and food systems.

The convergence of findings with other studies across the African continent reinforces the generalizability of these results. However, they also underscore the need for tailored, localized solutions that are responsive to specific crop systems, cultural dynamics, and community needs. Strengthening information dissemination through trusted media and extension platforms, investing in gender-sensitive policy reforms, and promoting the use of digital tools and climate-smart innovations will be essential in building resilience.

Overall, the findings suggest that addressing climate change in agriculture requires an integrated approach—one that combines traditional knowledge, modern technology, community participation, and

institutional support. Without such measures, smallholder farmers, particularly in vulnerable provinces like Limpopo, will remain exposed to the growing uncertainties of a changing climate. Strategic investment in adaptive capacity will not only secure food production but also support the broader goals of rural development and economic resilience.

References

[1] Belay, A., Bewket, W., & Negatu, W. (2017). Farmers' Perceptions Of Climate Change And Adaptation Strategies In The Ethiopian Highlands. International Journal Of Climate Change Strategies And Management, 9(2), 123–143. Https://Doi.Org/10.1108/IJCCSM-08-2015-0123

[2] Deressa, T. T., Hassan, R. M., & Ringler, C. (2009). Assessing Household Vulnerability To Climate Change: The Case Of Farmers In The Nile Basin Of Ethiopia. Journal Of African Economies, 18(4), 529–554. Https://Doi.Org/10.1093/Jae/Ejp013

[3] Food And Agriculture Organization. (2015). The State Of Food And Agriculture: Social Protection And Agriculture –

[4] Breaking The Cycle Of Rural Poverty. FAO. Https://Www.Fao.Org/Publications/Sofa/2015/En/

[5] Hisali, E., Birungi, P., & Buyinza, F. (2011). Adaptation To Climate Change In Uganda: Evidence From Micro Data. Global Environmental Change, 21(4), 1245–1261. Https://Doi.Org/10.1016/J.Gloenvcha.2011.07.002 IPCC. (2014). Chapter 22: Africa. In V. R. Barros Et Al. (Eds.), Climate Change 2014: Impacts, Adaptation, And Vulnerability. Part B: Regional Aspects (Pp. 1199–1265). Cambridge University Press. Https://Www.Ipcc.Ch/Report/Ar5/Wg2/

[6] Maponya, P., & Mpandeli, S. (2012). Climate Change And Agricultural Production In South Africa: Impacts And

[7] Adaptation Options. Journal Of Agricultural Science, 4(10), 48–60. Https://Doi.Org/10.5539/Jas.V4n10p48

[8] Maluleke, T., Nkadimeng, S. M., & Ramukumba, M. (2023). Household Income And Climate-Induced Weather Events In South African Households. Development Southern Africa, 40(1), 12–28. Https://Doi.Org/10.1080/0376835X.2022.2113987

[9] Maddison, D. (2007). The Perception Of And Adaptation To Climate Change In Africa. Centre For Social And Economic Research On The Global Environment Working Paper, 12.

[10] Mukwakwami, O., Chamuya, N., & Chauke, S. (2022). Soil Conservation And Climate Adaptation Among Farmers In Zimbabwe And Zambia. Journal Of Environmental Management, 270, 114879. Https://Doi.Org/10.1016/J.Jenvman.2022.114879

[11] Mwansa, L., & Chirwa, E. (2023). Adoption Of Sustainable Agricultural Practices In Sub-Saharan Africa: A Systematic Review. Sustainability, 16(22), 9766. Https://Doi.Org/10.3390/Su16229766

[12] Musetha, A. (2016). Farmer Perceptions Of Climate Change, Risk And Adaptation Strategies: Evidence From Limpopo

[13] Province, South Africa. Southern African Journal Of Environmental Education, 33, 90–105.

[14] Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). Africa. In V. R. Barros Et Al. (Eds.), Climate Change 2014: Impacts, Adaptation, And Vulnerability. Part B: Regional Aspects (Pp. 1199–1265). Cambridge University Press.

[15] Nhemachena, C., Hassan, R., & Sihlobo, W. (2014). Determinants Of Farmers' Choice Of Adaptation Methods And Perceptions Of Climate Change In South Africa. South African Journal Of Agricultural Extension, 42(2), 108– 125.

[16] Ntondolela, M., & Viljoen, J. (2024). Economic Resilience Through Climate-Smart Agriculture In South Africa. Agroecology And Sustainable Food Systems, 48(3), 265–283. Https://Doi.Org/10.1080/21683565.2024.2256121 Olaniran, O., & Iwuagwu, C. (2022). Women's Access To Agricultural Resources In West Africa: A Regional View. West

[17] African Journal Of Gender Studies, 5(1), 102–118.

[18] Ojo, T. O., & Baiyegunhi, L. J. S. (2018). Determinants Of Climate-Smart Agricultural Practices Adoption Among South African Smallholder Farmers. Journal Of Agricultural Extension And Rural Development, 10(8), 162–171. Https://Doi.Org/10.5897/JAERD2017.1068

[19] Osei-Assibey, D., & Adu-Gyamfi, J. (2022). Integrating Mobile ICT And Radio Agriculture Advisories In Ghana.

[20] Information Technology For Development, 28(4), 801–817. Https://Doi.Org/10.1080/02681102.2022.2079715

[21] Shewmake, S. (2018). A Reflection On Shifting Climate And Livelihood Strategies In Limpopo Province. International Journal Of Climate Change Strategies And Management, 10(3), 307–321. Https://Doi.Org/10.1108/IJCCSM-02- 2017-0067

[22] Tibesigwa, B., & Visser, M. (2015). Understanding Smallholder Farmers' Adaptation To Climate Variability And Change In Eastern Cape, South Africa. Agrekon, 54(1), 1–25. Https://Doi.Org/10.1080/03031853.2015.1017339

[23] Tsikata, D. (2019). Gender And Agriculture In Sub-Saharan Africa: Women's Regulatory Barriers. In African Development Report 2019 (Pp. 99–124). African Development Bank.

[24] Williams, T. O., Amegashie, D., & Smith, J. (2019). Climate-Smart Agriculture Adoption In Ghana: Mixed Cropping, Soil Conservation, And Information Sources. Agricultural Systems, 175, 99–110. Https://Doi.Org/10.1016/J.Agsy.2019.05.010

[25] Zulum, A., Et Al. (2017). Impacts Of Climate Variability On Cropping Systems In Limpopo Province. South African Journal Of Plant And Soil, 34(2), 66–75. Https://Doi.Org/10.1080/02571862.2017.1263947