FACTORS INFLUENCING SMALLHOLDER CROP FARMERS' AWARENESS AND ADAPTATION MEASURES ON CLIMATE CHANGE IN MOPANI DISTRICT MUNICIPALITY IN THE LIMPOPO PROVINCE, SOUTH AFRICA

MOHALE, C. T. – MTHOMBENI, D. L.*

Department of Agriculture and Animal Health, University of South Africa, Florida Campus, Johannesburg 1710, South Africa

**Corresponding author*
e-mail: mthomdl@unisa.ac.za; phone: +27-11-471-3121

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Abstract. Farmers are aware of challenges brought by climate change yet struggle with adaptation measures due to a lack of resources such as early warning systems, ecosystem restoration, climate-resilient infrastructure, and water supply. This study, undertaken to assess smallholder crop farmers' awareness of, and adaptation to, the impacts of climate change, was conducted in the three local municipalities of Mopani district in the Limpopo Province, South Africa: Giyani, Letaba and Maruleng. The proportionate sampling technique was used to obtain the study sample size of 291 farmers. A Statistical Package for Social Sciences (SPSS) version 28 was used to analyze data, along with descriptive statistics and a binary logistic regression model. The results indicated that 100% of smallholder crop farmers were aware of climate change but struggled to implement adaptation measures. The binary logistic regression results revealed that the variables gender, farm size and change of weather had a significant influence on farmers' adaptation measures. Ninety per cent of smallholder crop farmers were aware of, and implemented, climate change adaptation measures. The study recommends a heightened focus on improving the level of farmers' efforts to adapt, to mitigate the effects of climate change in the study area.
Keywords: *adaptation measures, climate change, descriptive statistics, logistic regression model*

Introduction

Climate change encompasses the natural cycles of weather patterns on Earth, resulting from changes in the amount of heat received from the sun (Rogelj et al., 2012; Koutsoyiannis, 2021). The Earth's climate goes through warm and cold periods, taking hundreds of years to complete a single cycle. According to Pepin et al. (2022) these changes affect the temperature, which in turn influences rainfall levels. Plants and animals can adapt to a changing climate, provided that these changes take place over centuries, but unfortunately human activities are currently causing the climate to change rapidly. According to Berrang-Ford (2021) adaptation to climate change can be referred to as a change in natural and human systems in response to climatic effects, which moderates harm or exploits beneficial opportunities. As is the case in the rest of the world, climate change is a major concern in South Africa as well. Studies by Madzwamuse (2010), and Oduniyi and Tekana (2019) indicate that climate change is already a reality, as it has adverse effects on agriculture. Agricultural production depends mainly on predictable climatic patterns, to be productive and maintain yields.

Climate change is expected to worsen a situation in which smallholder farmers who are reliant on rainfall to water and harvest their produce, are the most vulnerable and likely to be hindered by climate change. Moreover, climate change is also likely to

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accelerate, leading to an escalation in the phenomenon of food insecurity (Maponya and Mpandeli, 2013; Turpie and Visser, 2013; Ziervogel et al., 2014; Lee et al., 2023). Since erratic climatic patterns directly affect agricultural production, the sector is inherently sensitive to climatic conditions, and is one of the most vulnerable to the risks and impact of global climate change (Parry et al., 2005).

The livelihoods of smallholder and emerging farmers in rural areas are at risk, and this has compelled them to take adaptation measures to mitigate that risk. Agriculture is the backbone of South Africa's economy (Mandleni and Anim, 2011) and it is one of the major occupations in Limpopo province. Incidents related to climate change in Limpopo include fire outbreaks, floods, excessive temperatures, and reduced rainfall. These have had a negative impact on farmers' production. Studies on the impact of climate change on smallholder farmers have been conducted in South Africa (Maponya and Mpandeli, 2013; Turpie and Visser, 2013; Ziervogel et al., 2014; Chikosi et al., 2017; Phophi et al., 2020), yet very few studies have investigated the awareness of, and adaptation measures taken by smallholder farmers in attempts to mitigate climate change in Limpopo province. Research shows, however, that climate change mitigation strategies are rarely adopted in Africa, because of smallholder farmers' inadequate resources and low technical skills (Oduniyi and Tekana, 2019). This study on which this article is based, sought to examine which factors influence climate change awareness, which will lead to the adoption of mitigation strategies. The objective of this study is to determine the factors influencing smallholder crop farmers' awareness and adaptation measures on climate change in Mopani District, Limpopo, South Africa.

Materials and methods

Study area

The study was conducted in the three local municipalities of Mopani district (one of five districts in Limpopo, South Africa), namely the greater Giyani, Letaba and Maruleng municipalities in 2022. The selected local municipalities are where the most crops are produced in the district, with most farmers being smallholders. Smallholder farmers in the study area produce crops such as maize, sunflower, soybean, groundnut, vegetables, tea, citrus, and subtropical and deciduous fruit. In *Figure 1* all the five local municipalities of Mopani district are shown including the two municipalities of Ba-Phalaborwa and Tzaneen, which rate low in terms of crop production and excluded in this study.

An updated list, which consisted of 1 228 smallholder crop farmers, was obtained from the Limpopo Department of Agriculture and Rural Development at Mopani District Municipality in 2020, covering the three local municipalities.

Methodology

The study adopted the method for determining sample size proposed by Krejcie and Morgan (1970), which was employed in a study by Rahi (2017). For a population size of 1 228, a sample size of 291 needs to be obtained.

The formula is constructed as follows:

$$s = X^2 NP(1-P) \div d^2(N-1) + X^2 P(1-P) \quad \text{(Eq.1)}$$

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The proportionate sample size technique was further used to determine the samples for each of the three study areas, as follows:

$$\text{Sample size for Letaba} = (433/1228) \times 291 = 103$$

$$\text{Sample size for Maruleng} = (230/1228) \times 291 = 54$$

$$\text{Sample size for Giyani} = (565/1228) \times 291 = 134$$

The study employed a purposive random sampling technique, for data-collection purposes. From the sample pool of 1 228, random sampling was used to select 291 smallholder crop farmers, to eliminate any bias and give each small-scale crop farmer in the area an equal chance to participate in this study.

Data were collected using semi-structured questionnaires. The questionnaire was divided into three sections consisting of the farmer's socio-economic questions, climate change awareness and adaptation questions. Some smallholder crop farmers were interviewed face-to-face on their farms. Those who were not comfortable being in a one-on-one interview provided telephone numbers and were interviewed telephonically.

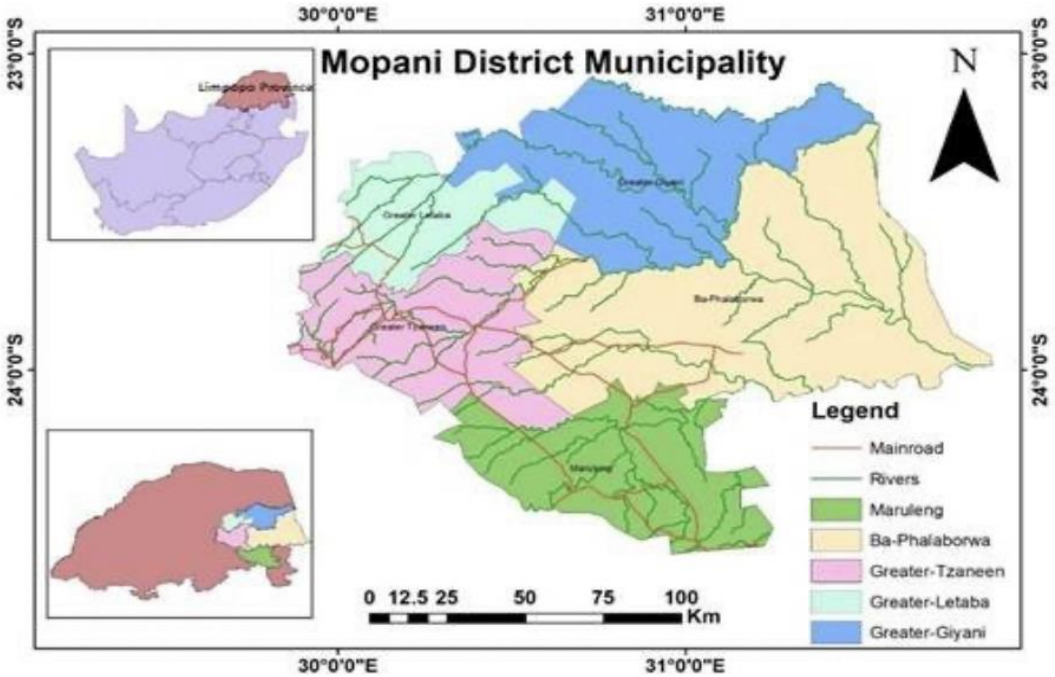

Figure 1. *Mopani district municipality map (Nembilwi et al., 2021)*

Data analysis

The primary data were organized, coded, processed and analyzed attentively. The Statistical Package for the Social Sciences (SPSS) version 28 was used for this purpose.

The binary logistic regression (Logit Model) was used to analyze the factors influencing smallholder farmers' awareness of climate change. Descriptive statistics were used to analyze the climate change adaptation measures which those farmers employed, using frequency distribution, and percentages presented in the form of a pie charts.

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The Logit Model was used to analyze dichotomous outcome variables, meaning that the dependent variable had only two outcomes. The smallholder farmers who were aware of climate change 〖P〗_1, or the smallholder farmers who were not aware of climate change 〖P〗_0. In the Logit Model, the log-odds of the outcome were modelled as a linear combination of the predictor variables. The logit function is specified as the inverse of the sigmoidal "logistic" function or logistic transform used in mathematics, and particularly in statistics. When the function parameter represents a probability p, the logit function gives the log-odds, or the logarithm of the odds p/(1 − p).

The logit of a number p between 0 and 1 is given by the formula according to the model adopted from a study by Kunene et al. (2019):

$$\operatorname{logit}(p) = \log\left(\frac{p}{1-p}\right) = \log(p) - \log(1-p) = -\log\left(\frac{1}{p} - 1\right) \quad \text{(Eq.2)}$$

The "logistic" function of any number is given by the inverse-logit:

$$\operatorname{logit}^{-1}(\alpha) = \frac{1}{1+\exp(-\alpha)} = \frac{\exp(\alpha)}{\exp(\alpha)+1} \quad \text{(Eq.3)}$$

If p is a probability, then p/(1 − p) is the corresponding odds; the logit of the probability is the logarithm of the odds. Similarly, the difference between the logit of two probabilities is the logarithm of the odds ratio (R), thus providing shorthand for the correct combination of odds ratios simply by adding and subtracting:

$$\log(R) = \log\left(\frac{p_1/(1-p_1)}{p_2/(1-p_2)}\right) = \log\left(\frac{p_1}{1-p_1}\right) - \log\left(\frac{p_2}{1-p_2}\right) = \operatorname{logit}(p_1) - \operatorname{logit}(p_2) \quad \text{(Eq.4)}$$

So, putting all this together, the key equation, usually termed the "multivariate logistic regression equation" or "multivariate logistic regression model" to which one fits the data, is as follows:

$$\log\left(\frac{p_i}{1-p_i}\right) = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip} \quad \text{(Eq.5)}$$

where Pi is the probability that Yi is 1.

Pi / (1 – Pi) is called the "odds". In the analysis, the function is estimated with the minimum likelihood method and if Y = 1, the smallholder farmer is aware of climate change adaptative measures; and if Y = 0, the smallholder farmer is not aware of climate change adaptative measures.

Results and discussion

Farmers' awareness of climate change

The results of the study showed that all the smallholder crop farmers (100%) who participated in this study were aware of climate change in the area under investigation.

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This was not surprising, since the local Department of Agriculture and Rural Development often hosts events such as agricultural information roadshows, climate awareness campaigns, farmers' days, radio climate talk shows and national summits, to share information related to agriculture – including raising awareness on climate change. Climate change awareness is often considered necessary in the first stages of the adaptation process to manage its impact (Ricart, 2023). The finding in this study matches those on a study about climate change awareness, conducted by Raghuvanshi et al. (2017), which revealed that all the farmers (100%) in that investigation were aware of climate change. Oduniyi (2013) reported that 82.9% of respondents in that study conducted in South Africa were not aware of climate change, while 17.1% claimed to be aware of climate change, due to awareness drives in their area. A study in Nigeria by Olayinka (2013) revealed that most people still perceive climate change to be attributable to natural causes and industrialization, with awareness of the various causes of climate change generally being found to be below average. Fewer than 50% viewed climate change in terms of reduced agricultural productivity or ozone layer depletion, which indicates that the remaining half were unaware of these issues (Below et al., 2012). As Oduniyi and Tekana (2019) report, most farmers in their study area were aware of climate change yet failed to implement mitigation strategies. This is in line with the findings reported by Harmer and Rahman (2014), who found that high levels of awareness may not necessarily translate into an uptake of adoption strategies.

Awareness of climate change adaptation measures

The results of this study in *Figure 2* indicated that most of the participating farmers were aware of climatic change adaptation measures in the study area. Of the 291 farmers interviewed, 263 (90.38%) were aware of such measures, while 68 (9.62%) were not. Several studies have been conducted around the globe on how smallholder farmers adapt to changing climate, and the importance of adapting agricultural practices to changes in climate (Deressa et al., 2009; Mertz et al., 2009; Hisali et al., 2011; Kemausuor et al., 2011; Below et al., 2012). All these studies concluded that most farmers perceive that the climate is changing and are taking measures to reduce the impact of that change.

Adaptation measures to deal with changes in temperature

The results in *Figure 3* illustrate that most farmers reported changing their planting dates, particularly by adopting the late approach were (51.20%); (31.27%) employed a building water harvest scheme (collecting run-off from roofs and gutters), (13.06%) used a mixed cropping approach, and (4.47%) used crop and variety diversification. None of the farmers indicated any other adaptation measure that they implemented. The results indicated that most smallholder crop farmers depended on the adaptation measure of changing planting dates, as their preferred means of dealing with rising temperatures. Relatively inexpensive measures, such as changing planting dates and diversifying crops were used, while those that are more costly or require more capital (such as irrigation systems) tended to be used by very few farmers. This finding is in line with that of Below et al. (2012). Thus, the choice of adaptation option is largely influenced by farmers' financial capabilities. This aligns with what Turpie and Visser

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(2013) reported on crop diversification and the changing of planting and harvesting dates, as potential strategies to adapt to climate change.

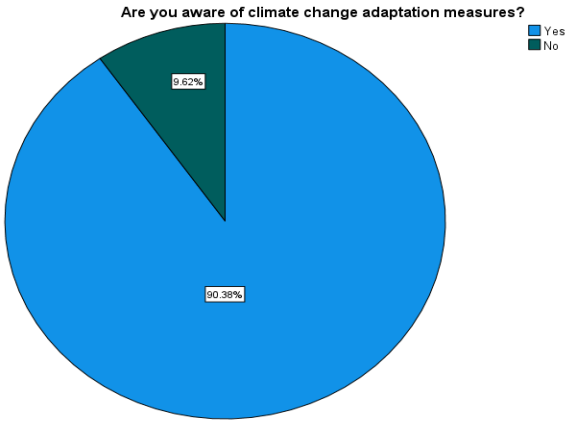

Figure 2. *Smallholder farmers' awareness of climate change adaptation measures*

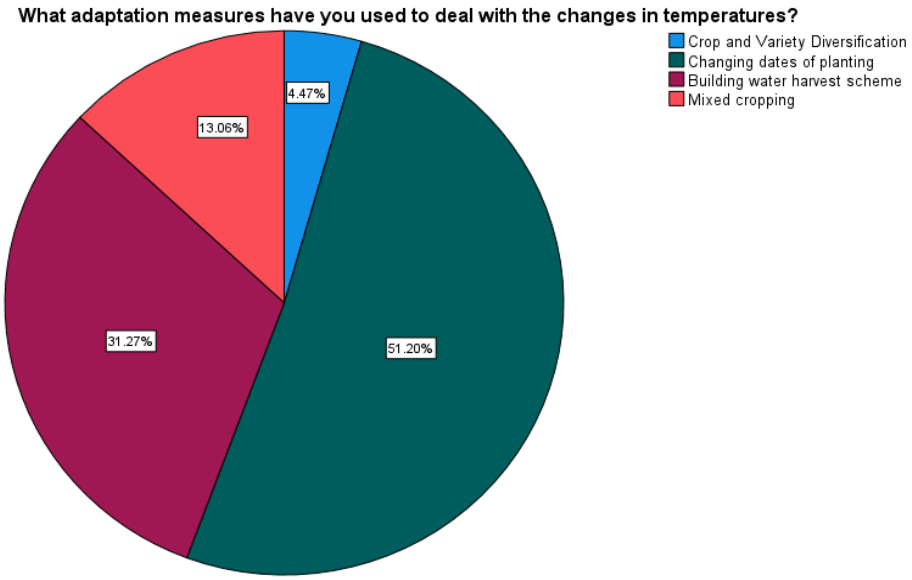

Figure 3. *Adaptation measures to deal with changes in temperatures*

Factors influencing smallholder farmers' awareness of climate change

The results of the study (*Table 1*) indicated that the variable *gender* of the farmer had a statistically significant effect on awareness of climate change, with a negative coefficient (sig.084). The descriptive statistics however, revealed that all the respondents were aware of climate change. As Harmer and Rahman (2014) found, the effects of climate change have different impacts on different people. Notably, differently positioned women and men perceive and experience climate change in diverse ways because of their distinct socially constructed gender roles, responsibilities, status and identities, which result in varied coping strategies and responses (FAO, 2009; Lambrou and Nelson, 2010). The study by Nhemachena and Hassan (2007) acknowledges women's contribution in the agricultural sector, in adapting to climate change. According to the United Nations

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Development Programme (UNDP, 2009), across developing countries women's leadership in natural resource management is well recognized.

The variable *size of the land/farm* was found to be statistically significant, with a negative coefficient. This implies that a unit increase in farm size resulted in a decrease in the farmer's awareness of climate change. The majority of farmers (58%) had more or less three hectares of land for their farming activities. This is contrary to the findings of Mandleni and Anim (2010), who indicate that the coefficient was not statistically significant, even at the 10% level of confidence, though it was positively related to climate change and adaptation. A study measuring vulnerability to climate change in Iran conducted by Jamshidi et al. (2019) identified land as one of the factors contributing to climate change vulnerability.

The variable change of weather, which sought to determine whether smallholder crop farmers had noticed a change in weather or not, had a significant influence on farmers' awareness, with a negative coefficient. This implies that all smallholder crop farmers notice change of weather, were aware of climate change.

Table 1. *Factors influencing climate change awareness among respondents*

Variables	Coefficient	Std. error	t	Sig.
Municipality	0.008	0.007	1.203	0.230
Gender	-0.016*	0.009	-1.737	0.084
Age	-0.001	0.002	-0.410	0.682
Household size	0.004	0.008	0.591	0.555
Marital status	-0.001	0.004	-0.328	0.743
Educational level	-0.005	0.005	-1.029	0.304
Source of income	0.017	0.011	1.512	0.132
Household income	0.009	0.006	1.467	0.144
Farming experience	0.005	0.004	1.437	0.152
Size of the farm	-0.016***	0.005	-3.172	0.002
Farm ownership	-0.002	0.004	-0.586	0.559
Source of information	0.001	0.003	0.332	0.740
Change of weather	-0.339***	0.044	-7.742	0.001
Consent	0.985	0.034	29.277	<.001

*, **, *** represent significant levels at 10%, 5% and 1% respectively
Source: Survey data (2022 - 2023)

Conclusion

It is evident from the findings that all 291 (100%) smallholder crop farmers (both male and female) were aware of climate change. However, the majority of the smallholder crop farmers (51.2%) adapted changing date planting as a mitigation measure to deal with climate change. More awareness of climate change adaptation and mitigation strategies should be done to equip the smallholder farmers with the right choices on other climate change adaptation and mitigation strategies. Both female and males smallholder crop farmers involvement in agriculture did not vary much (female 53.26%) compared to their male counterparts at 46.74%, support to increase awareness and access to agricultural inputs should be awarded to both females and males since they are all involved in agriculture.

Factors such as gender, change in weather and size of the farm or land had an influence on the awareness of smallholder crop farmers. Therefore, policies aimed at improving awareness in climate change among smallholder crop farmers should be

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informed by these factors. There is a need to educate farmers' through information days, demonstrations, farmers' exposure visits, extension conferences and workshops in order to equip farmers' to effectively and efficiently adapt to the changing climate in order to produce quality yields and feed the nation and maintain poverty reduction. Even though farmers are aware of climate change, there is still a need for a deeper foundation in terms of climate adaptation mitigation measures for farmers to adopt to the changing climate conditions, the department of agriculture and other key stakeholders must key part take in order to help farmers in sustaining their businesses and have a yield production to maintain food security and up take the country's economic standard.

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