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Impact of Extension Services on the Use of Climate Change Coping Strategies for Smallholder Ruminant Livestock Farmers in Raymond Local Municipality, Eastern Cape Province, South Africa

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ABSTRACT

The study assessed the impact of extension services on the use of climate change coping strategies for livestock farmers in Raymond Local Municipality, Eastern Cape Province, South Africa. The study utilised a cross-sectional survey design with 82 livestock farmers obtained through a purposive sampling method. The study used Propensity Score Matching (PSM) to analyse the data. Most respondents were single females aged 63, with average household sizes of 6, and had primary education, mostly keeping small stock. Climate change was mainly witnessed through changes in rainfall, with 80% of respondents indicating that it is caused by deforestation. The results suggest that access to extension services impacted the extensive utilisation of climate change coping strategies that decreased the livestock numbers at the 10% statistical level. Access to extension appears to limit the available options as coping strategies for climate change resulted in decreased livestock numbers. In conclusion, access to extension has negatively affected the use of various climate change-induced coping strategies for reduced livestock numbers, with no effect on the other coping strategies. Recommendations include retraining extension officers on various climate change coping strategies they can impart to livestock farmers. Also, agricultural climate policy should focus on creating awareness and increasing access to extension services among livestock farmers on climate risk coping strategies to mitigate the impact on rural livestock farmers.

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1. INTRODUCTION

Agriculture is an important sector in the South African economy and remains a significant provider of employment, especially in rural areas, and a primary foreign exchange earner. However, climate change and variability have negatively affected agricultural production, especially rural smallholder farmers, because they depend on nature for survival. Agriculture is one of the most climate-sensitive sectors directly affected by physical and chemical climate changes (Mitter *et al*., 2019). Literature also suggests that smallholder farmers face numerous challenges such as drought, increase in temperature, deterioration of pastures, increased number of parasites and diseases and low production due to climate change as it brings many complex and unpredictable changes that affect farming management systems and agricultural productions (Tomlinson & Rhiney, 2018). According to Ubisi *et al*. (2017), the literature also argues that smallholder farmers are most affected by climate variability and may suffer more if appropriate coping strategies are not implemented. However, the discussions on climate change and its impacts on agriculture are fundamental to every nation. South Africa is also vulnerable to climate change and its consequences because it includes some of the poorest provinces with many smallholder farmers, such as the Eastern Cape, Limpopo and Kwazulu Natal (Maponya & Mpandeli, 2014).

Therefore, agricultural extension has a vital role to play in diffusing the change for smallholder farmers. This is because adaptations to climate change impacts require a change in people's knowledge, attitudes, resilience capacities and skills (Maponya & Mpandeli, 2014). Agricultural extension can bring this change because the sole purpose of agricultural extension services is to advise farmers on ways to cope with different threats and boost their production and returns. As a structured government activity, extension services have been practised in South Africa for about 100 years and are commonly regarded as a core component of the government's broader farmer support system. Agricultural extension is a form of adult education whose purpose is to provide agricultural support to farmers and assist farmers in making decisions that will better their farming practices and ensure food-secured communities in South Africa. Because agricultural extension services enhance farmers' efficiency in making adoption decisions, this will also assist in adopting climate change coping strategies by smallholder livestock farmers. Maponya and Mpandeli (2014)

argue that farmers with access to extension services tend to adopt more new farming technologies than farmers without access to extension contact. Previous literature also suggests that the use of extension approaches on the diffusion of knowledge and adaptation to climate change coping strategies by smallholder farmers is cost-effective and can improve the smallholder farmer's adaptation responses to the seasonal manifestations of climate change and variability (Mfitumukiza *et al*., 2017). With that background, there's an increasing need to investigate the impact of extension services on climate change coping strategies for smallholder livestock farmers of the Eastern Cape Province.

2. METHODOLOGY

2.1. Study Area and Research Design

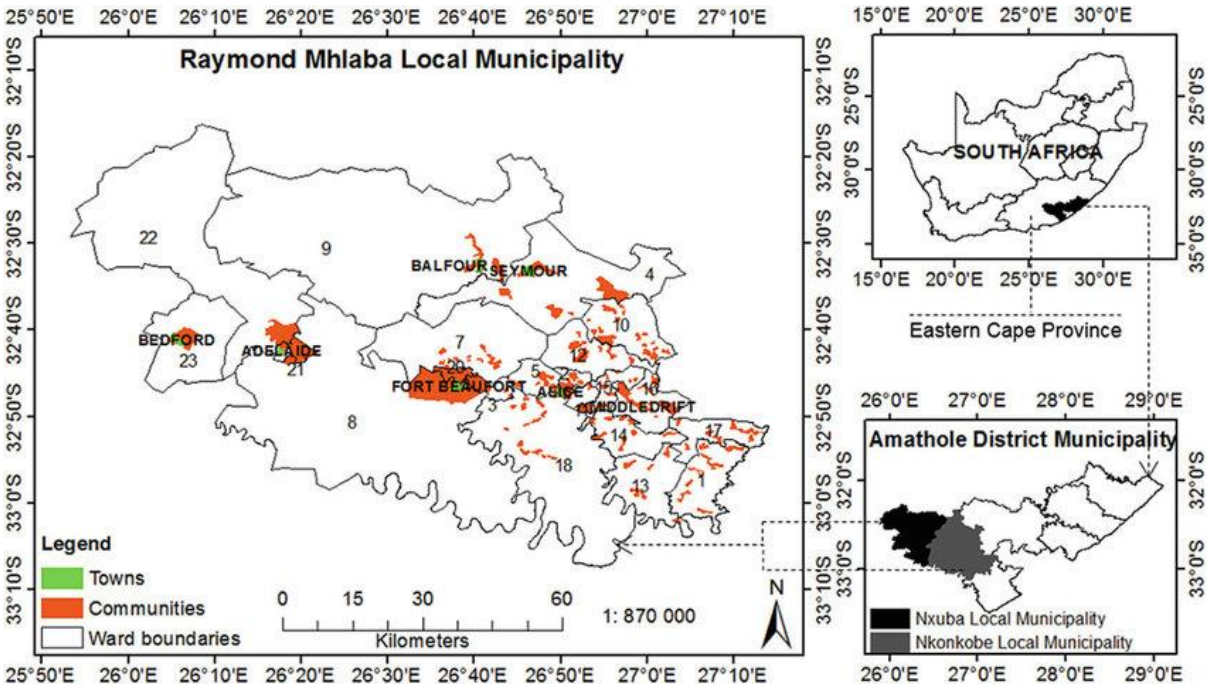

FIGURE 1: Location of Raymond Mhlaba Local Municipality (Source: Chari, 2020)

The study was conducted in Raymond Mhlaba Local Municipality, Eastern Cape, South Africa, with particular reference to Gaga and Msobomvu locations (Figure 1).

Raymond Mhlaba (formerly Nkonkobe) Local Municipality is the largest local municipality in the Amathole District, with a total area of 6 357 km^2, consisting of 41 022 households, a 65.3% population between 15 years and 64 years and a dependency ratio of 53.2 (Municipalities of South

Africa, 2021). Gaga has a population of 558 in 170 households on an area of 0.84 $km^{2,}$ and Msobomvu sits on 2.68 km^2 with a population of 1 765 in 482 households (StatsSA, 2011a, 2011b, 2011c). Raymond Mhlaba Local Municipality has a total population of 159 516, with 92.7% being Black African (ECSECC, 2017). The local municipality has 51.8% of the population being female, with 43.1% being youths aged between 15 and 34 years. The poverty rate in Raymond Mhlaba Local Municipality is 64.7%, and the unemployment rate stands at 46.7%, with 43.8% having attained some secondary schooling (ECSECC, 2017). However, in Amathole District Municipality, Raymond Mhlaba has the highest human development index. Raymond Mhlaba Municipality's GDP is at R5.2 billion (2016 levels) at 18.6% of Amathole District Municipality's total. The agricultural sector contributes 8.5% to Raymond Mhlaba's GDP (the highest in Amathole District Municipality), at R400 million, after community services, trade and finance, respectively (ECSECC, 2017).

These locations within the municipality were selected based on the region's large numbers of livestock farmers and well-pronounced communal rangelands for their livestock, grazing, and browsing (Mdiya *et al.*, 2020). Furthermore, most rural communities in Eastern Cape derive their livelihoods through livestock and crop farming. The study utilised a cross-sectional design.

2.2. Sampling procedure and sample size

The study used qualitative and quantitative approaches, with purposive and random sampling used to select respondents. The study was done in two locations (Gaga and Msobomvu) of Raymond Mhlaba Local Municipality, which was purposively selected. The sample size of 82 livestock farmers was selected from the study area, and only people actively involved in livestock farming were selected.

2.3. Data collection

The study used primary data, which was collected through a survey. A structured questionnaire was developed as the primary data collection tool. To check the validity and some errors of the questionnaire, pre-testing was done in both locations of the study area, but the respondents used in the pre-testing were not used in the primary survey. This also helped in training the enumerators to be familiar with the questionnaire. The targeted respondents were the household heads, using

face-to-face interviews and the local language IsiXhosa to accommodate the elderly people with no formal education and also get the proper meaning of the content in the questionnaire. However, in the absence of the household head, the spouse or any family member directly involved in livestock farming was also interviewed.

2.4. Data

TABLE 1: Description of Variables Used in the Study

Variable	Description	Measurement	Expected sign
Independent variables			
X_1	Gender of the farmer	1= Male, 0 = Female	-
X_2	Age of the farmer	Actual years	-
X_3	Marital status of the farmer	Single=0, Married=1, Divorced=2, Widowed=3	+
X_4	Family size of the farmer	1 = > 4, 0 = If less	+
X_5	Level of education by the farmer	Primary=0, High school= 1, Tertiary=2	+
X_6	Household source of income by the farmer	Social grants= 0, Farming sales=1, Salary from employment=2	-
X_7	Farming years by the farmer	0-10 years=0, >10 years =1	+
X_8	Distance to the agricultural marketing centre	1= 10 km, 0 = Otherwise	-
X_9	Access to extension services by the farmer	1=Access to extension agents, 0 = If not	+
X_{10}	Access to a financial institution by the farmer	1=Access to finance, 0 = Otherwise	-
X_{11}	Member of farm organisation	1=Member of farm organisation, 0 = If not	+

X_{13}	Occupation by the household head	0 = Part time farmer, 1= Full time farmer, Employed=2	+

2.5. Analytical Framework

The study utilised Propensity Score Matching (PSM) to measure the impact of extension services on the use of climate change coping strategies for smallholder livestock farmers in Raymond Local Municipality. The propensity score is a probability of being treated conditional on the given observed covariates (Johara *et al.*, 2021), and matching on propensity scores has been shown to perform better in reducing bias compared to other propensity score techniques in individual studies (Austin *et al.*, 2016). According to Heinrich *et al.* (2010), PSM is used when using information from a pool of units that do not participate in any intervention to identify what would have happened to participating units in the absence of the intervention. In the PSM model, for a farmer q, (where $q = 1 \dots Q$ and Q denotes the population of farmers), the impact evaluation separated the impact of using extension services ($Ex_q = 1$) on a certain outcome $Y_q(q)$ [utilisation of coping strategies (pasture deterioration, parasites and diseases, decreased livestock numbers, decreased livestock production and livestock weight)] from what would happen without using the extension services ($Ex_q = 0$), the counterfactual. This is the difference between the outcome of using extension services for farmers q and the counterfactual potential before/without extension services.

$$\emptyset_q = Y_q(1) - Y_q(0)$$

The impact $\emptyset_q$ cannot be observed since a household either uses extension services or does not, but never both. The next stage was to ascertain the average treatment effect of the treated (ATET):

$$\emptyset_{ATET} = E[\emptyset|Ex = 1] = E[Y(1)|Ex = 1] - E[Y(0)|Ex = 1]$$

The resulting PSM estimator for ATET was generalised as:

$$\emptyset_{ATET}^{PSM} = E_{\Pr(X)|Ex=1}\{E[Y(1)|Ex = 1, \Pr(X)] - E[Y(0)|Ex = 0, \Pr(X)]\}$$

Kernel, radius, stratified and nearest neighbour methods were used to match farmers using extension services to those not by using propensity score values for estimating the ATET.

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3. RESULTS AND DISCUSSION

More than half (55.0%) of the respondents were from the Gaga location, and about 45.0% were from Msobomvu (Table 2). A third of respondents were female and single, with 40.0% having obtained primary education. These results also agree with Matebeni (2018) that most households are females actively participating in agricultural activities, while male counterparts migrate to towns for non-government employment to support their families.

TABLE 2: Descriptive Statistics

Variable		%
Location		
	Msobomvu	45,0
	Gaga	55,0
Gender		
	Male	33,8
	Female	66,3
Marital status		
	Married	11,3
	Single	63,8
	Widowed	25,0
Education level		
	No formal education	27,5
	Primary school	40,0
	Secondary school	27,5
	Tertiary education	5,0

The study results in (Table 3) show that the average age of the respondents was 63 years, with household sizes of six. These findings disagree with Mdiya (2021), who stated that grown-up people tend to be unable to perform hard labour due to their old age. However, the results may also indicate that older people use agricultural activities to keep themselves busy as they have nothing much to do at home because most are pensioners and are unemployed. These results also

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indicate that the average livestock sizes were nine cattle, 58 sheep and eight goats per household, with 19 years of farming experience.

TABLE 3: Descriptive Statistics

Variable	Mean	Std. Deviation	Skewness	Kurtosis	Minimum	Maximum
Age	62,59	12,201	-1,331	1,105	30	81
Household size	5,51	2,381	-0,010	-0,510	1	10
Number of cattle	9,86	7,189	0,890	-0,109	1	28
Number of Sheep	58,18	81,636	1,804	1,750	0	221
Number of goats	8,00	5,614	0,645	-0,961	1	18
How long farming	19,34	15,351	0,605	-0,961	1	52

Regarding livestock ownership by the smallholder livestock farmers, results indicate that about 86% of the households keep sheep, relative to 57.5% and 17.5% that keep goats and cattle, respectively (Figure 2). This indicates that livestock production is predominately small stock. However, a study conducted by Bonis-Profumo *et al*. (2022) indicated that most women and men keep their livestock and make decisions on their production to generate more income and support their families.

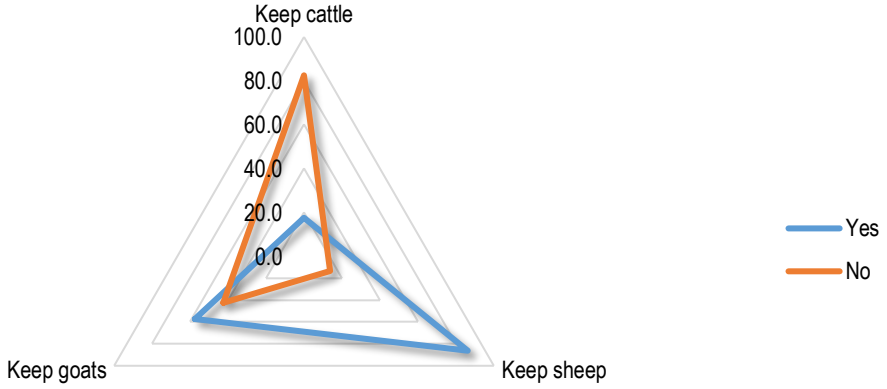

FIGURE 2: Ruminant Livestock Kept by the Respondents

Figure 3 shows that the respondents that have witnessed climate change have done so through changes in rainfall (98.8%), excessive floods (68.8%), prolonged drought (61.3%) and change in temperature (55.1%). This may indicate that most farmers have some knowledge of climate change through these scenarios. These findings are also in line with Chapke and Kammar (2021), who discovered that most farmers experience climate change through an increase in average temperature, the occurrence of droughts, uneven distribution of rainfall, decrease in average rainfall, decreased yield, reduction in average productivity, a decline in quality of produce, increased water stress and heavy terminal rain.

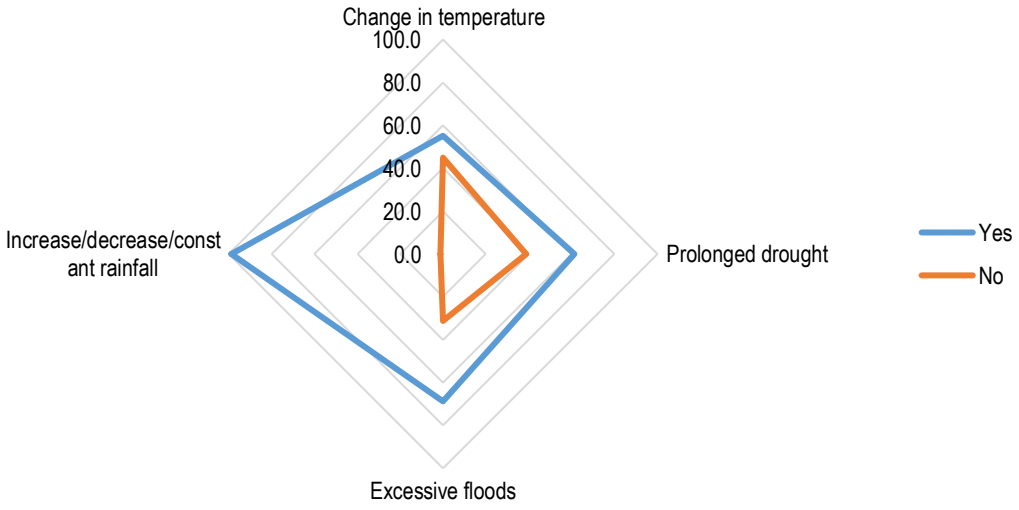

FIGURE 3: Evidence of Climate Change

With regards to causes of climate change, among respondents that know about climate change, about 80.0% indicate that it is caused by deforestation, while 71.4% indicated that it is caused by natural activities, about 63.3% show that it is caused by God's will and 52.9% highlight that human activities cause it. Results from Shahzad (2015) also indicated that burning fuels produce gases like carbon dioxide, and deforestation is the leading factor in climate change and global warming.

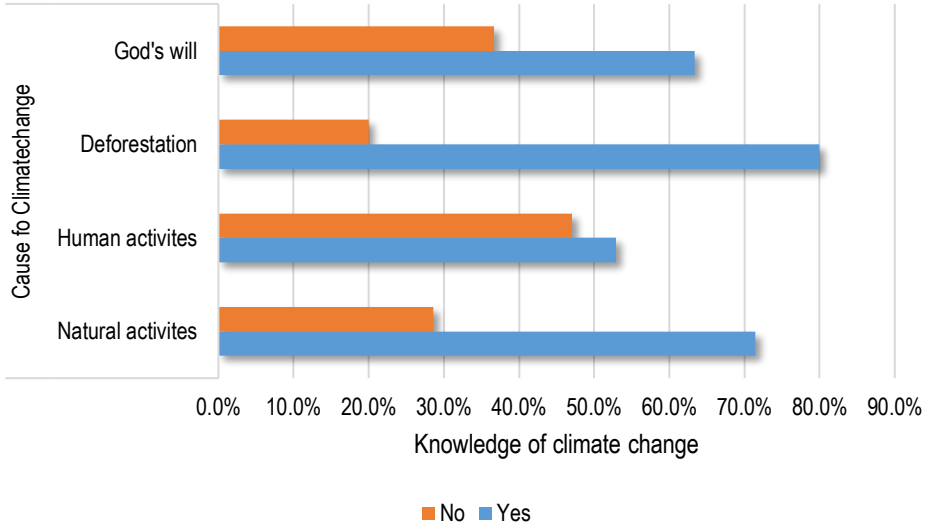

FIGURE 4: Knowledge and Causes of Climate Change

Figure 5 shows the various climate coping strategies that respondents use. In terms of pasture deterioration caused by climate change, the respondents were coping through dividing camps (71.9%), dipping (64.6%) and buying lucerne (57.1%). However, in a study conducted by Bahta (2020), results indicated that farmers sold their livestock to other people to cope with climate change. Furthermore, results showed that farmers used divided camps to rotate their livestock, kept drought-tolerant breeds, and received government animal feed and relief grants. Others used their savings and investments as a coping strategy against climate change (Bahta, 2020). Climate change-induced parasites and diseases were counteracted by dividing camps (66.7%) and dipping (59.1%). Climate change-induced decrease in livestock numbers was averted through vaccination (100.0%), buying lucerne (72.7%), dividing camps (59.5%) and dipping (50.0%).

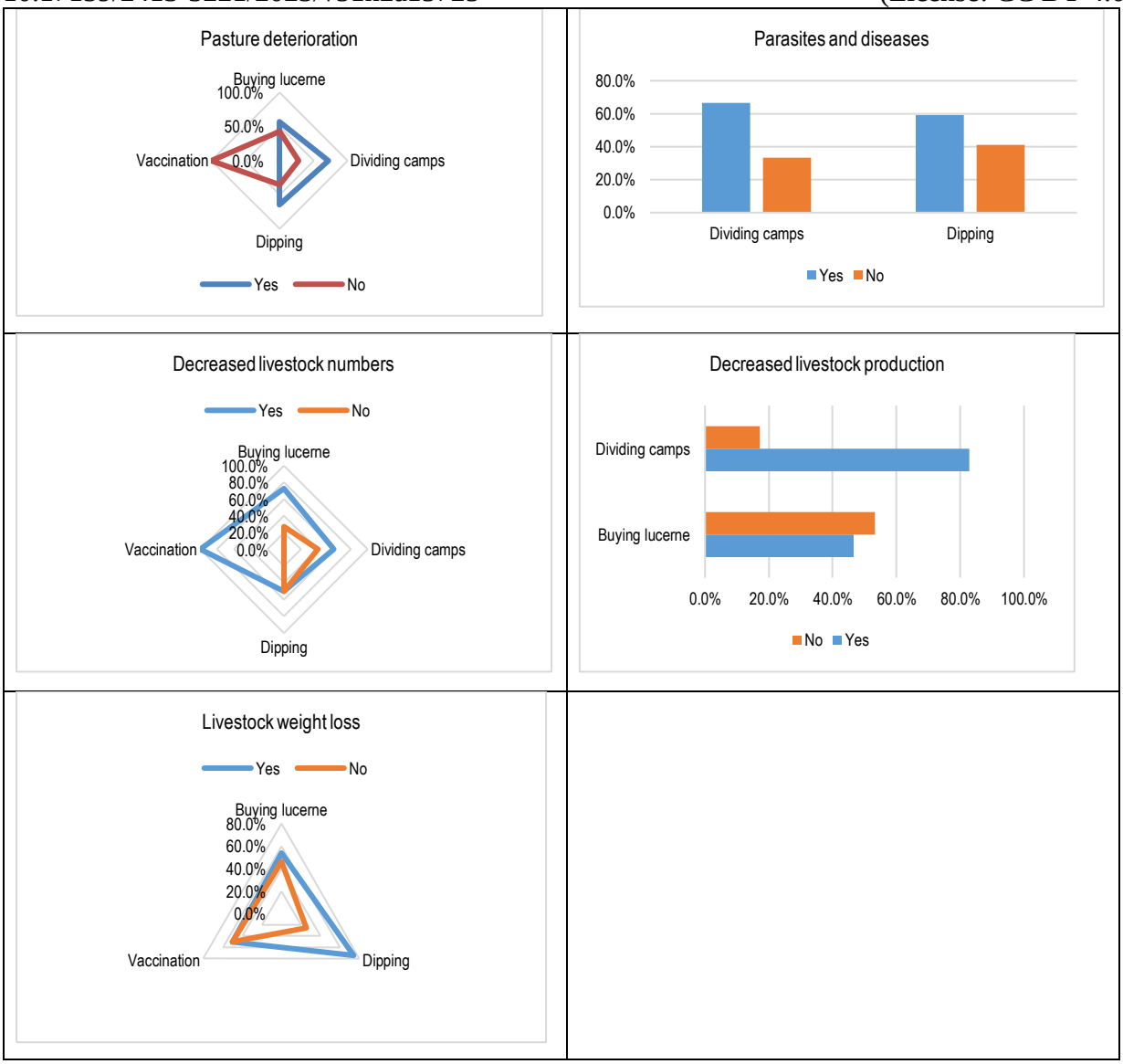

FIGURE 5: Coping Strategies Caused by Climate Change

Dividing camps and buying lucerne were coping strategies for 82.9% and 53.3% of respondents who had climate change-induced decreased livestock production (Figure 5). Dipping (74.3%), buying lucerne (53.8%), and vaccination (50.0%) were coping strategies for climate change-induced livestock weight loss. These results align with Bahta (2020), who discovered that farmers used animal feed such as lucerne and relief grants provided by the government as a coping strategy against climate change.

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Table 4 shows that factors such as gender and marital status were significant in obtaining extension services at the 1% level, while household size was significant at the 5% level. There is a 22% probability that female respondents are likely to receive extension advisory services compared to males. These findings are in agreement with Atsbeha and Gebre (2021), who discovered that variables such as household size, age, farmland size, information about livestock extension service, number of visits by extension agents and access to livestock production training have a significant influence on the probability of farmers' access to extension service. The likelihood of obtaining extension services when the respondent is widowed is 14%, whilst there is a 4% chance that a household will receive extension services when there is a larger household size. The overall model was acceptable at the 5% level and the R^2 showed that the model was only explained by 11% of the variables.

TABLE 4: Probit of Factors Affecting Reception of Extension Advisory Services

	β	Std Err	z	$P > \|z\|$	Marginal effects	
					$\frac{dy}{dx}$	$P > \|z\|$
Gender	0.65	0.36	1.81	0.07	0.22	0.05
Age	0.01	0.02	0.59	0.56	0.004	0.56
Location	0.18	0.30	0.58	0.56	0.06	0.56
Marital status	0.43	0.22	1.91	0.06	0.14	0.04
Household size	0.11	0.07	1.72	0.09	0.04	0.07
Educational level	0.30	0.23	1.28	0.20	0.10	0.188
Constant	-3.15	1.26	-2.48	0.01	-	-
χ^2	11.84					
Sig	0.07					
R^2	0.11					

Access to extension significantly impacted decreased livestock numbers at the 1% level, as shown in Figure 5. It did not significantly impact the other climate change-induced coping strategies. However, acceptable access to extension services greatly enhances farmers' capacity to improve

the perception and adoption of agricultural coping strategies against climate change (Maka *et al*., 2019). Access to extension services decreased the number of climate change-induced coping strategies for decreased livestock numbers. This might be because extension training and facilitations from the extension officers help farmers be aware of various climatic-related coping strategies. This also suggests that frequent visits by extension officers to farmers are significant because agricultural extension is the most important source of information for farmers (Agbamu, 2002). This also indicates the likelihood of utilising non-convectional coping strategies for climate change-induced decreased livestock numbers. Access to extension appears to limit the available options as coping strategies for climate change induced a decrease in livestock numbers. Therefore, this may suggest that indigenous knowledge systems are more likely to be used to counter decreased livestock numbers.

Table 5 shows the impact of extension services on the utilisation of climate change-induced coping strategies. The results indicate that extension services significantly utilised coping strategies related to decreased livestock numbers at the 10% level. The positive coefficient indicates that if the farmers have access to extension services, they will likely use coping strategies related to decreased livestock numbers. This reflects livestock's social and symbolic status in rural communities where numbers matter, and the farmers will pursue objectives that maintain or increase their numbers (Ngarava, 2019). This is due to the social status that large number of livestock have in the rural communities.

TABLE 5: ATT of Extension Services on Coping Strategies

	β	Std Err	z	P > |z|
Pasture deterioration copying strategy	0.25	0.24	1.05	0.294
Parasites and diseases	-0.25	0.20	-1.22	0.222
Decreased livestock numbers	0.26	0.16	1.58	0.091
Decreased livestock production	-0.24	0.18	-1.34	0.182
Livestock weight	-0.19	0.18	-1.07	0.285

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The study used a propensity score matching approach to assess the impact of extension services on the use of climate change coping strategies for smallholder ruminant livestock farmers. In this approach, the nearest neighbour matching (NNM) algorithm was employed for the estimation, as the nearest neighbour matches with the similar nearest neighbour in the opposite group. Table 6 shows that the PSM was acceptable, as the matched variables had no significant differences. These results indicate that farmers coping strategies stand a good chance in assisting livestock farmers against climatic-related changes that cause pasture deterioration, parasites and diseases, decreased livestock numbers, decreased livestock production and livestock weight loss.

TABLE 6: ATT of Matching Methods

	Pasture deterioration copying strategy	Parasites and diseases	Decreased livestock numbers	Decreased livestock production	Livestock weight
Nearest neighbour	-0.02 [0.35] (-0.05)	-0.25 [0.08] (-3.10)	0.26 [0.11] (2.45)	-0.24 [0.10] (-2.50)	-0.70 [0.16] (-4.45)
Radius	0.13 [0.16] (0.82)	-0.06 [0.04] (-1.48)	0.20 [0.23] (0.89)	-0.29 [0.10] (-2.83)	-0.76 [0.11] (-7.01)
Kernel	0.08 [0.23] (0.35)	-0.07 [0.04] (-1.77)	0.21 [0.11] (2.01)	-0.25 [0.11] (-2.19)	-0.614 [0.51] (-1.22)
Stratification	0.051 [0.28] (0.18)	-0.08 [0.12] (-0.62)	-0.01 [0.13] (-0.05)	-0.18 [0.12] (-1.49)	-0.76 [0.14] (-5.63)

The matching methods reduced bias by a range of 0.09% and 0.19%, increasing the reliability of the impact results.

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TABLE 7: Reduction in Bias

	Pasture deterioration copying strategy	Parasites and diseases	Decreased livestock numbers	Decreased livestock production	Livestock weight
Nearest neighbour	0.24	0.10	0.01	-0.07	-0.09
Radius	0.08	0.04	-0.06	0.02	0.10
Kernel	0.006	0.09	0.02	-0.05	0.28
Stratification	0.19	-0.06	-0.03	-0.01	0.04

4. CONCLUSION AND RECOMMENDATIONS

The analysis of this study from Figure 3 showed that livestock farmers are aware of climate change caused by deforestation. In contrast, other farmers believed that it resulted from punishment from God and human activities. However, most farmers used the following coping strategies: dipping, vaccination, dividing camps, and buying lucerne to cope with climate change. The study also indicated that farmers keep sheep more than any other livestock, and most farmers are at the age of 63 years. The study used a propensity score matching approach to assess the impact of extension services on the use of climate change coping strategies for smallholder ruminant livestock farmers. Results showed no significant differences in the matched variables. Based on the study results, the following recommendations are made:

- Training of extension officers on various climate change coping strategies they can impart to livestock farmers.
- Also, agricultural climate policy should focus on creating awareness and increasing access to extension services among livestock farmers on climate risk coping strategies to mitigate the impact on rural livestock farmers.

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