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Assessing the Contribution of Agricultural Extension Support to Climate-Smart Technology Adoption among Smallholder Farmers in Raymond Mhlaba Local Municipality

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Abstract

Agricultural extension services are widely considered as critical institutional mechanisms in the adoption of climate-smart-technologies (CST) among smallholder farmers. However, smallholders' adoption of climate-smart technologies (CST) remains a challenge. The objective of this study is investigating the role of agricultural extension services in shaping the awareness, perception and the adoption of CST among smallholder farmers in the Raymond Mhlaba Local Municipality, Eastern Cape Province, South Africa. Guided by the Diffusion of Innovations Theory, the study employs the mixed-methods approach, including key informant interviews and surveys to examine smallholder farmers' perspectives, service accessibility, and determinates of the CST adoption. The findings revealed that most smallholder farmers are aware of CSTs practices, the adoption remains uneven due to limited agricultural extension services, coupled with socioeconomic factors, poor infrastructure, age and employments status. These difficulties highlight the need for improved, more targeted well resources and technical responsive extension services to support the adoption of CST to promote climate resilience and sustainable agriculture transformation for smallholder farming communities, in South Africa.

Keywords: Climate-smart technologies, smallholder farmers, agricultural extension services, adoption, Raymond Mhlaba Local Municipality, Eastern Cape Province, South Africa

1. Introduction

South Africa is increasingly vulnerable to the impacts of climate change, with significant consequences for the agricultural sector (Slayi, Zhou and Jaja, 2023). Rising temperatures, erratic rainfall patterns, prolonged droughts, and frequent extreme weather events threaten agricultural productivity, water availability, biodiversity, and rural livelihoods(Gwala *et al.*, 2024). The Eastern Cape Province, characterised by high poverty levels and predominantly rainfed farming systems, is particularly exposed to these climatic risks (Zhou *et al.*, 2022).

Agriculture in South Africa operates within diverse agroecological and socioeconomic contexts, ranging from well-resourced commercial systems to resource-constrained smallholder and subsistence farming (Mdoda *et al.*, 2024). Smallholder farmers in the province face reduced crop yields, livestock losses, and growing food insecurity, compounded by limited access to financial resources, markets, irrigation infrastructure, and climate-resilient technologies(Nocezo *et al.*, 2024).

Smallholder farmers are especially vulnerable to climatic variability due to their heavy reliance on rainfall and limited adaptive capacity (Qange *et al.*, 2025). In areas such as Alice and Port St. Johns, recurrent droughts and flooding have disrupted farming activities, damaged infrastructure, and intensified food insecurity (Bontsa *et al.*, 2023). These conditions highlight the urgent need for adaptation strategies that enhance resilience while sustaining productivity (Mdiya *et al.*, 2023).

Climate-Smart Agriculture (CSA) has emerged as a strategic approach to address the dual challenges of climate change and food security (*BUFFALO CITY METRO MUNICIPALITY SOCIO ECONOMIC REVIEW AND OUTLOOK, 2017*, 2017). CSA seeks to (i) sustainably increase agricultural productivity, (ii) strengthen resilience to climate variability, and (iii) reduce greenhouse gas emissions where possible. Climate-smart technologies (CSTs) including conservation agriculture, drought-tolerant crop varieties, improved grazing management, water harvesting techniques, agroforestry, and climate information services offer practical pathways to achieve these objectives (Lufume, Gwala and Zhou, 2026). However, despite their potential benefits, adoption rates among smallholder farmers remain uneven and often low (Mugandani and Mafongoya, 2019).

Agricultural extension and advisory services play a critical role in facilitating the adoption of CSTs (Popoola, Yusuf and Monde, 2020; Ojo *et al.*, 2021). By serving as a bridge between research institutions and farming communities, extension services disseminate climate information, provide technical training, conduct on-farm demonstrations, and support farmers in adapting practices to local agroecological conditions (Vincent, 2022). Effective extension systems can enhance farmers' knowledge, build adaptive capacity, and improve decision-making under climate uncertainty (Maiwashe-Tagwi and Khoza, 2023). Nevertheless, challenges such as limited extension coverage, inadequate training, insufficient resources, and sociocultural constraints continue to hinder the effective promotion and uptake of climate-smart technologies (Assédé *et al.*, 2024).

While considerable research has examined climate change impacts and CSA adoption in crop systems, less attention has been given to the institutional role of extension support services in influencing technology uptake among smallholder farmers in vulnerable rural municipalities (Mbelebele *et al.*, 2024). Understanding how extension services shape awareness, perception, and adoption of climate-smart technologies is therefore critical for strengthening adaptation strategies (Gidi *et al.*, 2024).

Against this backdrop, this study evaluates the role of agricultural extension support services in promoting the adoption of climate-smart technologies among smallholder farmers in Raymond Mhlaba Local Municipality, Eastern Cape Province (Gwala, Monde and Muchenje, 2016). The findings aim to contribute to policy and practice by identifying institutional and capacity-related factors that influence climate adaptation in smallholder farming systems(Manyike, Taruvinga and Zhou, 2025).

2. Methodology

2.1 Study Area

The Raymond Mhlaba Local Municipality in the Eastern Cape, South Africa, is where this study was carried out. Alice experiences warm, rainy summers, brief, mild, dry, and windy winters, and mainly clear skies all year round. Rarely does the temperature fall below 39 °F or rise above 93 °F throughout the year; it usually ranges between 45 °F and 83 °F. The optimum time of year to visit Alice for warm weather activities is from late November to late April, according to the tourism

score (Amoussohoui *et al.*, 2023). Backyard farming was the norm for Alice farmers, who farmed their crops for their families' consumption rather than for commercial sale (Gyimah *et al.*, 2020).

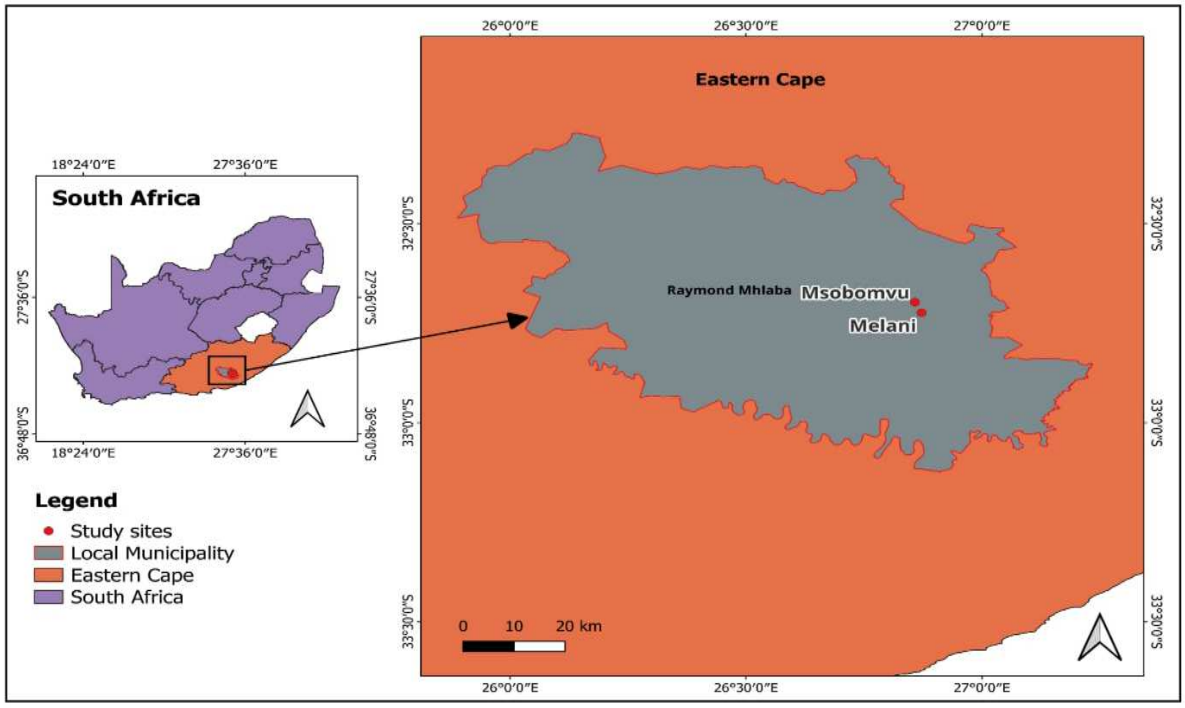


Figure 2.1 Map of the Study Area

Other studies conducted in the Eastern Cape Province found that many small-scale farmers who were served by government extension agents only interacted with them once or twice over the course of a 12-month period (Aliber, 2019). The vegetation shifted from forest to thorn trees, scrubs, and poor grass cover due to high summer temperatures, evaporation, and low rainfall. Two communities—Msobomvu and Melani—were chosen at random from the Raymond Mhlaba Local Municipality. IsiXhosa was the main language used by the locals in both settlements (Census, 2011).

2.2 Research Method

The quantitative research methodology, which is focused on the methodical gathering and statistical analysis of numerical data, was used in this study. The goal of quantitative research is to measure the correlations between variables and make it possible to extrapolate results from a

sample to the entire population. It usually makes use of structured instruments like questionnaires, surveys, or statistical datasets and is based on objective measurements and analysis through the use of computer, statistical, or mathematical methods.

2.3 Research Design

The study adopted a descriptive research design whereby a wide range of methods for data collection, such as questionnaires, surveys and interviews, were used to obtain accurate results from small-scale farmers in the study areas

2.4 Sampling Method and Procedure

Random sampling was used for small-scale farmers. As the name suggests, random sampling literally means selecting the sample randomly from a population without any specific conditions. This was done by selecting the sample from a list obtained from both the community leaders and DRDAR Offices in Alice, such as a directory, or physically at the location of the survey.

2.5 Sample Size

Using a conventional sample size calculator, the Taro Yamane formula was used to calculate the sample size: n=N1+N(e)2n = \frac{N} {1 + N(e)^2} n=1+N(e)2N. The variation in sample sizes depending on various confidence levels and intervals was investigated using a standard sample size calculator for the villages surrounding Alice, Msobomvu, and Melani. The margin of error, another name for the confidence interval, can be either positive or negative. This is the range where there is a chance of a reaction. +/- 5 was the most often utilized confidence interval. For a population of 260, the sample size would be 158 if a 95% confidence level and a 5% confidence interval were used (Statistics South Africa, 2022). This population estimate was further verified through information obtained from the DRDAR office and community leaders. Where N represents the total population size, which in this study is 260 small-scale farmers. PN represents the required sample size after applying the confidence level (95%) and margin of error (5%). Using the above formula, the calculated sample size is PN = 158.

$$PN= \frac{N}{1+N(0,05)2}$$

Where N= 260

$$PN = \frac{260}{1+260(0.05)2}$$

PN = 158

2.6 Data Collection and Tools

Semi-structured questionnaires that were given out during interviews were used to gather data. The survey's objectives were to assess farmers' knowledge and comprehension of climate-smart technologies (CSTs), learn more about the variables affecting their uptake, and pinpoint the difficulties farmers have when putting CSTs into practice. The survey examined how important agricultural extension services and technology are in helping small-scale farmers in Msobomvu and Melani villages deal with the effects of climate change. The participants were questioned regarding climate change, how it affected their farms in terms of producing for sale, and how agricultural extension services on climate-smart technologies can help small-scale farmers. Farmers' knowledge on how to use modern farming technologies was assessed using a five-point Likert scale. A 5-point Likert scale (strongly disagree, disagree, neutral, agree, strongly agree) was also used in the study to collect respondents' opinions, attitudes, and degrees of agreement or disagreement with a variety of statements pertaining to agricultural extension services and climate-smart technologies (CSTs). Information from the participants was recorded on their phones.

2.7 Data Analysis

In order to identify patterns of resemblance and difference among participants and groups, the researcher used theme analysis to analyze the data. To find themes or categories of responses, the recordings were transcribed, and content analysis was done. The quantitative data was also analyzed using descriptive statistics (using the SPSS software program). Demographics, Farm Features, Technology Awareness and Use, Agricultural Extension Service Access, and Difficulties Descriptive statistics were used to analyze the variables. To find out if farmers who regularly engage with extension services are more knowledgeable about climate-smart technologies than those who have less access, cross tabulation was employed. Institutional Constraints Affecting CST Adoption were examined using binary regression, with $*p < 0.05$ and $**p < 0.01$. To demonstrate a substantial difference, a p value of $**p < 0.01$ is considered extremely significant.

2.8 Ethical Clearance Statement

Ethical approval for the study was obtained from the University of Fort Hare Research Ethics Committee prior to data collection (GWA011SLUF01). Permission to conduct the study was granted by the Eastern Cape Department of Rural Development and Agrarian Reform (DRDAR), local municipal authorities, and community leaders. Participation was voluntary, and informed consent was obtained from all respondents before interviews commenced. Participants were assured of anonymity, confidentiality, and their right to withdraw from the study at any stage without penalty.

3. Results and Discussion

The results of a survey that was carried out to evaluate agricultural extension services in the adoption of climate-smart technologies among small-scale farmers in the communities of Msobomvu and Melani in the Eastern Cape province's Raymond Mhlaba Local Municipality are presented in this chapter. The socioeconomic traits of small-scale farmers are discussed in this chapter. Data on CC, information sources, farming activities, land ownership, household demographics, income sources, farm management techniques, climate adaption, and extension services. Understanding the type and quality of extension services, climate mitigation tactics, and obstacles faced by farm beneficiaries in these villages, as well as the adoption of climate-smart technologies by small-scale farmers, is made possible by the variables outlined.

3.1 Demographic profile of small-scale farm household heads in Melani and Msobomvu

Significant demographic trends among small-scale farmers in Melani and Msobomvu are revealed by the current study (Table 3.1). Gender composition, age distribution, marital status, household size, education level, work status, and household income sources all differ significantly.

Important information on the demographic makeup of smallholder farmers engaged in agricultural activities may be gleaned from the age distribution of respondents from Msobomvu and Melani communities. The majority (73 respondents, 46.2%) of the 158 respondents who took part in the poll were over 60. This suggests that elderly people are the ones who farm the most in both villages. Due to physical constraints and limited access to digital resources, this group was less likely to

embrace novel and creative techniques like climate-smart agriculture (CSTs), despite the fact that they provide invaluable indigenous knowledge.

This demonstrates that the sector is dominated by elderly people, as the average age of farmers in both communities is roughly 55 years old. The variance and standard deviation, which were computed using the following formulas, were also used to evaluate the variability in the age distribution: $[\Sigma f(x - \text{mean})^2] / N = \text{Variance } (\sigma^2)$ and Standard Deviation $(\sigma) = \sqrt{\text{Variance}}$

Considering the information: Standard Deviation = -129.11 ≈ 11.36 years, Variance = 129.11

Although the farmer population is older, there is still a discernible age distribution, according to this moderate standard deviation. Regarding particular age groups, 35 respondents (22.2%) fell into the 50–60 age range, indicating a sizable portion of farmers who are still in the workforce and may be more receptive to new ideas. Younger farmers are underrepresented, meanwhile, with only 27 respondents (17.1%) in the 30- to 40-year-old age group and 23 respondents (14.6%) in the 40- to 50-year-old age group. In terms of generational continuity and the long-term viability of the local agricultural sector, this represents a worrying trend.

Overall, the age group results indicate that both Msobomvu and Melani villages have a noticeable aging farming population. The need for focused interventions that assist senior farmers and promote youth involvement is highlighted by the mean age of 55 years and the standard deviation of 11.36 years. Younger farmers are more inclined to adopt new techniques if given the necessary encouragement, training, and incentives, therefore this age distribution is probably going to have a big impact on the adoption of CSTs.

Table 3: Mean Age and Standard Deviation (Mean ± SD) of Respondents in Msobomvu and Melani Villages n=158

Age Group	Frequency (f)	Midpoint (x)	fx	Mean	X-Mean	(x - mean)² × f	Standard Deviation

30	≤*x*<	27	35	945	55	-20	$(35 - \mu)^2 \times$ 27= 10800	11.36
40								
40	≤*x*<	23	45	1035	55	-10	$(45 - \mu)^2 \times$ 23= 2300	11.36
50								
50	≤*x*<	35	55	1925	55	0	$(55 - \mu)^2 \times$ 35= 0	11.36
60								
≤ 60		73	65*	4745	55	10	$(65 - \mu)^2 \times$ 73= 7300	11.36
Total		**158**	—	**8650**			$\Sigma(x - \mu)^2 \times$ f= 20400	11.36

Source (field survey 2024)

Distribution of Gender

Between the two villages, there were notable differences in the distribution of genders. Male farmers made up 52.9% of the farming population in Melani, while female farmers made up 47.1%. The farming population in Msobomvu, on the other hand, was primarily female, with 90.1% of farmers being female and only 9.9% being male. This discrepancy raises the possibility of gendered patterns in agricultural engagement, which could be impacted by socioeconomic circumstances, cultural norms, or migration.

Status of Marriage and the Make-Up of the Home

In Melani, the majority of farmers (54.0%) were married, followed by divorced farmers (34.5%) and widowed farmers (11.5%). There was a greater percentage of single and widower farmers in Msobomvu, with 39.4% of the population being married, 31.0% being divorced, and 23.9% being widowed. These patterns might be a reflection of more general demographic trends, such as migration, mortality rates, or family structure-altering economic constraints.

In both villages, household sizes were comparatively comparable. In Melani, households with 1–5 people made up 78.2% of all households, and households with 6–10 people made up 21.8%. With 71.8% of households consisting of 1–5 people and 28.2% of households consisting of 6–10 people, Msobomvu had a somewhat greater percentage of larger households. Food security and

the availability of agricultural labor are significantly influenced by household size, especially in smallholder farming systems.

Status of Education and Employment

Farmers in the two villages have varying levels of schooling. In Melani, 46.0% of farmers had finished primary school, 37.9% had finished secondary school, and 16.1% had no formal education. While no farmers in Msobomvu reported having no formal education, a somewhat greater percentage of farmers had formal education, with 54.9% having primary education and 45.1% having secondary education. In Msobomvu, higher education levels might facilitate better knowledge sharing, easier access to extension services, and the uptake of better farming practices.

Both settlements have a large number of unemployed farmers. "Household head source of income," Table 3.1, lists the primary sources of income for household heads, which are divided into social grants, farming, and other sources. About 140 households rely on social grants, according to the data, indicating a substantial reliance on them. On the other hand, slightly over 10 households have other sources of income, while less than 20 households depend on agricultural operations. This glaring disparity demonstrates the community's substantial reliance on government aid, pointing to a socioeconomic environment in which social subsidies are essential to maintaining household incomes.

The economic difficulties in these neighborhoods are further highlighted by employment status. Just 14.9% of farmers in Melani were part-time farmers, while 85.1% of farmers were unemployed. All of the farmers in Msobomvu were unemployed, demonstrating a total reliance on agriculture or unofficial work for survival. Despite its structural and financial limitations, farming appears to be a vital source of income, as indicated by these high unemployment rates.

Sources of Household Income

Social grants were the main source of household income, especially in Msobomvu, where 95.8% of farmers depended on them, as opposed to 73.6% in Melani. With just 14.9% of farmers in Melani and an even lower percentage in Msobomvu earning a living from farming, agricultural

income was comparatively low. Furthermore, 4.2% of farmers in Msobomvu and 11.5% of farmers in Melani reported receiving money from other sources. The majority of households' high reliance on handouts may be attributed to issues including poor market access, scarce resources, and dangers associated with climate change.

An overview of the main conclusions

Understanding the socioeconomic dynamics and creating inclusive agricultural initiatives to help small-scale farmers in these areas depend heavily on these demographic facts. The results emphasize how crucial it is to take age, marital status, and gender into account when implementing policy changes in order to properly meet the needs of small-scale farmers.

According to the findings, Melani has a more evenly distributed gender distribution and a comparatively younger population than Msobomvu, which has an aging and predominately female farming community. Many of the farmers in both villages depend on social grants as their main source of income due to the high unemployment rates. Msobomvu has somewhat greater levels of education, but the country's reliance on agriculture is still mostly substance-based, with little involvement in farming. The findings point to the necessity of focused initiatives to raise agricultural output, assist younger farmers, and encourage economic diversification in order to improve rural livelihoods.

Table 3.1: Demographic profile of small-scale farm household heads in Melani and Msobomvu n= 158

	Melani	**Msobomvu**

Demographic characteristic	Category	Number	Percentage	Number	Percentage
Gender	Male	46	52.9	7	9.9
	Female	41	47.1	64	90.1
Marital status	Single	----	-----	4	5.6
	Married	47	54.0	28	39.4
	Divorced	30	34.5	22	31.0
	Widower/Widow	10	11.5	17	23.9
The number of people per household	1-5	68	78.2	51	71.8
	6-10	19	21.8	20	28.2
Highest education	No formal education	14	16.1	------	------
	Primary education	40	46.0	39	54.9
	Secondary education	33	37.9	32	45.1
Employment status	Unemployed	74	85.1	71	100.0
	Part time farmer	13	14.9	------	------
Household head income	Social grants	64	73.6	68	95.8
	Agricultural activities	13	14.9	------	-------
	Other	10	11.5	3	4.2

3.2 Land ownership and use in Melani and Msobomvu villages n=158

About 15% of farmers in both communities used communal land for farming, while 80% of farmers used freehold land (Figure 3.1). An overview of the various forms of land ownership among the 158 respondents is shown in Figure 4.1, which makes a distinction between communal ownership (land held by the community) and freehold ownership (land owned by the farmer). The findings showed that 84.2% of respondents, or a significant majority, owned land in a freehold manner, accounting for 84.2% of the total (Figure 3.1). This demonstrates the frequency of

individual land ownership in the sample by showing that the majority of respondents (80%) had complete ownership rights over their land. Conversely, only 15.8% of those surveyed were landowners. This discrepancy highlights the population's strong preference for freehold ownership.

This thorough analysis highlights the respondents' predominance of freehold ownership, indicating that while communal ownership is existent, it has a smaller function in the community's land tenure structure than private property ownership.

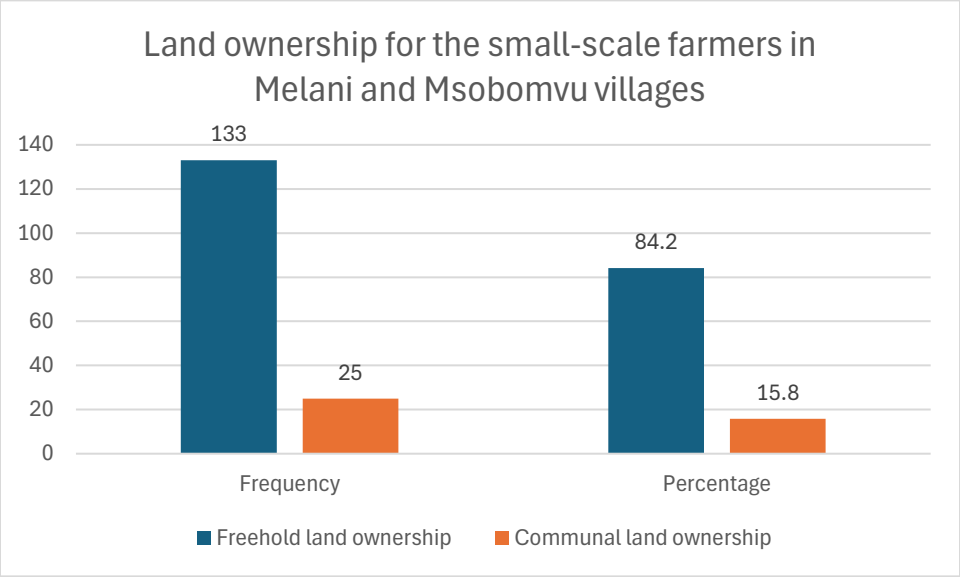


Figure 3.1 Land ownership for the small-scale farmers in Melani and Msobomvu villages Author's field data (2024)

3.2.1 Farming activities in Melani and Msobomvu

Crop production, livestock production, and mixed farming are the farming activities broken down in the figure 3.2. The findings showed that the two villages' farming methods differed significantly.

In both villages, the most prevalent agricultural method was mixed farming, which blends the production of crops and the rearing of livestock. But in Melani Village, where 73.6% of farmers practiced mixed farming, it was more widely adopted than in Msobomvu, where 50.7% did. This

implied that Melani farmers were more likely to use varied farming practices, possibly as a way to reduce their exposure to the unpredictable effects of climate change.

Another common activity was raising cattle, especially in Msobomvu Village, where 45.1% of the farmers were livestock farmers. In comparison, cattle husbandry was the primary emphasis of just 11.5% of Melani's farmers. Different biological circumstances, grazing land availability, or socioeconomic reasons influencing farmers' decisions could have all contributed to this discrepancy.

In both villages, growing crops was the least common farming activity. Just 4.2% of farmers in Msobomvu were entirely involved in agricultural farming, compared to 14.9% of farmers in Melani. The greater percentage of crops produced in Melani as opposed to Msobomvu may have resulted from improved irrigation availability, more conducive soil conditions, or local government and non-governmental organization support for agricultural cultivation.

Overall, the findings indicated that whereas Msobomvu showed a greater emphasis on cattle production, Melani's farming systems were more varied, with a larger prevalence of mixed farming and crop production. These results demonstrated the value of specialized agricultural extension services that were tailored to the unique requirements of every community, guaranteeing that farmers received focused assistance for their primary farming pursuits.

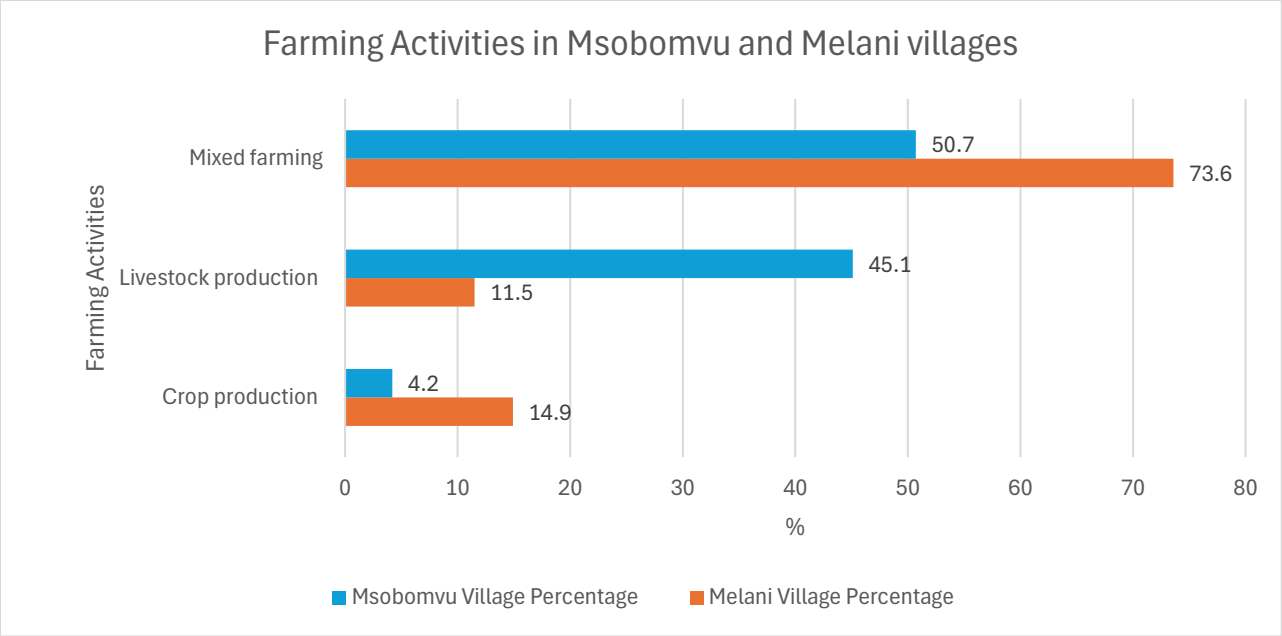


Figure 3.2 Farming activities in Melani and Msobomvu villages :Author's field data (2024)

3.2.2 Crops produced in Melani and Msobomvu villages

The distribution of crops grown in Msobomvu and Melani villages is shown in Figure 3.3, which also shows the percentage of households that produce crops as opposed to those that concentrate on animal husbandry, as well as variations in crop choices.

The findings show that 45.9% of the households in Msobomvu Village mostly focused on livestock farming rather than agricultural cultivation. 38% of those who grew crops used companion planting, which involved growing beetroot, potatoes, and cabbage together. Just 16.9% of farmers grew maize, making it the least prevalent crop.

On the other hand, the proportion of households in Melani Village that did not produce crops was lower (11.5%). Companion planting, which includes crops like potatoes, beetroot, and carrots, was used by most farmers (40.2%). Compared to Msobomvu, Melani had a higher percentage of farmers who grew maize (28.7%). Additionally, compared to Msobomvu, where this practice was not documented, 19.5% of farmers in Melani grew cabbage as a stand-alone crop.

According to the findings, Melani Village adopted crop production more extensively than Msobomvu, with a higher percentage of farmers cultivating maize and cabbage. A greater

traditional reliance on livestock as the main source of income and fewer conducive conditions for crop cultivation are indicated by the larger proportion of farmers in Msobomvu who only produce cattle. These results underline the necessity of focused agricultural assistance programs that take into account the farming preferences and limitations unique to each village in order to improve sustainability and production in both domains. Companion planting's prevalence suggests that local farmers are aware of the advantages of biodiversity in agriculture, including better crop resilience and pest control (Mutengwa, Mnkeni and Kondwakwenda, 2023). In addition to depicting the present level of crop production, this graph might also provide insight on changing regional agricultural patterns.

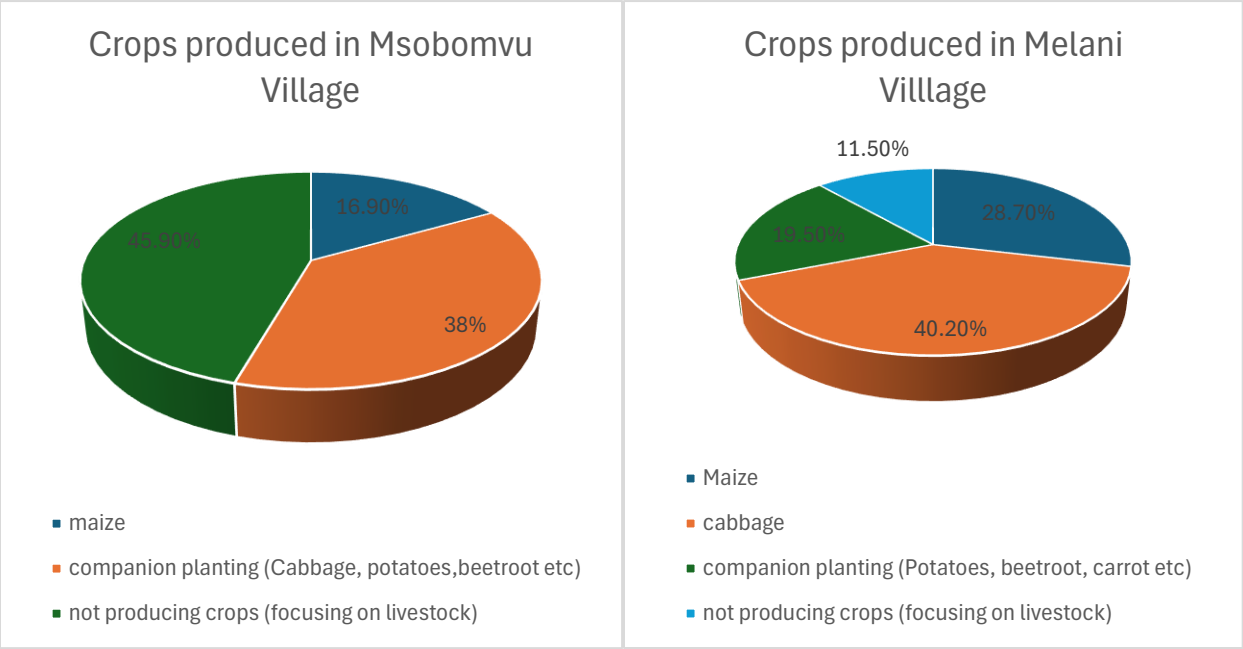


Figure 3.3 Crops produced in Msobomvu and Melani Villages

Source: Author's field data (2024)

3.2.3 Livestock reared in both villages

The distribution of livestock agricultural activities in Msobomvu and Melani villages is shown in the table 3.3, which also highlights the kinds of livestock kept and the percentage of farmers engaged in animal husbandry. The findings show that the two villages differed in their degrees of engagement and livestock preferences.

While 29.6% of farmers in Msobomvu Village maintained cattle, 45.1% kept goats. Furthermore, 21.1% of the farmers engaged in general animal husbandry, which could involve caring for several livestock species or other associated tasks. The percentage of Msobomvu farmers who did not raise cattle was 4.2%.

On the other hand, a significantly higher percentage of farmers in Melani Village kept goats (48.3%), whilst a smaller amount reared cattle (25.3%). Just 11.5% of Melani's farmers were involved in general animal husbandry, which is almost half of Msobomvu's percentage. Interestingly, a higher percentage of farmers in Melani (14.9%) did not raise animals, indicating a stronger preference for other agricultural pursuits like crop production.

With a larger percentage of goat farmers in Melani, these findings imply that goat farming was the predominant animal enterprise in both communities. Msobomvu's greater involvement in general animal husbandry might be a sign of a more varied approach to livestock management. Environmental variables, market accessibility, cultural preferences, or institutional support for particular livestock farming practices could all have an impact on the variations in livestock engagement.

Future extension efforts could concentrate on increasing livestock productivity, offering training on animal health management, and investigating market opportunities to improve farmers' livelihoods. These findings highlight the need for targeted livestock support programs, given the disparities in animal husbandry participation between the two villages.

Table 3.3 Livestock kept in Melani and Msobomvu villages n=158

Livestock kept in Msobomvu Village		
	Frequency	**Percentage (%)**
Farmers who kept Goats	32	45.10
Farmers who practice animal husbandry	15	21.10
Farmers who kept Cattle	21	29.60

Farmers who were not involved in livestock	3	4.20
Livestock kept in Melani Village		
Farmers who kept Cattle	22	25.30
Farmers who practice animal husbandry	10	11.50
Farmers who kept Goats	42	48.30
Farmers who were not involved in livestock	13	14.90

Source: Field survey 2024

3.3 Farmers' knowledge and understanding about climate change in Msobomvu and Melani

In both villages, the vast majority of farmers (99.99%) were well-versed in the effects of climate change. This high degree of knowledge implies that these groups are aware of the problem of climate change, possibly because it directly affects their means of subsistence. Farmers' firsthand experience with shifting weather patterns, crop yields, and livestock illnesses and deaths were cited as significant factors to their wide knowledge. Farmers also proposed that strong community engagement for information sharing, successful educational programs by governmental and non-governmental organizations, interactive media discussions, and climate resilience-focused policies from local authorities would help people learn more about and comprehend climate change. This high degree of comprehension is essential because it helps farmers adjust to shifting conditions, adopt sustainable practices, and support larger efforts to mitigate climate change. It also emphasizes the significance of ongoing education and assistance to guarantee that farmers can effectively address the challenges presented by climate change.

Based on a poll, Table 3.4 summarizes the farmers' perceptions about climate change. It divides their answers into three primary groups: variations in rainfall and temperature, meteorological conditions, and extended weather that predominates in a particular location. Sixty-one percent of the 158 respondents thought that climate change was a change in the weather. Temperature and precipitation variations were linked to another noteworthy percentage (33.5%). A lower percentage (6.3%) thought of it as extended weather that was prevalent in a particular location. These results

show that although most people understand climate change in terms of shifting weather patterns, many farmers are also aware of how it affects rainfall and temperature.

Table 3.4 Farmers' understanding of climate change n=158

Category	Frequency	Percent
Changes in temperature and rainfall	53	33.5
Change weather conditions	95	60.1
prolong weather that prevails in a certain area	10	6.3
Total	**158**	**100.0**

3.4 Climate Information Sources and Their Influence on Farmers' Adaptation to Climate Risks

According to Table 3.5, which shows the main sources of climatic information for farmers, radios were used by a sizable majority of them (91.8%). In comparison, only 8.2% of people watched television to learn about the climate. These numbers demonstrate how radio is the most popular medium for informing farmers about climate change, presumably due to its accessibility, reach, and usefulness in rural areas.

Table 3.5 Climate information sources n=158

Category	Frequency	Percent
Radio	145	91.8
Television	13	8.2
Total	158	100.0

3.4.1 Coping strategies for disasters associated with climate change in Melani and Msobomvu

The findings from farmers in the communities of Melani and Msobomvu provide insight into how they cope with climate change-related calamities. The percentage of farmers implementing different strategies to lessen the effects of climate-related issues is shown in Figure 3.4. These tactics include managing soil fertility, conserving water, managing cattle, and implementing grazing systems that are sensitive to changes in the environment.

Melani Village

Crop rotation, cattle dipping, rotational grazing, and drip irrigation are the four primary coping mechanisms found in Melani village. The most common approach, used by 45% of farmers, is dipping cattle. This tactic emphasizes how crucial animal resilience and health are in times of calamity like droughts or disease outbreaks. Another important tactic to enhance soil health and lessen susceptibility to insect outbreaks, which are made worse by climate variability is crop rotation, which is used by 29% of farmers.

15% of farmers use drip irrigation, which is a sign of a shift toward water-efficient technology to deal with unpredictable rainfall and protracted dry spells. With 11% adoption, rotational grazing shows efforts to maintain sustainable pasture resource use and reduce land degradation, both of which are frequently threatened by climate change.

Msobomvu Village

Crop rotation, water harvesting, and livestock dipping are the three main tactics that farmers in Msobomvu village concentrate on. With 49% of farmers implementing this prevalent practice, deeping cattle highlights the community's reliance on livestock as a vital resource in times of duress. Thirty percent of farmers use water collection, which addresses water scarcity and increases drought resistance as a proactive response to climate change. agricultural rotation, which makes up 21%, is still a crucial tactic for preserving soil fertility and lowering agricultural production risks associated with climate change.

Comparative Analysis

The findings show that dipping is a major coping mechanism in both villages. This emphasizes how important cattle are as a safety net against climate-related calamities like floods, droughts, and extreme weather.

Melani farmers prioritize rotational grazing (11%), and drip irrigation (15%), indicating an attempt to use contemporary and sustainable methods to address climate-related issues. On the other hand, Msobomvu farmers employ more traditional techniques, like water harvesting (30%), which reflects a regional strategy for coping with water scarcity and lessening the effects of drought.

Implications for Climate Change Adaptation

Farmers' coping mechanisms in both villages are a reflection of their distinct socioeconomic circumstances, resource availability, and environmental environments. Although dipping is a primary tactic in both societies, supplementary methods could be more widely adopted.

To strengthen resilience, the following recommendations are suggested:

1. **Expand Access to Climate-Smart Technologies**: Introduce and support technologies like drip irrigation and improved water harvesting systems in both villages to enhance water-use efficiency.
2. **Promote Sustainable Land Management**: Provide training on rotational grazing and crop rotation to reduce land degradation and maintain soil productivity under changing climatic conditions.
3. **Enhance Extension Services**: Build capacity through agricultural extension programmes to educate farmers on modern coping strategies tailored to their specific climate-related risks.

Farmers in Melani and Msobomvu communities can better adapt to the challenges presented by climate change by supporting these measures, protecting their livelihoods and guaranteeing sustainable agricultural practices going forward.

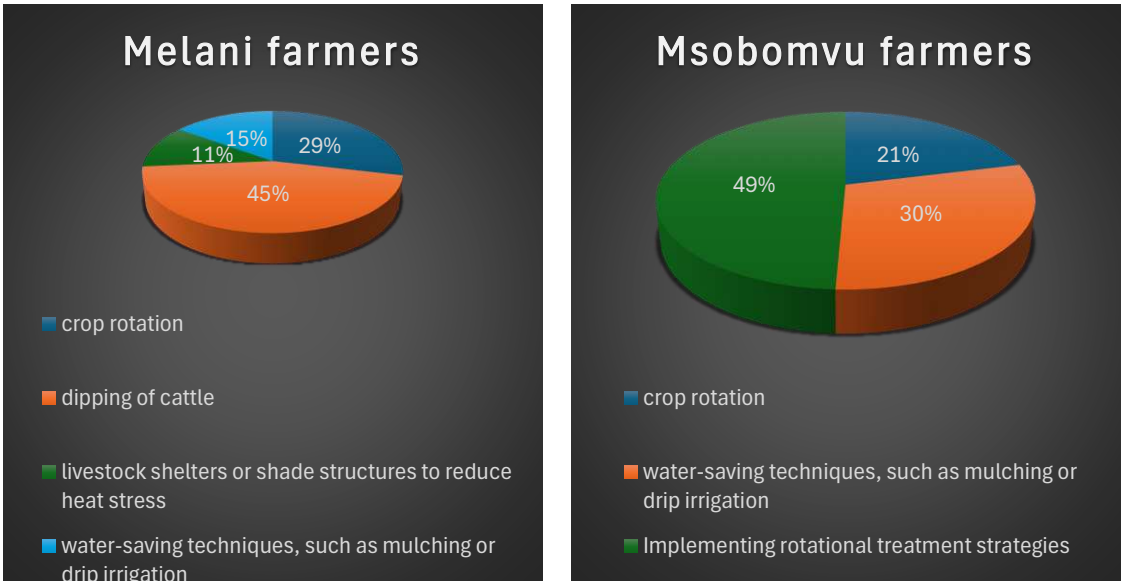


Figure 3.4 Coping strategies for disasters associated with climate change in Melani

Source: Author's field data (2024)

3.4.2 Adaptation strategies for disasters associated with climate change in Melani and Msobomvu

The adaptation tactics used by farmers in Melani and Msobomvu communities in response to climate change-related events are depicted in Figure 3.5 below. The findings emphasize significant distinctions in the ways that farmers in the two communities reduce the risks associated with climate change, showing differing degrees of adoption of various methods.

With a frequency of 60 and a corresponding percentage of 38%, water harvesting was the most commonly used adaptation approach. This implies that the farmers in both communities understand the value of conserving water in order to mitigate the effects of climate unpredictability, especially when it comes to guaranteeing water availability for crops and livestock.

With a frequency of 21 (13.3%), irrigation was embraced by fewer farmers, suggesting that financial limitations and restricted access to irrigation infrastructure hinder the strategy's widespread adoption. Likewise, 20 farmers (12.7%) practiced routine cow dipping, which is crucial for managing livestock health in the face of shifting climatic conditions.

Integrated methods to climate resilience are not yet commonly used, as seen by the tiny percentage of farmers (13, or 9%) who reported combining all adaptation measures. With 32 farmers (20.3%) implementing the practice, veld rotation, a technique to protect grazing pastures and lessen overgrazing was more widely employed. This emphasizes how important sustainable grazing management is as a crucial tactic for livestock producers.

22 farmers (13.9%) used destocking, which is lowering the number of animals to avoid resource depletion during droughts or other climate-related disasters. The use of destocking implies that some farmers were responding to climatic uncertainty by proactively modifying the number of their herds.

Overall, the findings show that veld rotation and water collection were the most widely used tactics, but integrated techniques were less often used. In order to improve climate resilience in both villages, these findings highlight the necessity of focused agricultural extension programs that support a variety of adaptation techniques. To successfully reduce climate-related risks, future interventions should concentrate on expanding access to irrigation facilities, supporting sustainable livestock management, and fostering the adoption of various climate adaption strategies.

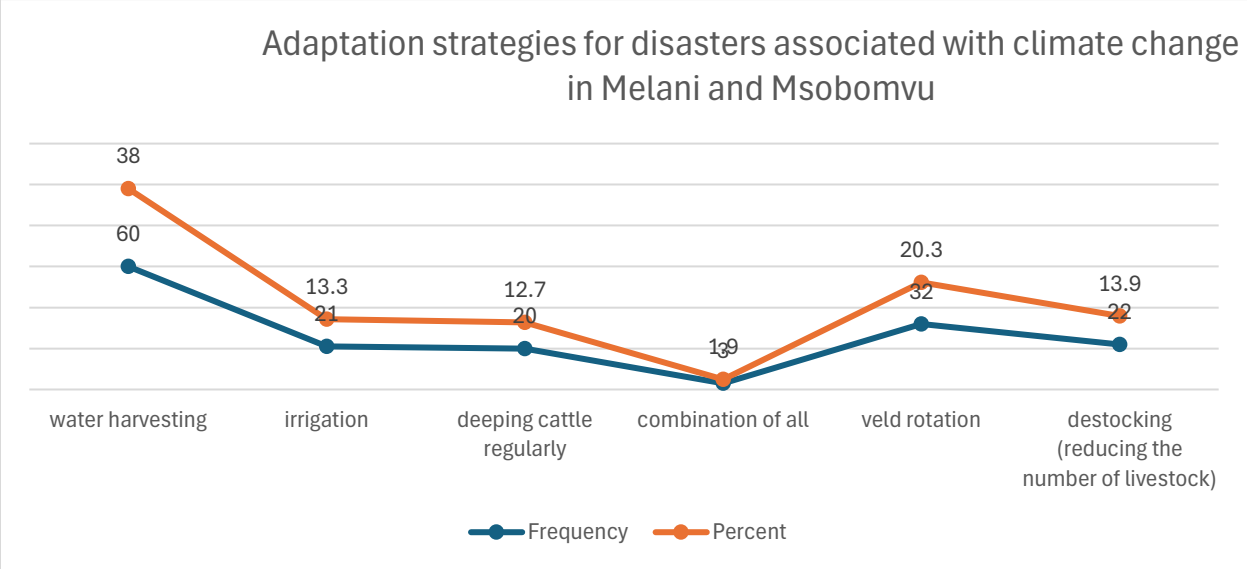


Figure 3.5 Adaptation strategies for disasters associated with climate change in Melani and Msobomvu

Source: Author's field data (2024)

3.5 Discussion

The findings reveal that the majority of respondents reported having no formal relationship with extension officers, indicating a significant communication and engagement gap between smallholder farmers and public extension services. This lack of interaction suggests limited extension coverage, inadequate follow-up, or weak institutional presence at the community level. In contexts where smallholder farmers rely heavily on external advisory support to navigate climate variability and technological change, such limited engagement may directly constrain the adoption of climate-smart technologies (CSTs).

Interestingly, among the minority of farmers who reported having a relationship with extension officers, the interaction was described as friendly and informal rather than strictly professional. While this may reflect trust and social cohesion between farmers and extension personnel, it may also indicate the absence of structured, performance-driven advisory support. Effective extension systems require both relational trust and technical guidance. When interactions remain largely social, without consistent technical backstopping, training, or monitoring, their impact on technology uptake may be limited.

These findings align with broader evidence from developing-country extension systems, where limited staffing, inadequate logistical resources, and high farmer-to-extension ratios often reduce meaningful engagement (Thorn, 2020). In rural municipalities such as Raymond Mhlaba, resource constraints may further restrict regular farm visits, demonstration activities, and climate advisory dissemination. As a result, farmers may depend more on peer-to-peer knowledge exchange than on formal extension channels, potentially slowing the diffusion of scientifically validated climate-smart practices (Zhou *et al.*, 2025).

From a diffusion of innovation perspective, extension officers serve as key change agents who facilitate awareness, reduce uncertainty, and enhance perceived benefits of new technologies (Mkuna and Wale, 2022). When regular contact is absent, the diffusion process is weakened at the awareness and persuasion stages (Munialo *et al.*, 2023). This may partly explain the observed gap between awareness and actual implementation of CSTs.

The findings therefore underscore the need for strengthening institutional extension support through improved outreach strategies, structured engagement frameworks, and accountability

mechanisms. Enhancing extension capacity through increased staffing, transport provision, digital advisory platforms, and performance monitoring could improve farmer contact frequency and technical depth. Moreover, integrating participatory approaches such as farmer field schools, demonstration plots, and innovation platforms may transform informal social interactions into structured learning opportunities that promote effective climate adaptation.

4. Conclusion

The examination of small-scale agriculture in the Melani and Msobomvu districts uncovered significant demographic, economic, and agricultural patterns that influenced the residents' livelihoods. The data revealed a notable gender imbalance, as women constituted the predominant demographic of farmers, alongside an aging agricultural workforce, with more than 60% of farmers aged 50 years or older. These demographics indicate a possible obstacle for succession planning and future agricultural viability. Furthermore, around fifty percent of the farmers were documented as married, a characteristic likely to affect the social and economic dynamics inside households. The study emphasized a significant dependence on social grants as the main source of income, illustrating the community's reliance on government assistance while exhibiting minimal engagement in agricultural operations despite participation in farming. This dependence highlights possible weaknesses and the necessity for income diversification to strengthen economic resilience. The examination of land ownership revealed a marked preference for freehold land, signifying a robust inclination towards individual land ownership and a little occurrence of communal land tenure.

Mixed farming has become the predominant practice among the surveyed population, with a substantial percentage of respondents participating in both crop and livestock production. Companion planting was significantly common, indicating a transition towards more sustainable and integrated agricultural practices that emphasized biodiversity and ecological equilibrium. The results underscore the ongoing significance of staple crops like maize and cabbage, indicating their economic and nutritional importance. The study provided a thorough analysis of the socio-economic and agricultural conditions in these places, offering significant insights into policy interventions and support mechanisms to enhance small-scale farming and community resilience.

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Author Contributions

S.L., L.G. and L.Z. contributed equally to the conception and design of the study, development of the research methodology, data collection, data analysis and interpretation of the findings. All authors contributed equally to the preparation of the manuscript, including writing the original draft, reviewing and editing the manuscript, and revising it critically for important intellectual content. All authors contributed to the interpretation and presentation of the results, approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

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Data Availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request. Access to the data may be subject to ethical and confidentiality considerations relating to the participating smallholder farmers.

Declarations

Ethical approval

Ethical approval for the study was obtained from the University of Fort Hare Inter-Faculty Human Research Ethics Committee (IFHREC) (Ethics Clearance Reference No. GWA011SLUF01). Permission to conduct the study was granted by the Eastern Cape Department of Rural Development and Agrarian Reform (DRDAR), local municipal authorities, and community leaders. Participation was voluntary, and informed consent was obtained from all respondents before data collection. Participants were assured of anonymity and confidentiality and informed of their right to withdraw from the study at any stage without penalty.

Ethical accordance

The study was conducted in accordance with the Department of Health (2015) guidelines and the applicable regulatory instruments, policies and standard operating procedures of the University of Fort Hare Inter-Faculty Human Research Ethics Committee (IFHREC), as specified in the ethical clearance certificate.

Consent for publication

Not applicable. No individually identifiable information or images of participants are included in this manuscript.

Clinical trial

Not applicable. This study was not a clinical trial.

Competing interests

The authors declare that they have no competing interests.

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