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Enhancing the Resilience and Adaptive Capacity of Smallholder Farmers to Drought in the Limpopo Province, South Africa

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Abstract: Climate change has caused substantial losses, especially to smallholder farmers whose main source of livelihood is derived from agriculture. Climate change impacts can be reduced by enhancing coping and adaptation strategies. This study explores the coping and adaptation strategies of smallholder farming communities in the Limpopo Province, South Africa. As part of the assessment and analysis of drought, multiple sources of data were consulted, including 200 households' socio-economic information, focus group discussions, and interviews. Extreme drought events are increasing, impacting negatively on smallholder farmers' livelihoods. Adaptations to changing weather patterns were observed in smallholder farmers through planting early-maturing plants and drought-tolerant crops, altering planting dates, crop diversification, and irrigating in addition to non-farming activities. There is a need to enhance these context-based adaptation strategies to reduce risks and vulnerability and increase household resilience. Several socioeconomic developments and significant ecological deterioration appear to limit opportunities for long-term adaptation to drought.

Keywords: resilience; coping; adaptation; smallholder farmers; sustainability; climate change

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1. Introduction

There has been an adverse impact of climate change on the physical and biological systems of most continents all over the world for the past few decades [1]. Global agricultural production has declined by 1–5% per decade due to climate change, according to Porter et al. [1]. Global agriculture will also be adversely affected by these changes, especially in tropical and subtropical regions [1]. In countries where agriculture dominates the economy, such as sub-Saharan Africa, climate change has a disproportionate impact on agriculture. Agricultural systems, especially food production, are already vulnerable to rapid and uncertain changes in temperature and rainfall patterns in the subcontinent [2]. Climate change in tropical regions is predicted to exacerbate this trend in the coming decades, resulting in a significant decline in the production of important and staple food crops [1,2].

As a result of a lack of knowledge and technology, rural communities in South Africa remain susceptible to natural disasters and climatic hazards [2,3]. Climate change has been connected to various natural disasters occurring in South Africa and causes widespread food and water insecurities [3]. South Africa is particularly vulnerable to climate change, because of its high dependence on climate-sensitive economic sectors and agriculture [1]. Smallholder farmers and rural-based communal farmers are highly vulnerable to climate change as they lack the resources to adapt [3]. Regardless of insufficient governmental support, a viable option is to use indigenous knowledge systems to mitigate the effects of drought on agricultural production in developing economies [4]. Frequent droughts will influence both rural economies and food security, as they will reduce agricultural outputs, which directly impacts rural communities [5].

South Africa's climate-related disasters are analyzed besides/in addition to/other than the food and water security challenges. However, identifying vulnerable households is critical to developing effective adaptation and mitigation strategies. These interlinkages between climate change, water, and food insecurity bring to the fore the need to adopt transformative and integrated approaches to address contemporary challenges that crosscut all sectors. Several studies that focus on South Africa have analyzed household vulnerability but have neglected to examine the dimensions of household vulnerability [6–8]. Consequently, due to climate change, the emergency response starts at the local level, which means determining who is likely to be affected and which households should be considered [8].

Increasing food security requires understanding and addressing socio-ecological thematic areas, such as drivers of change, risk, climate, food security, water security, food sustainability, and nexus planning [3,4]. In addition to ensuring human and environmental health, the above thematic areas demonstrate sustainable food systems and efficient water use in agriculture. Irrigation management has similarly become increasingly dependent upon remote sensing, particularly in irrigation scheduling. As precision agriculture advances, it is possible to determine the moisture content of crops in cultivated fields and determine crop water requirements, and estimate water required for crop growth using freely available remote sensing products [4]. Variable irrigation scheduling requires this kind of weather, rainfall, and soil moisture information. Exhausting social media and mobile applications can provide useful information to the farmers for better management and productivity, besides/in addition to market information.

Coping strategies are actions taken by people who have been threatened with loss of livelihood. This involves managing resources during and after a drought to mitigate the effects of drought. In the study by Eriksen et al. [9], coping mechanisms were defined as actions and activities that happen within existing structures and systems, for example, diversification on farms. Most agricultural programs are initiated at national levels of government for provincial and local implementation; however, such programs are not always adapted to local conditions (i.e., on the specific farm). Climate change will have local repercussions for all agricultural plans and programs, so they must focus on local conditions.

Water management has become more and more dependent on technology, specifically hydrological and water management models. The technological advances in agriculture applied through research on smallholder agriculture guide policy and decision-making on formulating coherent and strategic policies towards resilience and attainment of Sustainable Development Goals (SDGs). According to Maka et al. [10], smallholder farmers in South Africa have adopted several strategies, such as introducing diverse crop varieties, introducing new crop cultivars, changing the time of farmer operations, crop rotation, promoting crop diversification, promoting climate change awareness, using different planting dates, and educating farmers about climate change.

This study explored the resilience and adaptive capacity of smallholder farmers to drought in the Vhembe and Mopani districts of the Limpopo Province. Smallholder farmers' livelihood in the two districts relies on rainfed agriculture which is vulnerable to drought as rainfall patterns changes [3]. Therefore, there is a need to enhance the resilience of smallholder farmers through innovative technological interventions. This is necessitated by the high vulnerability and risk of smallholder farmers to worsening climate change conditions as they generally lack the resources to adapt. This study, therefore, intends to inform policy and decision-makers on informed strategies that enhance the resilience of rural livelihoods. There is no clear understanding of how farmers can be helped and empowered to cope and adapt to droughts in the long run. Therefore, this study proposes a framework for developing adaptation strategies for smallholder farmers to improve their livelihoods. These methods can be applied to other areas since adaptation strategies developed at the local level are more effective than those developed at the global level. The

results of this study add to the knowledge of coping and adaptation to drought and can be extrapolated to other areas facing similar climate change impacts.

2. Materials and Methods

2.1. The Study Areas

The study was conducted in the Vhembe and Mopani districts from January to April 2018. Smallholder farmers from 9 centers, namely, Guwela, Mhlava Welemu, Hlaneki, Berlyn, Naphuno, Mamitwa, Tzaneen, Lambani, and Khalavha. The service centers were invited with the help of agricultural advisors. Limpopo Province consists of five (5) districts, namely: Vhembe, Mopani, Waterberg, Capricorn, and Greater Sekhukhune (Figure 1).

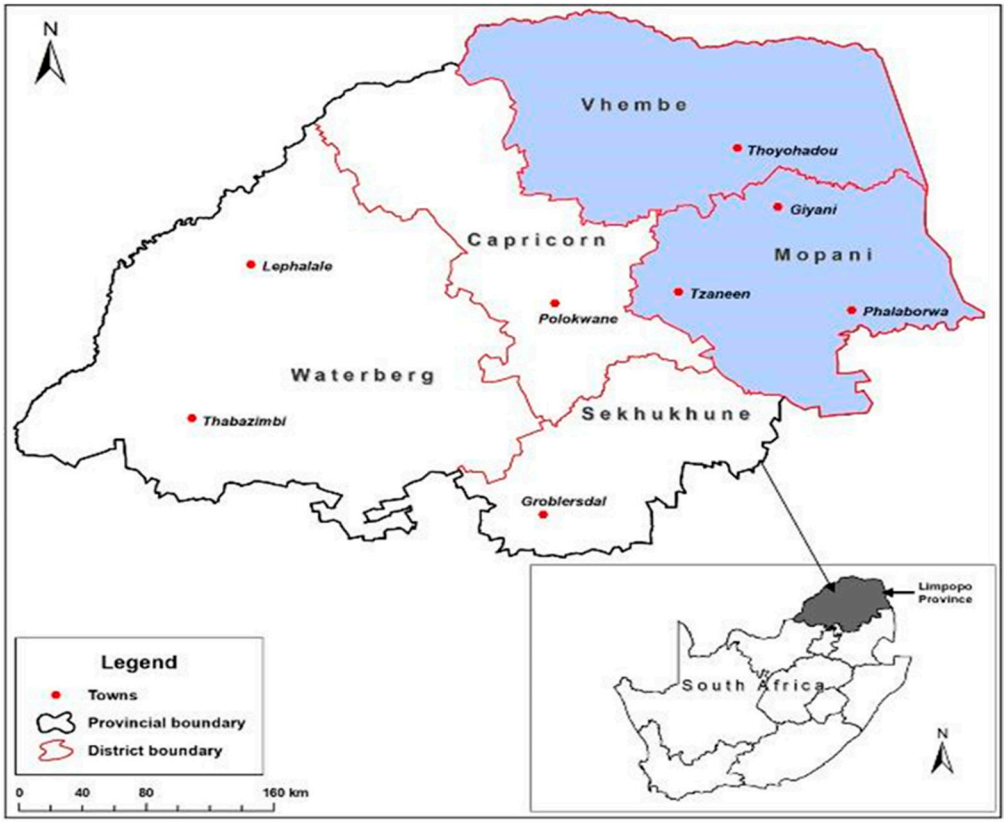


Figure 1. Limpopo Province map showing the location of Vhembe and Mopani districts.

Limpopo Province is situated in the northern part of South Africa and occupies an area of 12.46 million hectares. The study focused on the farmers from the Vhembe and Mopani Districts Municipalities since they are considered climate change hotspots in the province due to many smallholder farmers and the temperature variations that occur in the area [3].

The Vhembe District experiences average an annual temperature ranging between 14 °C and 29 °C [11]. Average rainfall of 300 mm to 400 mm per year falls during the summer in the district [11]. The Vhembe District has a unique characteristic of being suitable for growing tropical and subtropical fruits in the Levubu Tropical Valley. Several irrigation schemes are spread along the rivers of the Nwanedi Valley, which is known for its tomato production [11]. Therefore, many investments have been made in fruit and vegetable production and value-added infrastructure.

The average maximum temperature in Mopani for January ranges from 21 °C to 37 °C; the average minimum temperature is between 5 °C and 12 °C; the average annual temperature is between 13 °C and 27 °C [11]. Average annual rainfall of approximately 400–500 mm falls on the eastward side of the Drakensberg escarpment, while 600–800 mm and 800–1000 mm fall on the foot and along the escarpment, respectively [11]. Rainfall

in the Mopani District is generally low, particularly in the lower parts of the Giyani and Ba-Phalaborwa municipalities. Letaba River catchment and all its tributaries are the main source of surface water for Mopani. Borehole water has the potential to supplement surface water. There are rivers throughout the district, some of which are used for irrigation. Among the agricultural products are citrus, mangoes, vegetables, poultry, and livestock. The Tzaneen, Letaba, and Maruleng municipalities are also heavily dependent on agriculture as one of their key economic sectors. There is generally a shortage of water in Giyani, so irrigation is limited in this area. According to the Limpopo state of the environmental report [11], the district has a wide range of soil capabilities for crop and livestock production.

2.2. Data Sources

To explore participants' strategies for livelihoods, the questionnaire was based on the Sustainable Livelihoods Framework's assets. To achieve the research objectives and answer the research questions, the study collected both primary and secondary data. A variety of primary data sources were utilized to collect various aspects of drought and drought coping and adaptation strategies, including socio-economic interviews with 200 households, focus groups, and informal interviews with smallholders. Secondary data were sought from a variety of sources, including records, authentic materials, published and unpublished articles, websites, and books. In the study, only smallholder farmers engaged in dryland or mixed farming systems were considered.

2.3. Data Analysis

A statistical package for social sciences (SPSS) software program was used to enter, code, and analyze the information from the questionnaires. There were several analyses conducted, including the generation of descriptive statistics and forms of statistical analysis, such as comparison of mean and proportion. Through conducting thematic tree diagrams and engaging in a comparison of the themes found in interview transcripts and voice recorders, qualitative data were analyzed. A theme, a trend, and opinions that emerged frequently were analyzed. Participants' experiences, perceptions, and expressions were also considered in the analysis. Multiple data sources were used to collect information about drought conditions, impacts, events, drought adaptations, and coping strategies, including socio-economic interviews, focus group discussions, observation, and informal interviews with smallholders.

2.4. Conceptual Framework: Probit Model

The statistical data analysis, the StataCorp. 2021. Stata Statistical Software: Release 17. StataCorp LLC: College Station, TX, USA [12], was utilized to assess how smallholder farmers adapt to drought and factors that influence implementation strategies. To understand the factors that determine the capacity building of smallholder farmers, the study employed a binary probit model. The probit model is a statistical probability model with two categories in the dependent variable (one and zero). Probit analysis is based on the cumulative normal probability distribution. The probit model can be presented as follows:

$$\mathrm{Y} = \mathrm{Pr}\left(\mathrm{Y} = 1|\mathrm{X}\right) = \Phi\left(X^T\beta\right) \quad (1)$$

where Pr is the probability and Φ denotes the cumulative Distribution Function (CDF) of the standard normal distribution. The X^T is the vector of coefficients to be estimated and β represents the parameters to be estimated using the maximum likelihood method.

The binary dependent variable, Y, takes on the values of zero and one. The outcomes of y are mutually exclusive and exhaustive. The dependent variable, Y, depends on X^T observable variables. Although the values of zero and one were observed for the dependent variable in the probit model, there was a latent, unobserved continuous variable, y*. Hence

it can be shown that probit model is similar to the latent variable model which can be presented as follows:

$$y^* = X^T\beta + \mathcal{E}, \text{ where } \mathcal{E} \sim N(0,1) \quad (2)$$

The dummy variable, Y, was observed and was determined by y* as follows:

$$Y = \{1\ if\ y^* > 0;\ 0\ otherwise\} = \left\{1\ X^T\beta + \mathcal{E} > 0;\ 0\ otherwise\right\} \quad (3)$$

The point of interest relates to the probability that y equals one given the values of X. The two models in Equation (3) are equivalent by symmetry of normal distribution, and it can be shown as follows:

$$\begin{aligned} Y = \Pr(Y = 1|X) &= \Pr(y^* > 0) \\ &= \Pr\left(X^T\beta + \mathcal{E} > 0\right) \\ &= \Pr\left(\mathcal{E} > -X^T\beta\right) \\ &= \Phi\left(X^T\beta\right) \end{aligned} \quad (4)$$

where Φ was the cumulative distribution function of $\mathcal{E}$. The probit model assumed that the data were generated from a random sample of size N with a sample observation denoted by i, where i = 1, . . . , N. Thus, the observations of y must be statistically independent of each other to rule out serial correlation. Additionally, it was assumed that the independent variables (the responses to the consumer survey questions) were random variables.

In order to estimate the above model in (X), the maximum likelihood method is used. The relationship between a specific variable and the outcome of the probability is interpreted by means of the marginal effect which accounts for the partial change in the explanatory variable X^T on the probability Pr (Y = 1 | X), holding other variables constant.

3. Results and Discussion

3.1. Impacts of Socio-Economic Status on Coping and Adaptation

Around 71 percent of the farmers were over 56 years old, and only 6 percent were in the 18–35 age group (Figure 2a). Youth and middle age tend to cope and adapt to drought compared to the old people. However, the low participation in farming by youth is a major challenge and impacts the coping and adaptation to drought. Technology development in the agriculture and water sectors is important for resource management, besides sustainability and food security, hence young people cope and adapt to drought fast compared to old people. An alternative reason for slow adaptation is that older farmers tend to rely on their indigenous knowledge to manage their farms since they are less likely to adopt new sustainable practices [13]. They are losing the reliability of their indigenous knowledge due to frequent drought occurrences and rainfall and temperature variability.

A key to maximizing smallholder farmers' productivity is integrating indigenous knowledge with scientific agriculture management practices. If agriculture is to fulfill the mandate of being the main driver within the Vhembe and Mopani districts in the future, there is a need to establish younger farmers since the aging population structure of smallholder farmers seems to suggest that the numbers will decline in the future.

Based on the responses to the education questionnaire, four groups were developed, corresponding to the level of education of the farmers, ranging from no formal education to post-matriculation. A survey found that 17 percent of farmers had been to school beyond high school, 40 percent had reached primary school, 32 percent had no formal education, and 11 percent had attended post matric school (Figure 2b). Based on these findings, we can agree with other studies that most smallholder farmers have limited education [14,15].

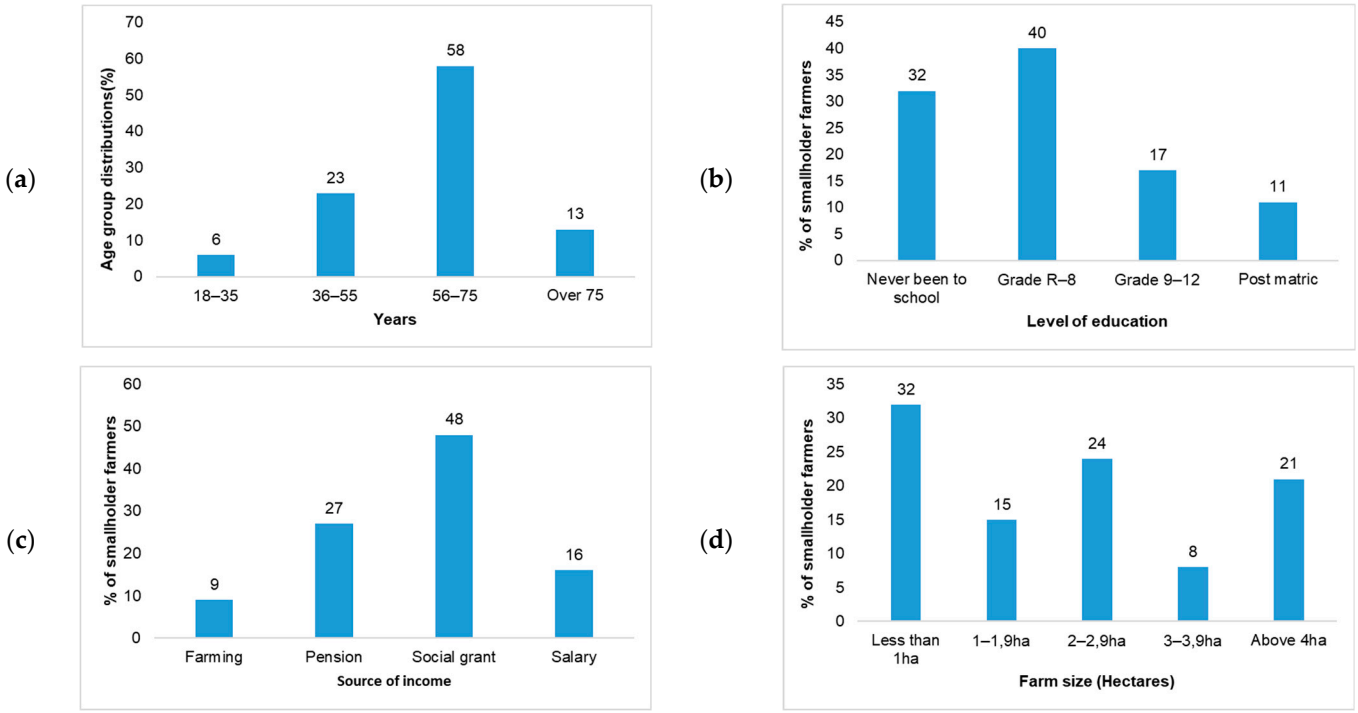


Figure 2. Smallholder farmers (**a**) age group, (**b**) education level, (**c**) source of income, and (**d**) land size in study area (n = 200).

Low literacy levels have an indirect impact on the coping and adaptation strategies since technology and information have both advanced, requiring a certain level of formal education and training. Investing in education can similarly improve literacy rates, which are a major barrier to many desirable outcomes for coping and adaptation strategies to resist drought impact. These rates are a key part of addressing recurring drought vulnerability in the study area. In most cases, climatic information is presented in scientific language, making it difficult for farmers who are illiterate to understand it. Drought is easier to cope with and adapt to for smallholder farmers with higher levels of formal education and training. Farmers' ability to carry out some farming activities may be affected by the level of education possessed or attained, and this may be linked to poverty in the study area.

About 48% of smallholder farmers in the Vhembe and Mopani Districts build their livelihoods using social grant payments from the government (Figure 2c). It is important to note that even though smallholder farmers received grants as their main income source, they continued to participate in farming activities, mostly to be less reliant on buying food from the market. Usually, these grants protect the rural poor from unemployment and isolate them from employment opportunities. Furthermore, these transfers are intended to reduce socio-economic distress; yet they also perpetuate a reliance on resources outside of the labor market. From a welfare perspective, food security, asset ownership, and credit access were the most vulnerable for smallholder farmers dependent on social grants, and they had the most difficulty coping with and adapting to droughts.

According to the size of a farmer's land holdings, responses were divided into five categories: less than 1 hectare; 1 to 1.9 hectares; 2 to 2.9 hectares; 3 to 3.9 hectares; and above 4 hectares. The average scale of farms per household is between 3.0 and 3.9 ha, and 47% of the farmers had farms smaller than 2 ha. About 24% of farmers had farms larger than 2 ha, followed by 21% of farmers with farms greater than 4 ha; and only 8% had farms smaller than 3.0 ha (Figure 2d). The results confirmed previous studies that showed most smallholder farmers in South Africa own less than 2 ha of land [15,16]. The findings by Mudhara [15], indicate that only 13% of South Africa's farmers are smallholders, and they tend to farm predominantly in former homeland areas, which are dominated

by resource-poor black farmers. Increasing farm production could assist in generating sufficient food for these households.

In addition to asking whether the respondents were employed, they were likewise asked if they had an additional source of income. A survey of 72% of respondents revealed that they were unemployed (Figure 3a). To meet their daily food needs, most farmers receive social grants from the government. According to the results of the survey, casual workers mostly work on the Department of Public Works projects in the area, including the Expanded Public Works Programme (EPWP). Most commercial banks prefer to lend money to farmers with a proven income stream and those who are economically active [17]. The lack of ownership rights to their land prevents most smallholder farmers in South Africa from obtaining loans to invest in their farms due to the lack of collateral [18]. Farmers can therefore overcome the financial constraints that prevent them from adapting to the drought when they need access to credit [15].

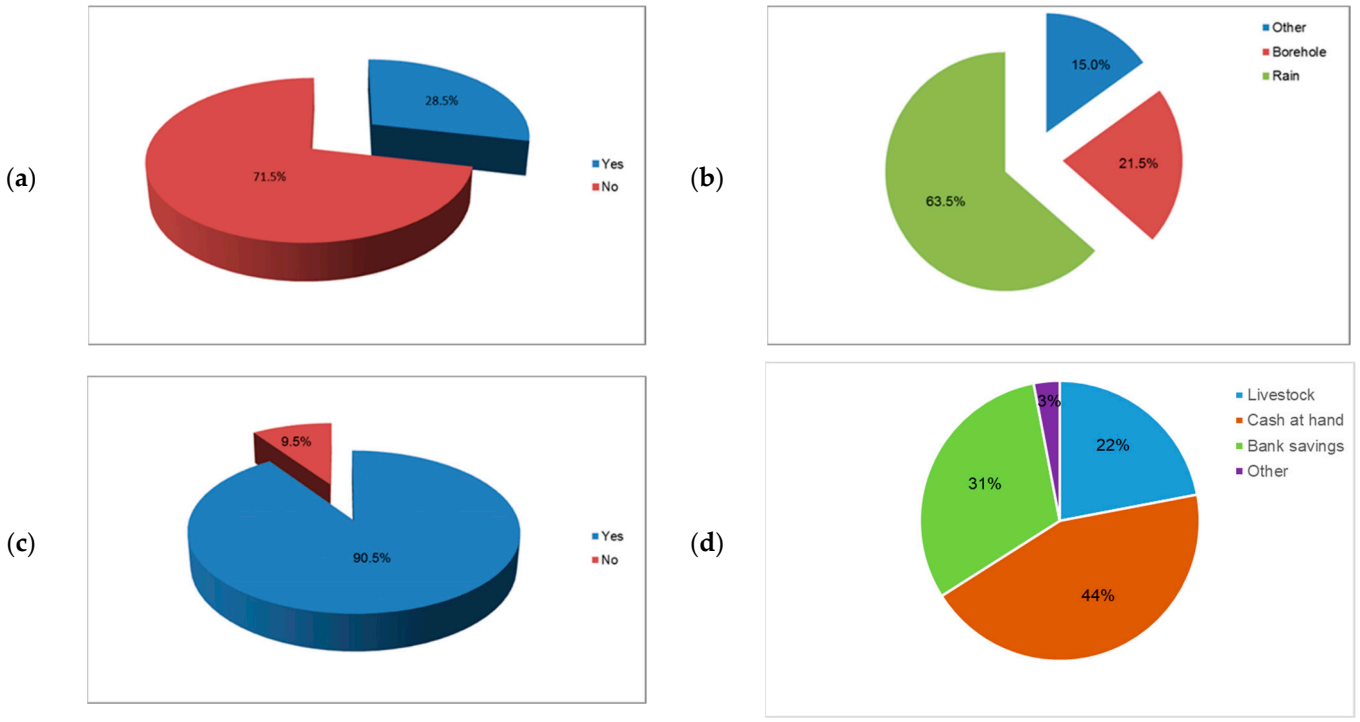


Figure 3. Smallholder farmers (**a**) water source, (**b**) employment status, (**c**) access to credits, and (**d**) saving money in study area (n = 200).

A well-developed commercial farming community owns 87% of the total area [15]. As a result of apartheid, the system of commercial farming and smallholder farming in South Africa remains dualistic [19]. Additionally, apartheid created inequalities within the population, resulting in constant poverty and food insecurity for most black people, even after quite 28 years of democracy. There are many uncertainties associated with the ownership of communal lands in the Limpopo Province, which makes it difficult for smallholder farmers to adapt to drought impacts. This, in turn, requires specialized equipment and financial investment to deal with drought.

Moreover, the study explored the identification of the available water resources; farmers must identify the source of their farming water. Figure 3b shows the water sources used by the farmers in the study area. The study shows that 64% of the farmers rely on precipitation to grow crops and raise livestock, and 22% had their own boreholes. It may be that this explains why their farming is mainly seasonal and why their output is low. The challenge of water access in the study areas, particularly Greater Giyani, is by all accounts predominant, and water shows a basic role in the coping and adaptation to drought.

In focus group discussions, respondents frequently emphasized the difficulty of obtaining credit facilities as the most significant constraint to the adoption of preferred coping and adaptation strategies as feasible. Most farmers never received credit for crop production or livestock and only 10% received credit from commercial banks, according to the study results (Figure 3c). Most commercial banks need security for loan approval and the casual workers or social grant beneficiaries are left out. Figure 3d demonstrates that 43.5% of smallholder farmers do not have financial balances compared with 31% who save their cash in the bank. Most farmers reported that it is hard to save cash in the bank if the balance is insufficient.

3.2. Determinants of Capacity Building of Smallholder Farmers towards Drought

Table 1 shows the determinants of capacity building of stallholder farmers in the Vhembe and Mopani districts, Limpopo Province.

Table 1. Determinants of capacity building of smallholder farmers towards climate change.

Variables	Coefficients	Standard Errors
Age	−0.0265 **	0.0133
Household Size	0.1970 ***	0.0608
Salary	7.6444	275.080
Employment	−6.9432	275.08
Land size	0.1388	0.1191
Borehole	2.5592 ***	0.4832
Social grant	0.8862 **	0.4303
Farming income	1.3554 **	0.5646
Two types of farming	−2.0073 **	0.7915
Three types of farming	−1.6086 **	0.7201
Education status—Grade 12	2.6292 ***	0.5002
Access to dam water	0.3698	0.3610
Constant	−2.1771	1.1973
Summary of the model		
N = 200 Log Likelihood = −77.134 Pseudo R-square = 0.4270	LR Chi-square = 114.94 Prob (Chi-sq) = 0.000	

Source: Author computations. Note: ** and *** denote $p < 0.05$ and $p < 0.01$, respectively. Variable explanations: Age (Continuous variable); Household size (continuous variable); Salary (dummy variable: 1 = Yes, 0 = No); Employment (dummy variable: 1 = employed, 0 = Not employed); Land size (continuous variable); Access to Borehole (dummy variable: 1 = yes, 0 = No); Access to social grant (dummy variable: 1 = yes, 0 = No); Farming income (dummy variable: 1 = selling, 0 = Not selling); Education—Grade 12 (dummy variable: 1 = yes, 0 = No); Two types of farming (dummy variable: 1 = yes, 0 = No); Three types of farming (dummy variable: 1 = yes, 0 = No); Access to dam water (dummy variable: 1 = yes, 0 = No).

The output of the probit model shows that there are a number of factors that determine the capacity building of smallholder farmers. This is shown by the statistical significance of many variables. According to the results above, age and the type of farming are statistically significant and have a negative coefficient. The age of the farmer is statistically significant at the 5 percent significant level; this means that increasing age reduces the level of capacity building of smallholder farmers to combat drought. It is not surprising that when people become older, their level of work on the farm reduces, hence they are not active enough to build their resilience to drought through agricultural practices such as irrigation, mulching, and others. The type of farming is negative and statistically significant at a 5 percent significant level. This means when the amount of farming increases from two upwards, the farmer becomes less resilient to drought than when focusing on only one type of farming. The increasing number of types of farming may also reduce the resource and needed manpower to build resilience to climate change.

Other factors such as household size, access to boreholes, access to social grants, farming income (produce for sale), and level of education (grade 12) act as positive influences. The household size is statistically significant at the 1 percent significance level showing that increasing the number of members in households increases manpower which can help

to build resilience through assisting with the farm. Access to boreholes is significant at a 1 percent level showing that farmers with access to boreholes are getting reliable water as opposed to others and can augment water for irrigation during drought. The social grant is also statistically significant implying that, holding other things constant, farmers with access to social grants are more resilient to drought because they have financial resources to be used during drought or before drought as mitigation and adaptation. Similarly, farming income is also statistically significant (at a 5% level) indicating that farmers producing for sale have financial resources to prepare for drought hence more resilient as compared to their counterparts. The level of education up to grade 12 is statistically significant holding other things constant. This implies that farmers who completed grade 12 (matric) are more resilient to drought than their counterparts. This is not surprising as their level of scientific knowledge is higher, enabling them to think about proper solutions for drought.

3.3. Coping and Adaptability

The findings showed that extreme drought events are increasing in frequency and intensity and negatively impact smallholder farmers' livelihoods. Weather fluctuations, rising temperatures, and dry spells are some of the impacts of climate change on smallholder farmers. This leads to low crop yields/failed crops. In response to these climatic conditions, smallholder farmers have used different climate-related adaptation strategies to reduce the impacts of climate change. The on-farm adaptation strategies include irrigation, planting early maturing maize varieties, planting drought-resistant crops, changing planting dates, and applying fertilizers; non-farm adaptation strategies include establishing small businesses, casual work, and making local beer (Table 2).

Table 2. The percentage of smallholder farmers using climate-related adaptation strategies.

A Strategy for Adapting	Greater Giyani (%)	Greater Tzaneen (%)	Thulamela (%)
Irrigation	30	50	70
Early maturing maize varieties	80	70	80
Change in planting dates	45	35	75
Drought resistant crop	60	50	80
Crop diversification	75	60	50
Drilling boreholes	40	30	60
Rainwater harvesting	70	10	40
Mulching to conserve moisture	70	25	50
Application of pesticides	10	10	15
Applying cow dung/chicken manure	15	25	30
Non-farming activities	60	70	30

According to most respondents, part of the desired adaptation strategy is creating strategic feed reserves for livestock, irrigation farming, developing water sources, and establishing livestock insurance and saving plans. Many participants also indicated they would be interested in setting up storage facilities for grain and fodder, improving livestock breeds, making livestock products such as ghee for sale during the dry season, and increasing their herd size. However, households are not free to adopt whatever adaptations and coping strategies they wish. Participants cited several limitations to their strategies, including low incomes and capital, insecurity, illiteracy and a lack of technical knowledge, a lack of finance and access to credit, and insufficient markets and inputs.

Detailed changes in precipitation, heat stress, and Crop Moisture Index (CMI) had been observed in the study areas as illustrated in Table 3; this has an impact on crop production and should be considered as part of coping strategies to mitigate risk and build resilience. It is essential to build resilience to combat climate change, as a system should be able to absorb disturbances without crashing [3,20,21]. A resilient system built up by developing appropriate adaptation and coping strategies at the local level can withstand shocks and rebuild itself in the event of a fundamental shock. The availability

and accessibility of technologies and rural support systems as well as the intensity of the climate risks will determine the effectiveness of coping and adaptation strategies [20,21]. Several strategies can be adopted to adapt to climate change, including the adoption of autonomous adaptation such as shifting planting dates and cultivar substitution, embracing technologies such as climate-smart agriculture, addressing livelihood diversification, as well as improving trade policies, and encouraging shifts in diets (Table 3).

Table 3. Observations of climate change, identifying risks, and adapting accordingly.

Observed Changes	Risks That Have Been Identified	Strategy for Coping and Adapting to Drought
Frequent heatwaves	• Water levels in dams, wells, and rivers decline, causing water quality to decline. • Increased water stress in crops. • Increase the risk of disease outbreaks. • The decline in agriculture's output and income has led to an increase in immigration.	✓ Provision of seeds to support local fodder production. ✓ Provide supplemental feed for cattle as well as mineral feed. ✓ Drought resistant crop and/or animal. ✓ Mulching to conserve moisture.
Reduced rainy season	• Increasing water scarcity leading to water use conflicts in agriculture. • Rainfed production has decreased, especially maize. • A reduction in food production caused by the loss of crops and stock.	✓ Increasing access to climate information and services. ✓ Use early maturing maize varieties. ✓ Change of planting dates. ✓ Crop diversification. ✓ Use of rainwater harvesting and conservation techniques.
Variability of rainfall within and between seasons	• Increasing water scarcity leading to water use conflicts in agriculture. • Planting date selection. • Loss of income due to extensive agriculture production including vegetables and fruits.	✓ Use of climate smart agriculture technology. ✓ Change of planting dates. ✓ Crop diversification. ✓ Use of rainwater harvesting and conservation techniques.
Droughts occur more frequently and intensify	• Increased water stress in crops. • Increasing water scarcity leading to water use conflicts in agriculture. • Nature reserves would become less attractive if precipitation declined. • Increase the risk of disease outbreaks.	✓ Change in planting dates. ✓ Use of rainwater harvesting and conservation techniques. ✓ Drought resistant crop and/or animal. ✓ Crop diversification. ✓ Mulching to conserve moisture.

Further examining this issue through focus group discussions, several of the participants said that some of their preferred strategies require large investment capital up front, which is out of reach for many households, such as establishing irrigation systems and building water supply systems. Adaptation to drought by using improved livestock breeds was stated as an effective adaptation measure, however, affordability of these breeds and the availability of suitable veterinary services remains a challenge due to the poor social and economic status as well as poorly developed markets in the study area.

There is a need to better understand the connection between climate variability and social vulnerability so that this can help guide planning for increasing coping and adaptation of communities to current and future droughts. Several climate-smart innovation strategies are recommended, including greenhouses and hydroponics. These innovations are usually supported by government subsidies and loans. To successfully implement drought relief programs, governments must develop inter-governmental relations, strengthen research institutes, and utilize ICTs and social networks through investments in rural ICT infrastructure, broadband, and the development of affordable, user-friendly applications, as well as training public extension and advisory services. Planning for the emergence of cohe-

sive strategies that are geared towards resilience and sustainability occurs as the result of transformative and dynamic processes within a socio-ecological system. Figure 4 illustrates the current concepts of coping and adaptation to a proper planning guide for increasing coping and adaptation.

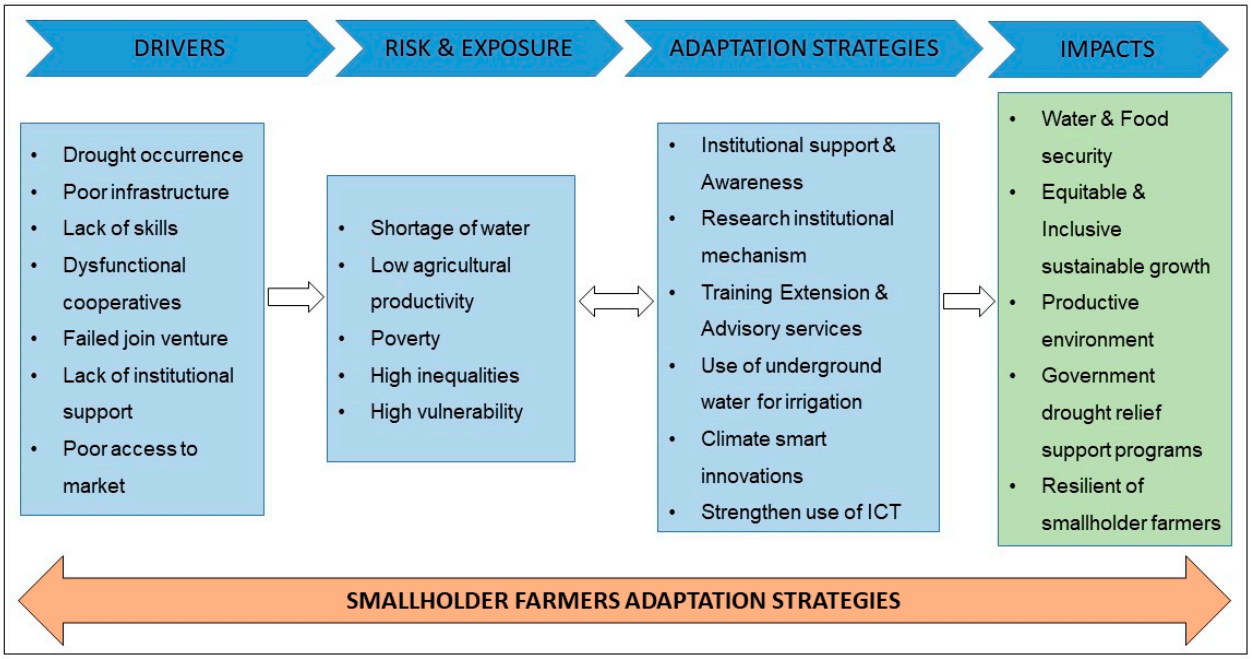


Figure 4. Policy-relevant adaptation strategies for forming coherent policies.

3.4. Dependency upon Government Support during Drought

To assist all provincial governments in managing the drought, the national government has developed a drought management strategy. Depending on their specific needs, these provinces must then create their own programs. Moreover, metropolitan and district municipalities have a responsibility to set up and implement a framework for disaster management within their jurisdictions that meets uniform and integrated demands of disaster management in the region where they are located. The studies of drought assistance researchers show a consensus amongst analysts that, even though the government has provided drought relief for a few years, the assistance has been ineffective, poorly coordinated, and untimely [22]. In the research, there is an overemphasis on the chances and coping mechanisms, but not enough emphasis on how they impact the situation.

A study conducted by Rukema [23], who also examined drought, people's resilience, and their ability to withstand disasters in the Msinga Local Municipality in Kwa Zulu-Natal, recommended ensuring that any financial or bureaucratic bottlenecks are removed to ensure program outreach occurs on schedule. Furthermore, disaster risk management should involve non-government organizations and community-based organizations.

Although the study found that smallholder farmers did not have enough independence when it came to dealing with hardships caused by the drought, it acknowledged that the most effective coping mechanisms were possible when drought planning was undertaken. Farming was inadequately assisted during a recent drought from 2014 to 2016. The cattle owners too had to provide validation documents, in addition to the long queues and strict requirements. The findings revealed that not every cattle owner possessed brand mark certificates or cattle dipping records. Due to this, some owners gave up trying to meet these demands, forfeiting needed assistance. Climate change can significantly impact cattle owners due to poor planning and management, which leads to a high dependence on government support.

3.5. Extension Services to Increase Drought-Resilience

Participants cite extension advisory services as crucial for smallholder farmers to cope and adapt to drought. Smallholder farmers remain among the main beneficiaries of support services in the agricultural sector, for purposes of rural development, commercialization, food security, poverty reduction, and income generation. Smallholder farmers who have access to sufficient farmer support services are better equipped to cope with droughts and boost farm income. Approximately 70 percent of farmers lacked access to extension services, with only 30 percent receiving crop production information through extension services. The agricultural extension services in South Africa are challenged with improving food security, creating sustainable employment, and developing rural areas through increased agricultural production [24].

As a result of several barriers contributing to the inefficiency of the management of droughts, agricultural advisors in the study areas pointed to the lack of resources, in particular in the transport of officers. Most smallholder farmers are located far from the district office or service centers where most of the agricultural advisors tend to live. Hence, agricultural advisors require transport to get to the farming areas. Regrettably, many agricultural advisors do not have their own means of transport and this has a direct impact on the role of extension advisory to reach vulnerable smallholder farmers in providing drought-related advice, it undermines the delivery of information to support effective adaptation and coping. This finding is in line with previous studies in Ghana, which revealed a lack of transportation to farming communities is a major obstacle to agricultural extension officers feeling motivated to perform their duties [25]. According to Belay and Abebaw [26], agricultural extension officers in southwestern Ethiopia stated that the lack of transportation facilities significantly hampers their efforts to disseminate information regarding modern agricultural technologies.

Another barrier for smallholder farmers to access extension services is the low agricultural advisors to farmer ratio. Fanadzo and Ncube [27] reported that the ratio of extension officers to farmers in South Africa is 1:878. The President of South Africa during the 2021 State of the Nation Address (SONA) in Parliament said the government is planning to recruit over 10,000 extension officers to reduce the ratio of extension to farmer ratio to 1:250. When he delivered his budget speech two weeks later, the Minister of Finance reiterated the same sentiments. The high ratio of extension officers to farmers increases the workload for agricultural advisors which could potentially cause agricultural advisors to lack time to acquire skills and competencies to cope and adapt to drought, particularly in dryland farming systems. Our findings agree with previous studies that found that only about one out of every 1000 farmers have access to frontline extension workers in Kenya, compared to a required one out of every 400 [28]. According to Chenseu et al. [29], although 93% of their participants say their sections have extension officers, only 25% of their participants reported receiving an extension visit every month, and 22% only received one in the complete cropping season. This is a worrying factor because vulnerable smallholder farmers need the necessary technical understanding of adaptations to cope and adapt to drought.

Participants gave different answers in response to a question about support services. According to the sampled farmers, 70% do not receive any support services and rely on their own resources. Adaptation methods can only be implemented if there is adequate funding to fund drought coping and adaptation strategies. Previous studies have noted that it is difficult for smallholder farmers to implement adaptation strategies recommended by agricultural advisors because of insufficient funding [30,31]. Smallholder farmers are often required to make financial commitments to drought adaptation and coping strategies, which include planting drought-tolerant varieties of crops and early maturing breeds of crops. Poor credit conditions make adaptation measures impossible, thus aggravating poverty. Due to this, farmers have a difficult time adopting adaptation strategies and implementing interventions that reduce their vulnerability through other agricultural innovations in the face of climate change.

Agricultural advisors similarly highlighted that there is some reluctance among farmers to adopt new technologies and innovations that can help them to cope and adapt to drought. Smallholder farmers are using their traditional farming methods. Nevertheless, improved agricultural farming can assist smallholders to decrease their vulnerability to drought when adopted as advised by agricultural advisors. Many smallholder farmers find it difficult to abandon older practices due to social beliefs and values [32]. In their study of agricultural technologies' adoption, Meijer et al. [32] report that both extrinsic and intrinsic variables contribute to adopters of agricultural innovations' behavior, knowledge, attitudes, and perceptions. Farmers' resistance to change is linked to a general lack of trust in science, largely due to past failures in predicting the weather and innovations that did not meet their expectations [33].

The majority of smallholder farmers in Limpopo Province desire visits from agricultural advisors for information concerning climate change impacts such as drought, which are often presented in scientific language and therefore difficult to understand [34]. A farmer's most important source of information is the agricultural extension. Research indicates that farmers with access to good quality extension services and technical information are better prepared to cope and adapt to drought [35].

4. Conclusions

A majority of drought-resilient strategies are reactive and typically intensify the use of existing resources, which may, in turn, undermine the lives of those they are intended to benefit/relieve. Smallholder farmers have used different climate-related adaptation strategies to reduce the impacts of climate change. The adaptation strategies include irrigation, planting early maturing maize varieties, planting drought-resistant crops, changing planting dates, small businesses, and casual work. A number of socioeconomic developments and deteriorating ecological conditions limit opportunities for long-term drought adaptation strategies. Lack of farmer education to understand climatic variability, poor management, lack of farming skills, difficulties accessing formal markets for remunerative crops, high transportation costs, lack of market information, and inadequate government support are the main factors. There are likewise high levels of dependence on government drought relief support among smallholder farmers in the Limpopo Province as they lack a well-structured risk mitigation plan. In order to address common challenges associated with climate change adaptation, institutions working with smallholder farmers need to be well coordinated. To successfully implement important alternative technologies, young educated farmers must be targeted; the main issues contributing to non-adoption, such as drought warnings, must be addressed. National and Provincial governments must invest resources in strengthening adaptive leadership and building capacity to be better prepared for the drought.

5. Recommendations

The study recommends that extension officers and other stakeholders in the agricultural sector continue to empower smallholder farmers to resist the effects of climate change, especially since they are often negatively affected by it. Farmers' ability to perceive and adopt agricultural innovations such as climate change adaptations can be improved greatly by adequate access to extension services. As a result, proactive measures should be taken to protect the main assets, such as pastures and livestock. As communities become more aware of climate change, they should better understand how to use the limited resources they possess to build more resilient communities. To ensure science and policy interfaces function correctly, there are several elements that need to be addressed, including capacity building, technological demonstrations, and greater dissemination of knowledge. The study recommends the use of rainwater harvesting to conserve water during drought periods and alternative irrigation. It may be argued that during severe droughts, there may be few days of rain so the amount of water available for harvesting may be inadequate. A plan could be made to bring in water trucks to fill tanks. Additionally, without alternative

irrigation water sources, agriculture will be threatened in the long run, and households will have to find other livelihoods for themselves if the issue persists.

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