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Perceptions and Adaptation Strategies to Climate Change among Small-Scale Farmers in Mangolong Village, Eastern Cape, South Africa

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ABSTRACT

This study employed a qualitative research approach to explore the perceptions and adaptation strategies of small-scale farmers in Mangolong Village, Eastern Cape, South Africa. Data was gathered through in-depth interviews and focus group discussions and analysed using thematic analysis to identify key patterns and insights. The results revealed that social, economic and cultural factors influence adaptation to climate variability. Women emerged as key contributors in agricultural production, but they continue to face challenges such as limited access to land and lack of financial resources emphasizing the need for gender-sensitive adaptation strategies. The dominance of older farmers in agricultural practices highlighted a stronger reliance on traditional agricultural practices which are grounded in valuable indigenous knowledge. However, this may hinder the uptake of modern climate-resilient techniques. Education can also be very crucial along with indigenous knowledge exchange and social networks. The size of households also determined the adaptive capacity, especially in relation to available labour, and the economic constraints limited investing in new technologies. The farmers showed a strong attachment to their land and cultural earnings that influenced their perceptions about and reactions to the problem of climate change. The most cited adaptation interventions were cropping diversification, intercropping and adjustments to seasonal calendars. These results showed that adaptation lies in the context of complicated socio-cultural, economic, and environmental conditions. In this regard, successful adaptation should be a holistic process where integration of both indigenous knowledge systems with scientific innovation is a must. Women and other vulnerable groups need to be supported with capital so that they can acquire farming inputs and also give them the mandatory knowledge that integrates modern farming and traditional farming system.

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1. Introduction

Small-scale farming is a significant process in the determination of food security, and livelihood maintenance in developing nations. These agricultural systems tend to have small landholdings, low mechanisms of production, resort to family labor, utilization of a traditional type of knowledge. The Food and Agriculture Organization (2020) continues to argue that small-scale farms contribute over 70 percent of the food that people consume globally and are income and nutrition sources of rural communities. According to Siphesihle and Lelethu (2020), subsistence farming in South Africa agriculture is rapidly falling. In the Eastern Cape Province, subsistence farming is the primary source of livelihood and income of about 78 percent of rural households. The Eastern Cape agricultural productivity relies largely on rain-fed farming that leads to low productivity since fewer resources can be used to produce food.

South Africa has been unable to adjust to the increasing impacts of climate change. The development of resilience building has not moved much beyond the policy stage, even though South Africa has strong national adaptation policies and even a climate change bill in parliament (Ziervogel et al., 2022). In South Africa, in semi-arid parts, smallholders are especially vulnerable to extreme weather events and lack exposure to adaptive capacity. The sustainability of livelihoods and food security is at risk as a result of increasing pressures due to weather events, soil degradation, biodiversity loss, and population growth (Zuma-Netshiukhwi et al., 2023). The main source of income in rural Sub-Saharan Africa is subsistence rain-fed agriculture. Since 70% of farmers globally operate on a small scale, they are especially susceptible to the low agricultural output caused by the erratic rainfall patterns brought on by climate change. Rural farmers' livelihoods are especially at risk due to their reliance on agriculture and climate change-threatening natural resources

The Eastern Cape is most certainly a significant provider of both exports and the local agro-industry. This potential should be used in order to get rid of poverty and provide people in the province with the possibility to work more. Therefore, comprehensive approach to agriculture development can be employed to ensure that small-scale farmers benefit in the agricultural sector that is the most dynamic and diverse in Sub-Saharan Africa. To integrate the smallholder farmers into the highly developed agricultural value chains in South Africa, especially in Eastern Cape, there needs to be consistency in the policies and initiatives that address the challenges faced by these small producers (Hardwick & Lavinia, 2024). The rural farming community in the Mangolong village in the Matatiele local municipality of the Eastern Cape has been experiencing erratic climatic patterns increasingly. It results in low yields, water shortages, and a rise in societal vulnerability and socio-economic characteristics (Ahmad et al., 2021; Mdoda, 2020). Small scale farmers depend much on rainfed crops such as maize, beans, and vegetables because they have to rely on rainfall. These recent changes in the local climatic conditions like delayed rains, extended droughts, and sometimes floods have destabilized agricultural activities especially in remote rural areas, and exert further strain on the already scarce household resources (Chitongo, 2019). Despite these challenges, there is comparatively little research on how farmers in Mangolong receive climate change and what adaptive mechanisms they may be implementing to adapt.

It is important to understand the perceptions of the farmers and to record their adaptation strategies to make more informed decisions regarding intervention measures that are suited to a climatically resilient agriculture. The experiences, observations and adaptive measures of farmers provide information that is valuable in climate risks on a localized basis. Their experience can be used to influence policies and services that are context-specific to minimize vulnerability and enhance productivity. On the one hand, the national and regional literature has explored the topic of climate adaptation in South Africa; yet, on the other hand, there still was a gap in the literature addressing village-level

adaptation dynamics in Matatiele and other similar settlements. The purpose of this study is to find out how Mangolong Village's small-scale farmers view climate change and what particular adaptation techniques they are employing in response. The study adds to the body of knowledge on localized climate adaptation in smallholder agriculture by looking at perception and practice. For politicians, non-governmental organizations, and extension services looking to assist vulnerable farming communities, it also offers useful information. By gathering and sharing effective adaptation strategies, local farmers may increase their collective resilience. These insights can help develop actors formulate more equitable and focused policy responses. In terms of academia, this study expands to our knowledge of how socioeconomic and cultural factors influence farmers' capacity to adjust to climate risks in rural areas that have received little attention.

1.1. Study Area

This case study was carried out in Mangolong Village, a rural village within the Matatiele Local Municipality in the Alfred Nzo District in the Eastern Cape Province of South Africa. Figure 1 below presents the map of Mangolong village.

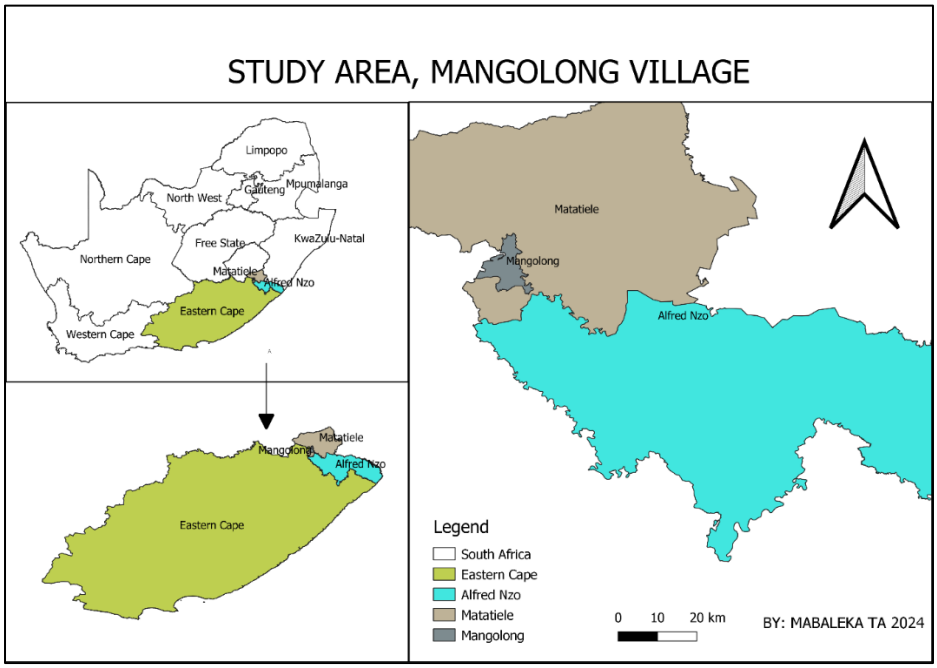

Figure 1: Mangolong Village, Matatiele Local Municipality, Alfred Nzo District Municipality, Eastern Cape, South Africa
Source: Author creation, Mabaleka, 2024

Mangolong Village is in the Eastern Cape, South Africa's Matatiele Local Municipality, which is part of the Alfred Nzo District Municipality. This rural village lies hidden in a mountainous area that is a part of the southern Drakensberg range, close to the Lesotho border. Steep hills, undulating meadows, and deep valleys define the region's terrain, which has a big impact on agricultural practices and land use. The region has a cold, moderate temperature with distinct seasonal rainfall patterns due to its elevation of 1,500 to 2,000 meters above sea level. Because of these physical features, Mangolong is both scenically rich and difficult to farm, particularly considering the changing climate that makes problems like soil erosion and water runoff worse. The village is home to approximately 1,580 residents across 350 households (Statistics South Africa 2021). Small-scale agricultural and animal farmers in the Eastern Cape Province are particularly vulnerable to the impacts of climate change, which includes warmer temperatures, changing rainfall patterns, and an increase in high impact weather events. Changes pose significant challenges to agricultural productivity because the region heavily depends on rain-fed agriculture. The main characteristic of the Eastern Cape is its beautiful coastline that borders with the Indian Ocean. It is populated by 6,996,976 and occupies a total of 168,966km 2. It is the second-

largest province in South Africa in terms of surface area and it has the third-largest population (Gidi et al., 2024).

In-person interviews with a total of 16 participants were conducted using a semi-structured interview guide that was constructed to explore the views on climate change and adaptation techniques. A detailed map of the study area, Mangolong Village, Eastern Cape and a table of demographic summary of the participants is provided to enhance contextual understanding. These visual aids enrich the interpretation of the qualitative results by giving details of the socioeconomic background and locations of the respondents. Table 1 below depicts demographic summary of participants.

Table 1
Mangolong Demographic Participants

Participant ID	Gender	Age Group	Education Level	Farming Experience	Farm Type	Household Size	Notable Characteristics
P1	Female	60+	No formal education	30+ years	Subsistence	6	Relies on indigenous knowledge
P2	Male	50-59	Secondary	20 years	Mixed farming	5	Actively engages in drought resistant crops
P3	Female	40-49	Primary	15 years	Subsistence	4	Is a member of a local farming cooperative
P4	Female	60+	No formal education	35+ years	Subsistence	8	Strongly uses traditional farming methods
P5	Male	60+	Secondary	25 years	Subsistence	3	Utilizes both local and indigenous knowledge systems
P6	Female	50-59	Secondary	22 years	Subsistence	7	Is a mentor and influencer in the community
P7	Female	30-39	Tertiary	10 years	Subsistence	5	Advocates for gender-sensitive approaches
P8	Male	40-49	Primary	18 years	Mixed farming	4	Owns small herd of livestock
P9	Female	60+	Lacks formal education	40+ years	Subsistence	6	Extensive knowledge of seasonal farming calendars
P10	Female	50-59	Secondary	20 years	Subsistence	5	Active member in community gardening for food consumption
P11	Female	60+	Primary	25+ years	Subsistence	4	Use traditional methods for crop protection
P12	Male	40-49	Secondary	12 years	Subsistence	6	Use composite methods of green manuring
P13	Female	60+	No formal education	30+ years	Subsistence	7	Has a strong cultural tie of farming practices
P14	Female	50-59	Secondary	20+ years	Subsistence	6	Has an interest in innovative modern farming practices
P15	Female	60+	No formal education	35 years	Subsistence	5	A leader of women agricultural education group
P16	Male	30-39	Tertiary	8 years	Subsistence	3	Is a young farmer that promotes innovation

Table 1 reflected the ageing nature of small-scale farming in Mangolong Village. The study comprised of 16 participants under which the majority were women below 50 and over 50. While some had secondary or university degrees, the majority had little formal education. Experience farming, mostly in subsistence farming, varied from 8 to more than 40 years. Participants depended largely on indigenous knowledge, community networks, and traditional practices, however a few younger and more educated farmers demonstrated openness to modern adaption methods. Household sizes varied, with the majority consisting of four to seven people, which affected the ability to adjust and the availability of labor.

Despite these constraints, farmers in Mangolong have demonstrated adaptability in the face of climate variability. Observed changes in seasonal rainfall, increased frequency of droughts, and other weather-related disruptions have prompted shifts in farming practices. These consist of changing the planting time, diversification of crops, and integrating the indigenous knowledge and external advice in the decision-making processes. The study area, Mangolong has been selected because it relies on rainfed agriculture, it is a socio-economically vulnerable area, and it does not present any study on localized climate adaptation. The results of this research are thus of significant value to the understanding of responses to climate change at the grassroots level in an environment typical of many rural regions in South Africa.

2. Literature Review

2.1. Climate Change and Its Impacts on Agriculture

Sustainable development and food security are susceptible, and climate change is a major challenge to all forms of agricultural practices (Shafiq et al., 2021). There are an estimated 475 million smallholder farmers (with less than two hectares of land under cultivation) worldwide. Many of these people work in highly hazardous conditions, live in poverty and are food insecure (Gillani et al., 2021). Smallholder farmers form one of the most vulnerable groups to the effects of climate change because of the small farmer being rain-fed, growing in marginal land, and the inability to access complex technology machinery (Kunda, 2022; Yang, Shafiq, Sharif, et al., 2024). It has also been found out that with the rising temperatures in the world, the changing rainfall patterns, and the frequency and severity of extreme weather conditions are disrupting food security and agricultural production (IPCC, 2021). Such effects are particularly devastating in regions that experience more poverty and agricultural sectors that are not sufficiently equipped to withstand climatic shocks.

2.2. Smallholder Adaptation Strategies: Global Perspectives

There are various adaptation measures that have been implemented by small-scale farmers throughout the world in respect of the altered climatic conditions. Among the crucial interventions are crop diversification to decrease the reliance on one type of crop and redistribute production risk; tolerance to drought and heat regarding crop types (Chitongo, 2019). Some of the common adaptation measures adapted by small farms farmers across the globe include crop rotation, utilization of new and improved seeds as well as crop varieties, fertilizer treatment, irrigation, intercropping, and alteration of sowing dates. Reusing soil and water, shifting animal species and breeds, manipulating grazing and reproduction schedules, and employing different and/or acculturated forage crops, other feeds, and concentrates are other adaptation strategies. Adaptation to climate change needs a combination of scientific knowledge with local knowledge and practices (Workalemahu & Dawid, 2021).

Climate change is a major global threat with far reaching impacts on human lives which include effects on ecosystems, production and food security (Wang et al., 2024). Its effects on small scale farmers in the vulnerable regions like sub-Saharan Africa where farmers are not well equipped and able to mitigate effects caused by climatic changes are especially disastrous. This is particularly the case at the Eastern Cape Province where this is still the case even in the current times making it one of the poorest regions in the entire

South Africa and with a strong focus on subsistence farming activities. In this instance, the climate-related issues such as the unpredictable rainfall, extended dry spells, elevated temperatures, and inconsistencies in the growing seasons have endangered the lives of the small scale farmer (Gidi et al., 2024). All SDGs are linked with agroecology which can advance in direct and indirect ways each with the provision of social and technical avenues of changing the global food system. Agroecology has the potential to enhance crop yields and animal production, thereby boosting aggregate farm produced outputs; diversify production to enhance resilience; enhance the resilience of farms to climate change; improve farm incomes and diets; protect biodiversity and the natural resource base; and reduce the vulnerability of farmers to external inputs. All these benefits are essential towards improving the standard of living of the smallholder farmers (Altieri & Nicholls, 2020).

2.3. Determinants of Adaptation Effectiveness

Smallholding farmers often fail to adapt due to high burdens of climatic information, agricultural extension services, and their limited access to these services. This information deficit compromises its long-term resiliency and makes them susceptible to climatic shocks especially in areas like Eastern Cape where small scale farming plays a central role to rural livelihoods and food security. Some of the adaptation strategies that several smallholder farmers in the Eastern Cape have adopted in order to combat the effects of climate change include the diversification of crops, the changing of planting and harvesting time, the use of better water management and in some instances early warning systems. It has also been shown that these strategies can guide farmers to mitigate some of the adverse effects of climate change by increasing their resilience (Gidi et al., 2024). As a research, the indigenous/traditional knowledge systems should be reinvented to enhance adaptive capacities. It will also be important to enhance the participation of women, young people, and other marginalized groups in climate adaption measures through channels of wealth creation such as financial resources, manufacturing, and access to markets. This could entail providing platforms for small-scale producers across larger agricultural landscapes in order to create opportunities beyond the farm level (Fonjong et al., 2024).

2.4. Adaptation Practices in Developed Countries

Water will become a limited resource in the future due to climate change scenarios. Sprinkler irrigation is a particularly effective method of managing maize water in both Brazil and the United States. Sprinkler and drip irrigation systems should be discouraged in the CSA for other cereals in regions with inadequate rainfall and soils that are more susceptible to the delivery system with particular area changes (Azadi et al., 2022). In Europe, sustainable farming practices such as cover cropping, organic farming, and rotational grazing are used to mitigate risks and improve soil health (Altieri & Nicholls, 2020). The most prominent adaptative methodologies US urban farmers adopted were implementation of Community Supported Agriculture (CSA) programs, where members and farmers shared probability of crop failure and provided farms with financial support to produce off-farm income to cover financial loss, and adapting careful site selection that minimized ecological risks (Venu et al., 2023). Those interventions play a role in climate resilience and long-term sustainability.

2.5. Adaptation Practices in Developing Countries

Farmers in Sub-Saharan Africa (SSA) have coped with the extreme effects of climate change through climate-smart farming, which helps them earn a living and plant resilient crops and advanced water and soil management practices. The SSA farmers have been adapting to the severe effects of global warming by embracing climate-smart agricultural methods, blending income, and adopting durable crops and new water and soil management methods. The availability of this technology in SSA and developing economies has been on the increase (Yang, Shafiq, Nazir, et al., 2024). To address climate change, farmers in the Sub-Saharan Africa have restructured their systems of farming by altering

their way of working, how things are done, and their systems. Such changes require the reformation of the approaches, practices, and frameworks (Sinore & Wang, 2025). Tunisia, Niger and the Democratic Republic of the Congo (DRC) are some of the African countries that have adopted low carbon emissions standards at national level as a measure to reduce greenhouse gas emission (UNFCCC, 2023). In the Democratic Republic of Congo, one million hectares of irrigable land will be developed by 2030 and sedentary agriculture will be promoted, increasing the renewable energy capacity of the country to 42.7 MW, as compared to 2.9 MW (Fonjong et al., 2024).

2.6. South African Experiences with Climate Adaptation

The province of E Cape in South Africa is being badly affected by climate change. The Eastern Cape is one of the most susceptible areas in South Africa to climate change and as a result adaptation practices are critical. The South African government acted consequently on the policy-based adaptation by reacting to the negative effects of climate change, on socioeconomic elements and livelihoods (Gadu et al., 2024; Wang, Gillani, Balsalobre-Lorente, et al., 2025). Climate change is a major problem in South Africa both environmentally and socially. In order to address the impact of climate change, the South African government implemented a range of initiatives that resulted in the dissemination of climate adaptation legislation across the branches of government. To understand the landscape of adaptation, the paper explores different climate change adaptation policies and climate policy paradigms (CPP); it also describes and compares how CPP has evolved in South Africa over the years (Khavhagali et al., 2024).

Climate-resilient development, or CRD, is the process of implementing greenhouse gas reduction and adaptation measures to support the sustainable development of all (Wang, Gillani, Sharif, et al., 2025). The concept of CRD has gained more value and South Africa has just recently adopted it. On the mitigation side, however, the progress in reducing South African greenhouse gas emissions mandated by the Paris Agreement of the United Nations and the implementation of these commitments is even slower. Despite ecosystem-based adaptation receiving the highest priority in the National Climate Change Adaptation Strategy of South Africa, its effectiveness remains largely unclear, except its ability to enhance water security (Ziervogel et al., 2022). The drought that struck South Africa in 2015–2016 was another significant occurrence that seriously harmed the country's agricultural industry. For instance, the South African agriculture sector fell 12.6% in the third quarter of 2015, and the provinces of KwaZulu-Natal, North-West, Free State, and Limpopo recorded large losses in livestock. South African farmers suffered damages of up to R10 million as a result of the drought in 2015–2016. The national herd stock fell by 15%, making the livestock industry which includes sheep and cattle one of the most severely affected by the drought. Agrarian communities have occasionally been more affected by drought than non-agrarian communities. Agriculture is the main source of revenue in non-metropolitan populations, and droughts significantly impede this sector (Okolie et al., 2023).

2.7. Climate Adaptation in the Eastern Cape

To assist local communities' livelihoods and cultural customs while promoting the protection of biodiversity and ecosystems, ethnobiologists should collaborate with communities to create and carry out community-based conservation projects grounded in local knowledge. Ethnobiology researchers must create methodological strategies for comparing study data from various places and build macro-scale analyses to actively engage in the global discussion on food security. In addition, better data collection, more innovative distribution methods, and best practices recommendations may be crucial (Albuquerque et al., 2024). The Eastern Cape's CRA practices were mostly focused on agricultural crop and livestock production and management, adopting better agricultural technologies, preventing soil erosion and land degradation, farming returns and other agricultural activities, and household livelihoods. Mabhaudhi et al. (2018) highlighted that given the socioeconomic vulnerabilities in this province, these low-cost and low-input

strategies are especially critical. Bontsa et al. (2024) argue that one of the Sustainable Development Goals (SDG) that requires urgent action to curb the impact of climate change is SDG 13, which can be achieved by adapting to the changing climate. The smallholder farmers in the communal areas of Eastern Cape Province in South Africa are ill-prepared to manage climate change. The main reason is that most smallholder farmers can only use short-term adaptation measures to counter the impact of climate change on agricultural production.

2.8. Evaluating the Effectiveness of Adaptation Strategies

In South Africa, climate change policies do not incorporate IKS which focuses on making societies resilient. The South African government recognizes that climate change negatively affects the process of implementing its sustainable development plans. The government reacted by developing its National Climate Change Response Strategy (NCCRS) in 2011, which spells out the national adaptation and mitigation commitments to achieve the transition to low-carbon development projects and climate-resilient solutions. Despite the fact that some of the main principles of the NCCRS have already been discussed, it is essential to keep in mind that the strategy is aimed at reducing the impacts of inevitable climate change (adaptation) and playing a significant role in the global effort to stabilize greenhouse gas (GHG) emissions (mitigation) 1 3 Climate Change (Nyahunda, 2024). Magesa et al. (2023) used household surveys in Amathole District in Eastern Cape, South Africa to demonstrate that the adaptation strategies employed by smallholder farmers like shifting planting dates, planting crops near water bodies, and planting crops in wetlands were insufficient to overcome the impact of climate change in the region.

Table 2
Below Shows a Comparative Summary Table of Adaptation Strategies from Different Regions that Highlights Both Similarities and Differences

Region	Main adaptation strategies	Similarities	Differences
Global	According to recent literature, governments and individual citizens of the world have adopted both short-term and long-term response strategies to tackle the uncertain aspects of climate change in the world.	At a global scale climate change is a critical issue which requires immediate action.	The level of response and resource availability differs greatly between regions and amongst countries.
Developed Countries	Literature has highlighted that developed countries have adopted GPS and CPA strategies. This supported by a study conducted by	Developed countries have already made efforts through different innovations and technologies	Higher capacity to implement high-tech and institutionalized strategies is required.
Sub-Saharan Africa (SSA)	Studies show that in sub-Saharan Africa, farmers who have adopted one or more CSAPs have experienced yield increase due to the practice (Ogisi & Begho, 2023).	There is a need to enhance advanced technologies in agriculture in vulnerable communities	The region is dependent on external support and lacks access to technology and finance.
Eastern Cape, South Africa	The study by Gidi (2024) et al. indicates that farmers in the Eastern Cape have adopted several measures that include crop rotation (22	The province remains behind in climate change adaptation but is working to address certain needs in farming areas	The factors that determine adaptation vary greatly depending on the context and are impacted by socioeconomic factors.

	percent), the use of improved varieties of crops (20 percent), planting at different times (12 percent) and mulching/fertilizing (12 percent). The determinants of adaptation are age, education, market proximity, extension services, frequency of droughts, perceptions of temperature and precipitation, radio ownership, farm income, size, and family size.		
South Africa	A study conducted by Prasad et al. (2023) demonstrated that the use of heat-tolerant, water-efficient crops, early maturing cultivars, and mixed farming to adjust to the rising temperatures is key in South Africa.	Agricultural adaptation is crucial to addressing climate impacts.	The national strategy highlights cultivar selection and farming changes as key adaption strategies.
Policy Level (South Africa)	The current National CC Adaptation Strategy (NCCAS) requires adaptation to be carried out on all levels of government and enables all relevant stakeholders to manage implications of climate change.	Alignment with global climate policy frameworks and multi-stakeholder engagement is key.	South Africa organized national policy framework and focus on institutional coherence and finance as components of adaption strategy make it unique.

Table 2 lists different regional approaches for adapting to climate change. Although responses differ depending on available resources, both short- and long-term methods are used globally. Developed countries use advanced approaches backed by robust technology, such as GPS and CPA. Smallholder farmers in Sub-Saharan Africa employ climate-smart techniques to increase yields, but they have little access to technology and funding. Farmers in the Eastern Cape use regional techniques like crop rotation and enhanced seed varieties, while socioeconomic considerations have an impact on adaptability. At the national level, South Africa encourages diversified farming and heat-tolerant crops. The NCCAS guarantees coordinated, financially driven adaptation that is in line with international frameworks at the policy level.

3. Methodology

The current study employed a qualitative research design in order to determine the way small-scale farmers perceive climate change and the adaptation strategies that are in use in Mangolong Village. The data were obtained using semi-structured interviews with purposively selected respondents, who were household heads, community leaders, and experienced small-scale farmers who had practiced agriculture over ten years. Magaldi and Berler (2020) highlighted that semi-structured interviews are exploratory interviews that are most frequently used in the social sciences to collect clinical data or for qualitative research. The semi-structured interview allows for exploration, with room to pursue topical trajectories as the conversation progresses, even while it often adheres to a guide or procedure that is developed beforehand and is centered on a central topic to provide a basic structure. This sampling approach ensured rich insights into farmers' views and practices.

A participant in research must be informed of the specifics of the study, such as any potential risks and benefits, in order to be able to give their informed consent. It is a legal and ethical requirement for all research studies involving human subjects. Any study involving human subjects must obtain informed consent, which is both ethical and legally required. Although the concept of informed consent is relatively new, it has become one of the foundations of research (Arellano et al., 2023). In the research the participants were informed about the objectives of the research, the methods of the research, the potential risks as well as the benefits to mitigate the informed consent and confidentiality of the participants. The consent was written or oral, it was ensured that the participant was aware that they could withdraw at any time and there would be no penalty. The use of codes instead of names, anonymity of responses, and secure data storage ensured confidentiality, and this mitigated the concern about data exploitation and ensuring understanding among those who have low literacy levels as ethical concerns. This was mitigated by ensuring the participants that their data will be used strictly in the study, explaining during consent in simple terms and translating articles where necessary.

The face-to-face individual interviews were conducted with 16 interviewees based on a guide prepared focusing on perceptions of climate change and climate adapter measures. Secondary data based on related scholarly publications and official reports were used in conjunction with primary data to give the data some background (Cooper et al., 2003). Thematic analysis is an approach to the analysis of qualitative data. It includes the process of recognizing and describing patterns in a data set and analyzing the patterns in terms of the implied meaning. The examples of these patterns can be located with the help of the analysis of keywords used by participants. The six stages involve generation of the transcript and getting conversant with the data, extracting keywords, coding, theme development, interpretation by ascribing meaning to keywords, codes, and themes, and generation of a conceptual model. These steps serve as a guideline to carefully work on the qualitative data, thus enhancing the rigor of the procedure and the depth of the investigation (Naeem et al., 2023). The study was conducted with the six steps of the thematic analysis prescribed by (Braun & Clarke, 2006).

4. Results and discussion

The study employed a qualitative approach, interviewing 10 small-scale farmers from Mangolong Village to explore their perceptions and experiences related to climate change and adaptation. Furthermore 6 key informants were interviewed to validate the data. Most participants were women underlining their importance to local agriculture despite gender-specific issues like lack of access to land, credit, and agricultural inputs. Such gender relations are critical factors to consider when developing inclusive and equitable adaptation plans to climate change. The findings obtained in the study showed that older people were dominating in smallholder farming. This highlights the impact of rural urban migration where most of the youths migrate to urban centers in search of greener pastures. The erratic rains in the area understudy have resulted in most of the younger generation migrating to Durban, Cape Town and other metropolitan provinces leaving the elderly generation vulnerable.

Household sizes ranged mostly from small to medium, affecting labor availability and farming capacity, which can influence adaptation potential. Income levels among respondents were generally low, constraining their ability to invest in climate adaptation inputs and technologies and increasing vulnerability to climate impacts. Majority of respondents agreed that maize was a dominant crop that is farmed in the region which underscores its importance as a staple and economic crop. Many farmers also engaged in fruit, vegetable, and bean cultivation, supporting nutritional security, economic stability, and agro-ecological sustainability through diversification and intercropping. Breen et al. (2024) stated that as a key component of food security in sub-Saharan Africa (SSA), seed security is essential for enabling farmers to produce food and animal feed, which in turn promotes the production of revenue from agricultural products. Legumes are one of the crops that smallholder farmers can grow that could provide a variety of advantages.

Legumes are rich in nutrients and improve soil health by fixing nitrogen. The creation, distribution, and release of improved legume varieties, however, frequently fall short of what smallholder farmers in SSA require. Thus, farmers in Mangolong Village ought to consider legumes since there are short season varieties and may also generate capital. Crops such as sugar beans and soya beans are vital in generating cash and are also quick to grow (Koussihouèdé et al., 2017). The demographic and agricultural characteristics of Mangolong's small-scale farmers shape their perceptions of climate change and their ability to adapt. Women's significant involvement, aging demographics, education disparities, household labor availability, income inequality, extensive farming experience, and crop diversity all influence vulnerability and resilience. These factors must be considered when designing effective climate adaptation strategies tailored to the community's needs and capacities.

4.1. A Comparative Analysis

Despite the significance of agriculture, most of the farming systems in the region, particularly in sub-Saharan Africa are dependent on rainfall and other limited technological applications. Only 5 percent of arable land in Africa is irrigated as opposed to 14 percent in Latin America and 37 percent in Asia. Most African farmers are also subsistence or small-scale farmers and lack access to information, capital and infrastructure (Magesa et al., 2023). Climate change has affected the smallholder farmers in Ghana immensely despite the measures that have been put in place in the country. Smallholders in Ghana practice the use of inorganic and organic fertilizers, the use of improved crop varieties, legume crop rotations, agroforestry, no-till or reduced tillage practices, the use of cover crops, mulching, integrated pest and water management, non-farm and crop diversification and other indigenous CC adaptation practices (Adeboa & Anang, 2024). Despite not having formal irrigation, Mangolong's farmers have started using creative, low-cost water-harvesting techniques tailored to the region's topography. Unlike many rural areas in sub-Saharan Africa, the community is also experimenting with solar-powered irrigation kits through a donor-supported initiative.

Various adaptation strategies are used by Cambodian smallholder farmers to address the challenges posed by climate change. Choosing cheaper, lower-quality inputs as a safety measure against possible losses is one such strategy. In addition, some smallholders diversify their sources of income by working outside the farm, while others vary their farming operations to mitigate financial risks in the face of shifting climate circumstances. These adaptation strategies align with more general adaptation approaches seen throughout Asia, especially in the areas of financial, agricultural, and farm management. On the other hand, site-specific adaptation strategies vary. Smallholders in Pakistan, for example, have adjusted by introducing water storage and farm diversification techniques, changing crop types and varieties, enhancing seed quality, using fertilizers and pesticides, and planting shade trees (Touch et al., 2024). Compared to Cambodia, Mangolong has fewer options for non-farming employment, even though some farmers have started branching out into chicken farming or casual labour. Mangolong is distinct, though, in that unofficial community savings organizations are starting to form to act as a buffer against disruptions to agricultural income.

Where will the next generation of farmers come from and if smallholder farming has a future are questions that smallholder farmers and those who advocate for smallholder farming futures face everywhere. This collection is a result of the parallels between the difficulties faced by younger farmers in various agricultural contexts in the Global North and the Global South, as well as those faced by older farmers in organizing generational transmission (Cassidy et al., 2019). Through businesses like farmer, WeGro, and Fashol, which have transformed agricultural services by offering e-commerce platforms, smart agriculture initiatives, and real-time advice, Bangladesh has made significant strides in agri-tech. Farmers now have better market positioning and higher productivity because of the innovations' improved supply chain efficiency, expanded market access, and financial assistance. By providing a range of services, such as finance alternatives, market access,

and real-time agricultural guidance, iFarmer is a prime example of smart agriculture. For farmers who need financing for seeds, fertilizer, and other inputs, these services like those offered by Sofol and KriShop are essential. Farmers may increase supply chain efficiency and financial results by using the platform's real-time assistance to make well-informed crop management decisions. Due to cellphones' accessibility and cost, more Kenyan smallholders are using the internet. By facilitating digital communication, facilitating access to agricultural knowledge, and facilitating buyer coordination through marketing platforms, these devices have increased farmers' revenue and productivity. Since many farmers in Mangolong work on informal or borrowed property, land tenure uncertainty is a significant barrier that reduces their desire to make long-term adaptation investments. However, farmers exhibit a strong sense of community and frequently base their actions on their shared understanding of climate change.

5. Perceptions of Climate Change Among Small-Scale Farmers in Mangolong

Climate change is affecting the livelihoods of the smallholder farmers and their agriculture in the Eastern Cape. Smallholder farmers have adopted a range of adaptation strategies to deal with climate change effects on smallholder farming enterprises. Farmers adapt to climate change through a number of adaptation interventions but there are various challenges they encounter that make adaptation difficult (Shiba et al., 2024). These perceptions are critical to the actions of farmers in farming communities as a means of mitigating environmental changes or adopting farming practices.

5.1. Observed Changes in Weather Patterns over the Past Decade

Nearly all respondents reported noticing changes in the weather over the last ten years, consistent with global reports highlighting increased climate variability (IPCC, 2021In South Africa, localized flooding is common in many places. It is necessary to look into whether the likelihood of significant to extreme daily rainfall in South Africa has changed, as climate change is already known to have an impact on rainfall intensity. One potential effect of a changing climate has been identified as modifications, such as intensification, in the hydrological cycle. These shifts may have a variety of societal and environmental effects, particularly regarding the frequency, severity, and length of precipitation episodes (Sun et al., 2025). Flooding events and potential damage to infrastructure that may have been built for a fixed climate are both genuine threats as rainfall events are predicted to intensify (more rainfall over shorter durations) globally in a warming planet (McBride et al., 2022). One farmer explained, "*The rains no longer fall steadily; sometimes it pours heavily in one day and then we get dry weeks.*" Farmers expressed concern about disruptions to planting seasons, with one stating, "*We cannot predict the rains anymore, and that affects when we plant*."

5.2. Effects of Weather Changes on Crop Production

With an estimated total area of 168 966 km2, the Eastern Cape is the second largest province in the country. KwaZulu-Natal's climate is subtropical, while the Western Cape Province has a Mediterranean climate. With a summer rain zone in the east and a winter precipitation zone to the west, the province exhibits a bimodal precipitation pattern. Growing seasons vary across the province because of erratic rainfall seasons. The climate of the province is conducive to agricultural development, particularly the production of crops, vegetables, citrus fruits, and animals (sheep and cattle). Smallholder farmers make up most of the province's population and rely on farming as their primary source of income (Mdoda, 2020). The Eastern Cape Province of South Africa is not an exception to the global threat posed by soil degradation and climate variability to livestock and crop production. On the other hand, not much is known about the indigenous farmers' perspectives and understanding of how soil quality and climate variability combine to affect crop and livestock yield (Nyambo et al., 2023).

5.3. Increase in Pests and Diseases

The output and productivity of animals are greatly reduced by parasites, which in turn reduces the supply of protein-rich food sources. In addition to frequently resulting in significant financial loss and negatively impacting animal wellbeing, parasites are a significant cause of disease and cattle productivity loss. An effective preventative or control measure to slow the tides of high parasitic illness prevalence during season active activity is the regular and appropriate use of insecticides, dewormers, and acaricides to control the parasites in Eastern Cape Province (Jaja & Ungeviwa, 2022). One farmer said, "*Pests attack our crops more than before and we lack means to control them*." This aligns with research showing that warmer climates increase pest metabolism and range expansions, raising food security risks (Bebber, 2015; Deutsch et al., 2018; Sharma et al., 2017).

5.4. Perceptions on Adaptation Capacity and Challenges

In Africa, women own just over one percent of the land. Since their husbands hold most of the property, they will have less decision-making authority and will be unable to change their farming cycles to adapt to changing climatic circumstances. This makes it more difficult for them to react appropriately to flooding and severe weather. Furthermore, as most crops will be exposed to great temperature extremes, the inability to obtain drought-resistant varieties suggests that women are unable to produce high-quality crops (Dibakoane et al., 2022). In many African nations, women's small-scale farming is essential to the supply of food and jobs. Smallholder farming provides food and money for many households in sub-Saharan Africa. Even though many female farmers work on uneven land, they continue to play a significant role in food production and are therefore valued members of the African community. Although women's smallholder farming has a lot of potential, there are some barriers that reduce its effectiveness in reducing poverty and insecurity. Climate change is one of the biggest risks to smallholder farmers on the continent, especially women, because these farmers are most exposed to changing weather patterns (Adeola et al., 2024).

Farmers voiced concerns about limited resources hindering their adaptation. As one noted, "*We want to try new seeds and irrigation but cannot afford the costs*." This reflects documented barriers including lack of access to knowledge and technologies (Deressa et al., 2020; Sloat et al., 2020). An agricultural extension worker highlighted the need for improved communication and support, saying, "*Farmers have traditional knowledge but need better access to climate information."* However, several issues confronting small-scale agriculture are made worse by factors like population growth, soil erosion, water scarcity, and climate change. Over the past few decades, there have been significant technological improvements in agriculture. For small and medium-sized farming businesses, however, access to these innovations has not always been financially feasible (Dhillon & Moncur, 2023). This is the case in the study area where there is limited infrastructure in form of road and transport. This greatly affects farmers to transport their produce to the market. Smallholder women in Mangolong find it difficult to pay for even the most basic farming supplies, such as seeds and implements, let alone contemporary technology. Their income and ability to adapt are further restricted by poor roads and transportation infrastructure, which further isolates them from markets.

Spiritual capital affects agricultural practices. A respondent related climate changes to spiritual or cultural causes, illustrating the socio-cultural dimensions of perception. One farmer shared, "*We believe the climate changes because the ancestors are displeased when the land is not cared for*." Farmers expressed apprehension regarding future climate impacts. One farmer stated that, "*If the rains keep changing, farming will become impossible for the next generation*." Thus, there is a need for inclusive planning and indigenous knowledge-based adaptation practices. According to a participant, "*The majority of smallholder women in Mangolong lack land ownership, which restricts their freedom to decide on crops or seasonal variations. In addition, they do not have access to seeds that can withstand drought, which makes it challenging for them to continue producing during*

dry seasons." Thus, because they perceive farming as becoming less and less viable, women in Mangolong are especially worried about the future of their children. Many people feel left out of the planning procedures intended to address these climate challenges because there are insufficient resources for education and support.

6. Climate Change Adaptation Strategies

Small-scale farmers in Mangolong Village face increasing challenges from shifting climate patterns, including unpredictable rainfall, prolonged droughts, and rising temperatures. To cope, they employ a variety of adaptation strategies aimed at sustaining agricultural productivity and protecting their livelihoods. The understanding that women play an active and significant role in the adaptation processes to climate change is a key takeaway from current CSA programs. Another lesson is that as rural women are key participants in the socio-economic value chain of the green economy, sustainable farming practices might be a good way for them to find work. Successful climate-smart initiatives provide women more influence and enhance their involvement in agriculture. For example, the processing and marketing of agricultural products makes it possible to diversify sources of income. However, more work is needed to ensure that women farmers do not lose out on the advantages of revolutionary changes in the agriculture industry (Adeola et al., 2024).

A common approach is crop diversification. Rather than relying on a single crop, farmers cultivate multiple species to spread risk. One farmer shared, "*I plant maize, beans, and vegetables together because if one fails due to drought, others might still survive.*" This reflects how diversification reduces vulnerability to climate stressors like drought, pests, and floods. Many farmers also reported switching to drought-resistant and climate-resilient crop varieties. As one respondent explained, "*The new seeds can survive when there is less rain, which is happening more now*." Dibakoane et al. (2022) highlighted that crop rotation increases soil health, which enhances crop yields, quality, and food security. The efficiency of the coping mechanisms used by the female farmers is diminished by the absence of greenhouse and irrigation systems. Due to declining rainfall in the majority of the municipality, the farmers should be assisted by the municipality with irrigation systems and greenhouses.

Water management is another key focus. Rainwater harvesting collecting and storing rain during wet periods for use in dry spells was frequently mentioned. A farmer noted, "*I built a small tank to catch rainwater so I can water my crops when the rains fail*." This allows the practice to increase availability of water to irrigate crops, reducing reliance on wildly fluctuating rainfall. Moreover, agroforestry which involves planting trees together with crops was also identified with several advantages. A participant noted that trees contributed in maintaining fertile soil and preventing soil wash when the rain falls intensely, as well as creating biodiversity.

Some of the adaptive measures that have been adopted by most of the smallholder farmers in the Eastern Cape to help them adapt to the impact of climate change are crop diversification, crop staggering, better water management and, in some cases, early warning of weather changes. Farmers can mitigate part of the adverse effects of climate change by adopting the following practices which have shown to enhance resilience. Farmers who are proactive and who can rapidly implement such adaptive strategies will have a better chance of improving crop yields and their overall well-being due to their increased ability to respond to unexpected climate disasters (Gidi et al., 2024).

Farmers also change planting seasons to suit changing weather conditions which may include changing timings of planting using the seasons to avoid drought or excess rain, which may cause destruction of young plants. One of the farmers stated that now he sows later than he did previously since rain arrives late. There is also integration of the conservation agriculture practices such as reduced tillage, leave soil cover and crop rotation to enhance soil moisture and fertility, which enhances long term productivity. Gidi et al. (2024) agree that despite the resilience of the Eastern Cape smallholder farmers, who have

put measures in place in ensuring food security, they require further support in being able to effectively manage risks of the climate and increase agricultural production. Although they are resilient, smallholder farmers in the Eastern Cape need additional support to ensure that they can adapt successfully to climate change. Some of the primary concerns include improving credit access decisions, providing financial support to irrigation and drought-resistant seedlings, and expanding the size of the extension service (Sustainability 2024,16,9986 29 of 32). This is also imperative to overcome psychological barriers such as fear of dwindling rainfall and introduce gender-sensitive policies.

Even with these encouraging moves, there are major obstacles that hinder the adoption of adaptation strategies at large. A significant number of farmers do not have access to quality seeds, fertilizer as well as irrigation infrastructure to ensure that they effectively adapt to climatic changes. A farmer complained, "We would like to apply superior seeds and equipment, but it is too expensive and difficult to access." Lack of access to climate information and extension services further limits the adaptive capacity, another respondent explained, "We are never sure what the weather will do and there is no one to teach us how to prepare against this." Smallholder farmers may be more prone to use rainwater, which decreases agricultural production and food security due to the reputation of South Africa as a water-scarce nation. Due to their dependence on rain-fed farming, inability to access land, abject poverty, low education level, limited access to agricultural extension trainings, and the unavailability of funds to take adaptive actions, smallholder farmers are particularly vulnerable to the effects of climate change (Ogundeji, 2022).

7. Conclusion

This paper reveals the acute problems and adaptation strategies of small-scale farmers in Mangolong village to the current effects of climate change. The results indicate that farmers adopt multiple adaptation measures, including crop diversification, changing planting seasons, soil erosion prevention, fertilizer use, and irrigation, to counteract negative outcomes of weather changes. The adoption and effectiveness of these strategies can however be limited by the lack of access to resources, climate information, training, and institutional support. Traditional knowledge is the most significant source of climate information which highlights the significance of culture-based practices in local adaptation. However, modern communication networks like radios, internet, and farmer cooperatives are also very useful in providing weather and climate information. Even with this, major resources such as agricultural extension services and NGOs are underutilized which signify a lack of outreach and support that limits the adoption of climate-smart practices to a wider audience. The fact that a moderate number of people took part in the community-based adaptation programs and the small percentage of farmers that received formal training suggest that there are significant obstacles to the complete participation and capacity building. These challenges are caused by factors like restricted access to training, distrust of institutions and socio-economic limitations. In general, the study has highlighted the necessity to increase the availability and combination of climate information, extend the work of extension and non-governmental organizations, provide access to cheap irrigation and climate-resistant seeds, promote the involvement of inclusive communities, and expand training programs adapted to the specifics of the region. The needs should be addressed to ensure that small-scale farmers in Mangolong village have adaptive capacity and resilience to secure their livelihoods and ultimately help create sustainable agricultural development in the face of climate change

7.1. Recommendations

7.1.1. Enhance Access to Climate Information

Small-scale farmers should have access to the right climate information at the right time to enable them to make the right decisions that will increase their resilience to climate variability. Both availability and accessibility of climate data should be worked on. This involves investing in infrastructure in rural areas like stable power, mobile phone networks and the internet to increase the coverage of digital tools like weather apps and social

media. Moreover, training would be able to address the digital literacy gaps and therefore enable the farmers to effectively utilize these new channels of information. At the same time, the traditional knowledge systems and mass communication tools like radio, which are still vital to many farmers in remote areas, need to be preserved and incorporated. By integrating scientific predictions with local understanding, climate communication can be more relevant and actionable such that farmers get credible and context-specific advice. According to Gidi et al. (2024), climate change poses a severe threat to global agriculture, and often it lacks any means or expertise to adapt to the small scale farmers. Agriculture in Africa is likely to suffer without effective coping and adaptation strategies, and this will contribute to poverty and food insecurity. The knowledge levels of farmers regarding climate change directly determine their ability to adapt to climate change, yet conflicting literature exists on this aspect. Therefore, policymakers should make sure that the South Africa Weather Services ((SAWS) customizes updates according to the smallholder setting and also invests in the digital infrastructure in the countryside. To reach wider, extension agents should liaise with local radio stations and focus more on training on mobile weather platforms.

7.1.2. Strengthen Agricultural Extension and NGO Presence

Agricultural extension services and Non-Governmental Organizations (NGOs) are crucial in reducing the knowledge gap that exists between research institutions and farmers. To enhance these services, greater funding, training, and personnel are necessary to improve outreach and offer climate-smart agriculture-specific technical assistance. The extension agents are to be updated regularly on the methods of adapting to the climate and be provided with resources that will be able to serve the smallholder farmers to the best of their ability. NGOs can supplement these efforts by introducing grass-roots programs aimed at capacity building, helping to access inputs such as drought-resistant seeds and organic fertilizers, and enhancing community-based adaptation programs. The cooperation of the government extension services NGOs with farmer cooperatives can develop a better network where the support system is more integrated and sensitive to local socio-economic conditions of farmers. The South African government has shown its commitment in supporting farmers by providing them with agricultural extension services as explained by (Mbatha, 2024). The agricultural extension agents were instrumental in helping farmers with the provision of extension services, which included seeds, manure, irrigation plans and farm fence.

7.1.3. Promote Affordable Irrigation and Seed Access

The irrigation system and the crops that mature quickly or are tolerant to droughts are important artifacts of climate adaptation that are not always within reach of poor farmers. The policies and programs must focus on reducing these constraints to access by subsidizing, microcredit, or revolving loan plans that are specific to the smallholder farmer. Adopting inexpensive and water saving irrigation systems like drip or treadle pumps can also aid in maximizing the use of water and minimizing the cost involved. In addition, seed distribution programs must focus on the provision of early maturing and pest-resistant and climate-resistant crop varieties that match the local agroecology. Increasing the capacity of local seed production and involving farmers in the multiplication of seeds can also increase sustainability and decrease reliance by external suppliers. These measures will enable farmers to better manage water scarcity and shortened growing seasons caused by climate change. Thabane et al. (2025) propounded that across the nine provinces of South Africa, the precipitation pattern is erratic and uneven. Agriculture, mining, and other social and economic endeavors in the nation are all facilitated by water resources. However, South Africa lacks water, thus rejuvenation is desperately needed to make more water available. Therefore, there is a need for laws and initiatives that support smallholder farmers' involvement in water management decisions and advance innovative irrigation methods. Coordination between the public and private sectors is necessary for effective solutions. Microfinance institutions which are devoted to climate-smart seed access and irrigation should be established by policymakers. Agroecological zone-specific seed needs should be

mapped by extension services, and certified local cooperatives should distribute the farming inputs.

7.1.4. Encourage Community Participation

Community-based adaptation programs are more effective when they foster broad and inclusive participation. To encourage greater engagement, it is important to identify and address social, economic, and cultural barriers that prevent some farmers from joining these initiatives. This can include providing transportation support, flexible meeting times, or childcare during sessions to accommodate women and marginalized groups. Transparency in program design and benefit-sharing mechanisms helps build trust and ownership among community members. Facilitating the creation of local leadership structures and peer networks empowers farmers to share knowledge, mobilize resources, and advocate collectively for their needs. By strengthening social capital and ensuring that adaptation programs are locally relevant and responsive, participation rates and program impact can be significantly improved. According to Mbatha (2024) establishing agricultural cooperatives that can communicate with other farmers and coordinate with agricultural extension officers when the officials are scheduled to visit them to provide extension services is necessary. It is imperative that policymakers mandate gender and inclusion audits prior to initiating adaptation initiatives. To ensure regular input and collaborative problem-solving, the extension services should co-found local farmer committees.

7.1.5. Expand Training Programs

Training is a key capacity building aspect in empowering farmers to make appropriate changes in their agricultural practices. Training programs should be designed to meet the specific needs and realities of farmers in Mangolong village, incorporating local languages, traditional knowledge, and participatory methods. Topics should cover a wide range of adaptation strategies such as soil conservation, crop diversification, water management, and the use of climate information tools. Practical, hands-on demonstrations and farmer-to-farmer learning exchanges can enhance understanding and uptake. Additionally, linking training programs with ongoing extension services and community initiatives ensures continuous support and follow-up. Addressing barriers such as distance to training centers, costs, and awareness through mobile training units or digital learning platforms can improve accessibility. Expanding and tailoring these programs will help equip farmers with the skills and confidence needed to build resilient agricultural systems under climate stress. Legislators ought to support mobile training programs and require that indigenous knowledge be incorporated into curriculum development. Extension agents are required to plan interactive, seasonal programs in accordance with Mangolong's seasonal farming calendar.

Authors Contribution

Alson Tlhompho Mabaleka: the lead author contributed significantly to the paper through conceptualisation, study design, data collection, presentation and analysis. The study is derived from his Bsc Honours in Geography research project, Department of Biological and Environmental Sciences, Walter Sisulu University, South Africa.
Siyanda Nkwenkwe: together with ATM conceptualised the initial draft of the paper. She was ATM’s main research supervisor, contributed to literature review for this paper and discussion of findings.
Lwanda Matiso: was ATM’s co-supervisor, contributed to development of methodology section for this paper and presentation of findings.
Leonard Chitongo: is the corresponding author who prepared the draft paper. He contributed immensely to restructuring the methodology, results and discussion of the findings. He further attended to all reviewer comments.

Conflict of Interests/Disclosures

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