South African Journal for Agricultural Extension

2024
Volume 52
Issue 4

Online ISSN 2413-3221
Print ISSN 0301-603X

S. Afr. J. Agric. Ext. Ramoroka, Tada & Banga
Vol. 52 No. 4, 2024: 1-16
https://doi.org/10.17159/2413-3221/2024/v52n4a16077

Evaluation of Non-Genetic Factors Affecting Birth Weight of Kalahari Red Goats in South Africa

Ramoroka, M.P.[1], Tada, O.[2] and Banga, C.B.[3]

Corresponding Author: M.P. Ramoroka. Correspondence Email: mamidprince@gmail.com

ABSTRACT

This study investigates the effect of non-genetic factors on the birth weight of Kalahari Red goats, a critical economic parameter in livestock production. Analysing data from 1902 goat kids born between 2008 and 2017 in different regions of South Africa, including the Northern (Gauteng, Mpumalanga, Northwest, and Limpopo), Southern (Eastern Cape and the eastern part of Western Cape), and Eastern (KwaZulu-Natal and the eastern part of Eastern Cape), the research employs a least-squares analysis of variance (ANOVA) using the General Linear Model (GLM) procedure. The results highlight the significance of various factors in determining birth weight. Season of birth, sire age, doe age, sex of the kid, breeder, year of birth, and birth type emerge as influential sources of variation ($p < 0.05$). Notably, region and kidding interval show no significant effect on birth weight ($p > 0.05$). Male kids generally have a higher average birth weight compared to females. Single births result in higher weights than multiple births (twins, triplets, and quadruplets). The study underscores the importance of considering these factors in genetic evaluation models. It emphasises their relevance in enhancing the understanding of prenatal growth and postnatal development in Kalahari Red goats within the context of livestock production.

Keywords: Adaptability, Growth, Reproductive Potential

[1] M.P. Ramoroka. PhD Student at the University of the Free State: Department of Animal Science, University of the Free State, PO Box 339, Bloemfontein 9300, South Africa. mamidprince@gmail.com, 0000-0003-3052-7092

[2] O Tada. Associate Professor at University of Limpopo, Department of Agricultural Economics and Animal Production, P. Bag X1106 Sovenga 0727, South Africa. obert.tada@ul.ac.za, 0000-0003-4330-164X

[3] C. Banga. Professor at Botswana University of Agriculture and Natural Resources, Department of Animal Science, P. Bag 0027, Gaborone, Botswana. cbanga@buan.ac.bw. 0000-0002-0316-8752

Vol. 52 No. 4, 2024: 1-16
https://doi.org/10.17159/2413-3221/2024/v52n4a16077

1. INTRODUCTION

Goats are considered valuable genetic resources for producing meat, milk, skin, and fibre (Atoui et al., 2017). Furthermore, they play a crucial role in the socio-economic aspects of human lives. Due to their remarkable adaptability to diverse environments, goats are extensively distributed in tropical and subtropical regions (Mbayahaga et al., 1998). Kalahari Red goats were developed from two lines of the brown lop-eared 'unimproved' Indigenous goats in South Africa and the Boer goats of Namibia (Campbell, 2003). In 1991, Albie Horn also conducted the selection of indigenous brown and brown and white goats from the former homelands of the Eastern Cape, the Karoo, and Namibia. In livestock production, birth weight is considered an economically significant trait (Atoui et al., 2017). It has been established by Bailgy et al. (1990) that birth weight influences the future performance of individuals within their respective environments. A positive genetic correlation exists between body weights at different stages of development (Safari et al., 2005).

Consequently, selecting for increased birth weight is anticipated to result in elevated mature body weight, positively impacting enterprise profitability. Birth weight is subject to influence by both genetic and non-genetic factors, with performance traits being susceptible to various factors (Afzal et al., 2004). Non-genetic factors such as the age of the animal, sex, birth type, and the age of the does significantly influence growth traits in many livestock species, including birth weight, as extensively documented in the literature.

However, there is a shortage of information regarding the growth traits and non-genetic factors affecting the South African Kalahari Red goat breed. To accurately estimate breeding values and ensure unbiased results in multiple trait analyses of growth traits, it is imperative to have precise knowledge of the covariances among random and fixed effects in the model (Neser et al., 2012). Incorrectly specified covariance components may lead to biased breeding values and an inaccurate assessment of the effectiveness of genetic selection. While various studies in South Africa have focused on traits such as milk yield in different goat breeds, there is limited research on growth traits. Similarly, studies on growth traits have been conducted for various breeds globally, but South Africa has yet to contribute significantly to this body of knowledge. Despite the indigenous status of the Kalahari Red goat breed, there is a notable scarcity of information about it in the existing literature. Understanding the impact of environmental factors on economically important traits is crucial for goat production. This knowledge can

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

contribute to reducing kid mortality rates and enhancing overall production potential (Husain, 2004). Production traits are known to be influenced by non-genetic factors such as sex, season, year, and type of birth (Kumar et al., 2007). Therefore, the primary objective of the current study was to assess the non-genetic factors affecting the birth weight trait of Kalahari Red goats in South Africa.

2. MATERIALS AND METHODS

2.1. Data Sampling

The SA Studbook availed a total of 26204 performance records for the purebred Kalahari Red breed. The records ranged from the year 1977 to 2018, and kids were born all year round in different provinces/regions of South Africa: Northern (Gauteng, Mpumalanga, Northwest, and Limpopo), Southern (Eastern Cape and the eastern part of Western Cape), and Eastern (KwaZulu-Natal and the eastern part of Eastern Cape). The information included pedigree information, birth date, season of birth, birth weight (BW), birth type, breeder, sex, age of sire & dam at kidding. Most of the provinces had no records on the birth weight of Kalahari Red goats. Birth weight, an important trait correlated with mature body weight and could have a desirable impact on overall profitability, was analysed. Purposive sampling was done, targeting goats with birth weight measurements.

2.2. Data Editing

Edits consisted of checks for sex, litter size, the season of birth, year of birth, sire ID, breeder, region, kidding interval, sire age, and dam age. All animals without birth weight were excluded from the analyses. Data for 10 years (2008 to 2017) was used because years before 2007 had a deficient number of records missing information on litter size, sire and the dam. Only sires with more than 15 progeny were retained. Breeders with less than 15 records were discarded. Only Eastern, Northern and Southern regions were used. Kidding intervals ranged from 170 to 390 days, and anything outside this range was discarded as they indicated errors in data capturing. Only 1902 kids were used after data editing. The structure of the edited data that was subsequently used in the analyses of non-genetic factors affecting BW of Kalahari Red goats is shown in Table 1.

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

TABLE 1: **Structure of Edited Data That Was Used in the Analyses of Non-Genetic Factors Affecting BW of Kalahari Red Goats**

Factor	Records of kids used.
Number of animals	1902
Number of Males	978
Number of Females	929
Kidding interval range (days)	170 to 390
Birth type	single (142), twins (330), triples (66) and quadruplets (4)
Breeders (code)	134091563, 480156152, 484770884, 503407721, 509512900, 541020517, 542190721, 610190480, 614783869, 698383515, 782691341
Period (year)	2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017

2.3. Data Analysis

The growth performance trait analysed was birth weight, measured using a weighing scale. Some of the data used were calculated as follows: birth weight was recorded at birth; age of dam and age of sire recorded at kidding and was calculated as kid birth date minus birth date of sire/does; kidding interval, calculated as number of days between successive dam kidding. The significance of fixed effects such as sex, birth type, season of birth, year of birth, breeder and region and random effects such as dam age, sire age and kidding interval was tested by conducting least-squares analyses of variance (ANOVA) using the General Linear Model (GLM) procedure of the Minitab 18.1 (2017) Statistical software. The model, in matrix notations, is presented as follows:

$$y = Xb + Zu + e$$

Where: y = vector of observation (BW); b = vector of fixed effects (sex, region, year of birth, season of birth, breeder, birth type); u = vector of covariates (animal effects: does age, sire age, kidding interval); e = vector of random residual effects; X and Z are incidence matrices relating records to the fixed effects and animal effects, respectively.

3. RESULTS AND DISCUSSION

The study evaluated non-genetic factors that influence the birth weight of purebred Kalahari Red goat kids from different flocks in three regions of South Africa, which include Northern

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

(Gauteng, Mpumalanga, Northwest, and Limpopo), Southern (Eastern Cape and the eastern part of Western Cape), and Eastern (KwaZulu-Natal and the eastern part of Eastern Cape). A summary of the Analysis of Variance (ANOVA) of BW is shown in Table 2. Fischer's Least Significant Difference was employed as the mean separation technique at a significance level of 5% ($\alpha = 0.05$).

TABLE 2: Analysis of Variance for Non-Genetic Factors Affecting BW of Kalahari Red Goat

Source	DF	SS	MS	P-Value
Kidding interval	1	0.04	0.03	0.73
Does age at kidding (days)	1	0.02	0.02	0.82
Sire age at kidding (days)	1	1.62	1.64	0.02
Sex	1	2.16	2.16	0.01
Birth type	3	3.23	1,08	0.01
Season of birth	3	2.59	0.86	0.04
Year of birth	9	90.51	10.06	0.00
Region	2	1.03	0.52	0.18
Sex*Season of birth	3	2.35	0.78	0.05
Error	517	154	0.30	

DF= Degree of freedom; SS= Sum of square; MS= Mean of square

TABLE 3: Least Squares Means of Birth Weight For Different Groups of Kalahari Red Goats' Kids

Factors	Mean ± SEM
Season	**S**
Autumn	3.12 ± 0.21^{a}
Winter	3.02 ± 0.21^{ab}
Spring	2.97 ± 0.21^{ab}
Summer	2.77 ± 0.22^{b}
Region	**NS**
Northern (Gauteng, Mpumalanga, North West, and Limpopo)	3.32 ± 0.15^{a}

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

Southern (Eastern Cape and the eastern part of Western Cape)	3.14±0.08[a]
Eastern (KwaZulu-Natal and the eastern part of Eastern Cape)	2.45±0.57[a]
Sex	**S**
Male	3.05±0.21[a]
Female	2.89±0.20[b]
Birth type	**S**
Single	3.11±0.19[a]
Twins	2.92±0.20[b]
Triplets	2.99±0.20[ab]
Quadruplets	2.87±0.35[ab]

Values with different superscripts in each column (or raw) significantly differ at $p<0.05$, S-Significant, NS-Not Significant.

3.1. The Effect of Season of Birth

Table 3 summarises the effect of season on birth weight. Kids born in the autumn and winter seasons had a higher average birth weight (3.12 ± 0.216 kg and 3.06 ± 0.215 kg) than those born in summer and spring (2.78 ± 0.218 kg and 2.97 ± 0.218 kg), respectively. However, only the autumn and summer seasons significantly affected the birth weight of Kalahari Red goats. These seasons are known to be lush with fresh grazing and browsing fodder. Moreover, no significant differences were recorded for the birth weight of kids born in winter and spring, which are cold and dry in most parts of South Africa. The season was found to have a significant effect ($p<0.05$) on the birth weight of Kalahari Red goats, which is consistent with the findings of Singh *et al.* (1992) and Mioč *et al.* (2011). Yadav *et al.* (2008) also reported that season significantly affected growth traits in Kutchi goats. This could be attributed to goat pregnancy occurring in different seasons and pastoral conditions (Khan *et al.*, 1983).

3.2. The Effect of Year

The birth year significantly affected the weight ($p<0.05$) of Kalahari red goats, as illustrated in the ANOVA in Table 2. The effect of birth year on birth weight is shown in Figure 1. The maximum birth weight (3.39 kg) was recorded for the kids born in 2015, whereas the minimum

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

(1.91 kg) was observed in 2016. From 2008 to 2015, an average birth weight of 3 kg was observed. However, in 2016, birth weight declined; this was attributed to the drought conditions in South Africa, leading to reduced pasture availability for adequate feeding. This fluctuation in birth weights may be linked to variations in rainfall patterns and the subsequent recovery of veld capacities. Notably, the diminished nutritional resources during the drought in 2016 resulted in insufficient feed for pregnant goats to sustain both the developing fetus and them. Subsequently, a recovery in birth weights commenced in 2017.

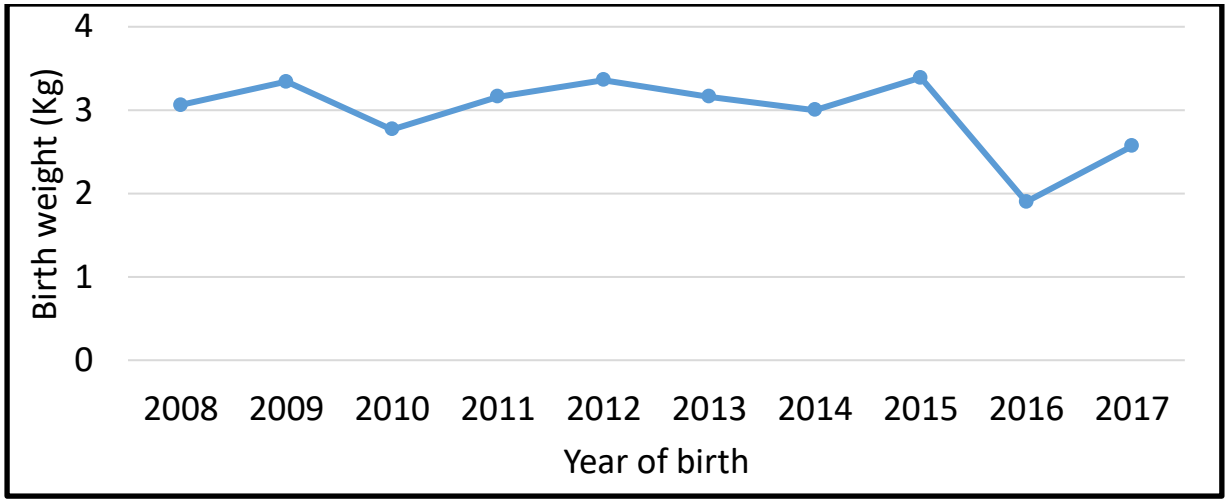

FIGURE 1: Means for Birth Weight Per Year for Kalahari Red Goats From 2008 to 2017

The contribution of the birth year can be highly variable due to differences in climatic conditions, feeding, and management, as well as the genetic composition of the herd (Smith, 2010). The results of the current study conform to the findings of Talekar (2015), who reported a highly significant ($p<0.01$) effect of the birth year on the birth weights of the kids in all months. However, Sharma *et al.* (1995) observed a highly significant effect of year of birth at all ages except for the third month of age in Jamunapari goats. Similarly, Kumar *et al.* (1993) reported that birth year directly and significantly influenced the relative growth rate in body weight at wither in Black Bengal and its half-bred goats with Jamunapari and Beetal. This result explains a variation in the birth weight of Kalahari Red goat's kids every year from 2008 to 2017. The trends can be explained by differences in rainfall, which leads to marked differences between each year's quality and quantity of forage available (Khombe, 1985).

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

3.3. The Effect of Region

The kids were born in different regions of the country; thus, the Northern, Southern, and Eastern, but no significant effect of region on birth weight was observed ($p>0.05$), as shown in Table 2 and Table 3. This indicates that the numerical differences across the region where the kids were born were not statistically different among the purebred Kalahari Red goats. However, it is important to note that a reduced weight at birth can be an adaptation to harsh environmental conditions in arid regions of other countries (Oltenacu, 1999). Furthermore, genetic variance in constant or unpredictable environments can reduce the population's mean fitness and increase the risk of extinction (Lande *et al.*, 1996). This justifies the difference in Kalahari Red goats' birth weight in other countries.

3.4. The Effect of Breeder

Table 4 illustrates the analysis of variance for the effect of the breeder on BW; it was tested at 95% level of significance. It can be seen that the breeder contributes significantly to the effects of birth weight ($p<0.05$). Sushma *et al.* (2006) found that young animals bred by different breeders differed significantly from each other due to environmental conditions and human choice variation. The decisions made by the breeder mainly relate to management practices, selection objectives, and the choice of breeding animal accounts for the majority of the variation associated with growth traits (Krupa *et al.*, 2005).

TABLE 4: Analysis of Variance (ANOVA) for Effects of Breeder on Birth Weight

Source	DF	SS	MS	P-Value
Breeder	10	411	41.1	0.000
Error	1896	841	0.444	
Total	1906	1253		

DF- degree of freedom, SS- sum of squares, MS- mean of squares

3.5. The Effect of Sex

The result in Table 3 indicates that male kids had a higher average birth weight (3.05 ± 0.21 kg) compared to female kids (2.89 ± 0.20 kg), and this difference was statistically significant ($p<0.05$), as shown in Table 2. This difference in weight between sexes may be due to the longer pregnancy period of carrying male kids for one to two days longer than those carrying

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

females (Ugur *et al.*, 2004). The literature supports these findings, with studies reporting similar results on the effect of sex on birth weight in various breeds (Husain *et al.*, 1996; Mioč *et al.*, 2011; Hristova *et al.*, 2013).

3.6. The Effect of Birth Type

The influence of birth type on birth weight is presented in Table 2 and Table 3, with a significant effect ($p < 0.05$) observed. The average birth weights of single, twin, triplet, and quadruplet kids were found to be 3.10 ± 0.198 kg, 2.92 ± 0.200 kg, 2.99 ± 0.205 kg, and 2.87 ± 0.36 kg, respectively (Table 3). The results showed that kids born as twins had significantly lower birth weights than those born as singles and multiples. This finding is consistent with previous studies, such as De Groot et al. (1992), who reported significantly lower birth weights of twin kids than single kids during the first six months. Moreover, Kuralkar *et al.* (2002) found that kids born as singles were significantly heavier than those born as twins and triplets.

3.7. The Effect of Dam Kidding Interval

The results in Table 2 show no significant ($p>0.05$) effect of kidding interval on birth weight. As shown in Figure 2, the Coefficient of Determination (R^2) value of 14% indicates that the kidding interval cannot explain the variation observed in the birth weights of the kids. This may be because the kidding interval is often associated with controlled mating (Wilson *et al.*, 1989). Kidding interval is more influenced by management restrictions than any other environmental factor.

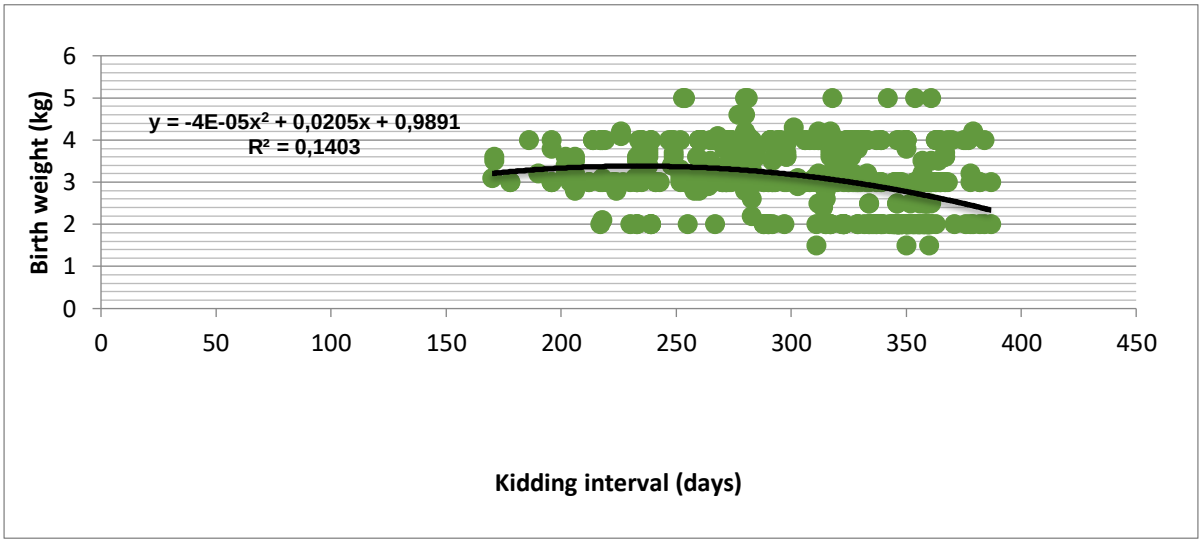

FIGURE 2: The Regression of Birth Weight on Kidding Interval for the Kalahari Red Goat

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

3.8. The Effect of Age of Dam

The results in Table 2 and Figure 3 demonstrate a significant ($p<0.05$) effect of dam age on birth weight. Birth weight steadily increased with dam's age up to 5 years, after which it declined with the advancing dam age. The maximum birth weight of 5.2 kg was observed in the 5-6 year group, while the minimum birth weight of 1.8 kg was found in the 7-8 year group. The R^2 value of 82% indicates a good account of the variation in birth weight over the different dam ages. The quadratic equation determined the optimum dam age of 4.5 years. It is generally accepted that older does give birth to heavier offspring than younger does (Portolano *et al.*, 2002; Liu *et al.*, 2005). Djemali *et al.* (1994) observed that kids born from the young dam had lower body weights than those from an adult dam and that growth traits increased with the age of the ewe up to five. The dam's capacity to nourish the developing foetus increases once they have reached reproductive maturity (Zishiri, 2009). As the dam becomes older, its ability to provide an adequate uterine environment for the unborn kids may diminish (Zishiri, 2009). This trend reflects the mature's greater ability to provide the foetus with the necessary nutrients and environmental conditions for its development (Elzo *et al.*, 1987). Likewise, as dams become older, their ability to provide an adequate uterine environment for the unborn kid may diminish. A similar trend has been observed in livestock species such as cattle and sheep (Elzo *et al.*, 1987).

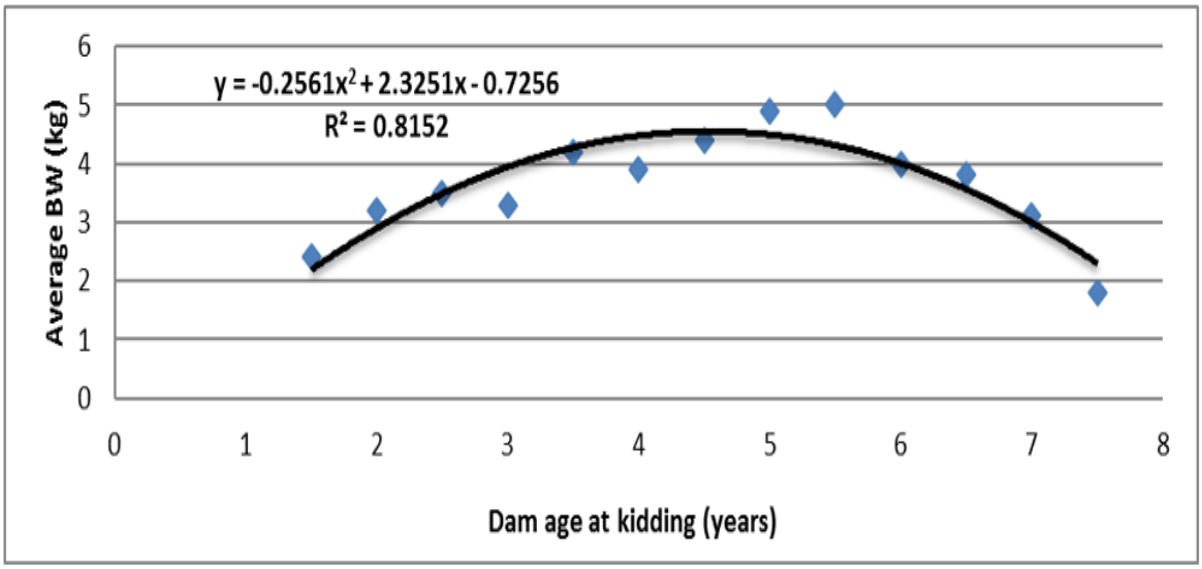

FIGURE 3: The Regression of Birth Weight on Does Age for the Kalahari Red Goat

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

3.9. The Effect of Age of Sire

The sire age significantly affected birth weight (p<0.05), as displayed in Table 2 and Figure 4. The young (1.5 years) and old (8.5 years) sires significantly affect birth weight. The R^2 73% gives a good account of the variation in birth weight on different sire ages, with the optimum age of 6 years. As illustrated in Figure 4, the highest birth weight of 3.1 kg was observed in kids aged 2-3 years, while the lowest birth weight of 2.4 kg was observed in kids aged 4-5 years. The results are consistent with previous studies by Karna *et al.* (2001) in Cheghu kids, which found that sire age significantly affected birth weight. The higher body weight and larger scrotal circumference of mature bucks result in increased semen and sperm concentration, which may explain the observed effect of age of sire on birth weight (Karna *et al.* 2001). The study's findings are also consistent with those of Salhab *et al.* (2003), who found a highly significant effect of sire age on morphometric traits at birth. Additionally, Dudhe *et al.* (2015) reported a highly significant effect of sire age on morphometric traits at birth. However, Tomar *et al.* (2001) reported no significant effect of sire age on the three morphometric traits. It is important to note that lack of experience and low libido in young bucks and senility in old bucks may contribute to the observed lower effects of the age of the sire on birth weight.

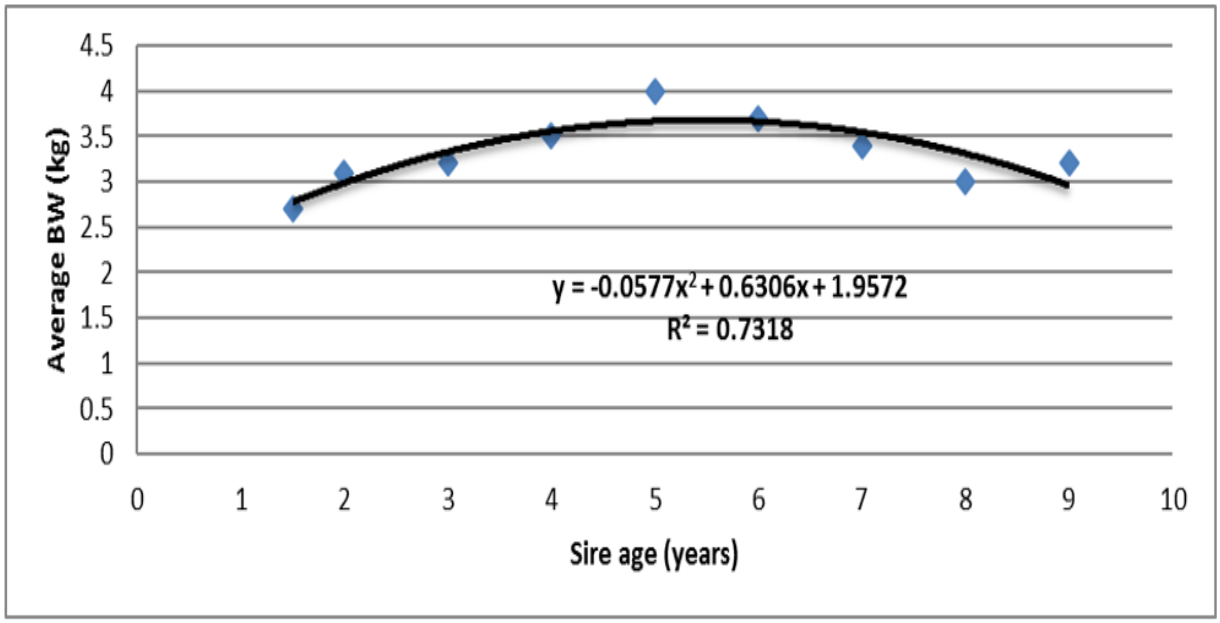

FIGURE 4: The Effect of Sire Age on Birth Weight for the Kalahari Red Goat

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

4. CONCLUSION

The study found that several non-genetic factors, birth type, year of birth, sex of kid, breeder, age of sire at kidding, age of does at kidding, and season of birth, significantly affected birth weight in Kalahari Red goats. These factors need to be accounted for in genetic evaluation models. Accurate adjustments for non-genetic factors are essential for predicting covariance components for growth performance and for genetic improvement of the breed. The positive response of Kalahari Red goats to the harsh and diverse conditions of South Africa provides a foundation for estimating genetic parameters and implementing a selection program for growth performance. Understanding the effects of different environmental conditions, reproductive parameters, and parental age factors on birth weight is a tool which can be used in breeding programs for goats. Since birth weight significantly impacts an animal's productive performance, it needs to be monitored and improved through sound recording and genetic evaluations.

5. ACKNOWLEDGEMENT

The authors wish to acknowledge the Department of Agricultural Economics and Animal Production, University of Limpopo, for supporting this study and SA Studbook for providing performance data.

REFERENCES

AFZAL, M., JAVED, K. & SHAFIA., 2004. Environmental effects on birth weight in beetal goat kids. *Pak. Vet. J.,* 24(2): 104-106.

ATOUI, A., HAJEJJI, M., ABDENNEBI, GADDOUR, A., & NAJARI, S., 2017. Environmental factors affecting birth weight of Tunisian local goat population kids. *J. New Scie Agric. Biot.,* 38: 2069-2076.

BAILGY, C.B. & MEARS, G.J., 1990. Birth weight in calves and its relation to growth rates from birth to weaning and weaning to slaughter. *Anim. Breed*., 58: 906.

CAMPBELL, Q.P., 2003. The origin and description of southern Africa's indigenous goats. *S. Afr. J. Anim. Sci.,* 4: 18–22.

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

DE GROOT, B.R., NARAYANPRASAD, R.L., SONI, P., NETT, & KROPF, W., 1992. *Performance of Sirohi goats under village conditions in Rajasthan*. Veterinary International Conference on Goats, New Delhi.

DJEMALI, M., ALOULOU, R. & BEN, SASSI, M., 1994, Adjustment factors and genetic and phenotypic parameters for growth traits of Barbarine lambs in Tunisia. *Sma. Rum. Res.,* 13: 41-47.

DUDHE, S.D., YADAV, S.B.S., NAGDA, R.K., URNILA, P. & GAHLOT, G.C., 2015 Genetic and non-genetic factors affecting morphometry of Sirohi goats. *Vet. World.,* 8(11): 1356-63.

ELZO, M.A., QUASS, R.L. & POLLAK, E.J., 1987. Effects of age-of-does on weight traits in the Simmental population. *J. Anim. Scie.*, 64: 992-1001.

HRISTOVA, T., SVETOSLAVA, S. & PENKOZUNEV, T.M., 2013. Non-genetic factors affecting birth weight off goat kids. *J. Agric. Sci.,* 42(1): 21-25.

HUSAIN, S.S., 1996. A study on the productive performance and genetic potentials of Black Bengal goats. Doctoral thesis, Bangladesh Agricultural University, Mymensingh.

HUSAIN, S.S., 2004. Preservation of buck semen and their use in Artificial Insemination for rapid Genetic Improvement of Rural Goats population. *Bangladesh J. Agric. Scie.*, 56: 36-45.

KARNA, D.K., KOUL, G.L. & BISHT, G.S., 2001. Birth weight, morphometry and relative gain in cheghu kids. *Ind. J. Anim. Scie.,* 71: 180–182.

KHAN, B.U. & SOHANI, K.L., 1983. Preweaning body weights and linear body measurements in Jamunapari goats under semi- arid farm conditions. *Ind. J. Anim. Sci.,* 53: 835-840.

KHOMBE, C.T., 1985. Environmental factors affecting the growth and viability of crossbred sheep and goats on range in Zimbabwe. In R.T. Wilson & D. Bourzat (eds.), *Small Ruminants in African Agriculture*. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia, pp. 46-52.

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

KRUPA, E., ORAVCOVA, M., POLAK, P., HUBA, J. & KRUPOVA, Z., 2005, Factors affecting growth traits of beef cattle breeds raised in Slovakia. *Cze.J. Anim. Scie.,* 50: 14-21.

KUMAR, A., SINGH, U. & TOMAR, A.K.S., 2007. Early growth parameters of Kutchi goats under organised farm. *Ind. Vet. J.,* 83: 105-106.

KUMAR, S., BHAT, P.N., BHAT P.P. & BISHT, G.S., 1993. An analysis of growth rate of Jamunapari kids. *Ind. J. Anim. Scie.,* 63: 774-775.

KURALKAR, S.V., ALI, S.Z. & TAKARKHEDE, R.C., 2002. The kidding and growth pattern of kids under organised farm conditions. *Ind. J. Sma. Rum.,* 8: 149- 152.

LANDE, R. & SHANNON, S., 1996. The role of genetic variation in adaptation and population persistence in a changing environment. *Evo.,* 50: 434-437.

LIU, W., ZHANG, Y. & ZHOU, Z., 2005. Adjustment for non-genetic effects on body weight and size in Angora goats. *Sma. Rum. Res.,* 59: 25–31.

MBAYAHAGA, J., MANDIKI, S.N.M., BISTER, J.L. & PAQUAY, R., 1998. Body weight, oestrous and ovarian activitiy in local Burundian ewes and goats after parturition in the dry season. *Anim. Rep. Scie.,* 51: 289-300.

MIOČ, B., SUŠIĆ, V., ANTUNOVIĆ, Z., PRPIĆ, Z., VNUČEC, I. & KASAP, A., 2011. Study on birth weight and pre-weaning growth of Croatian multicolored goat kids. *Vet. Archive.,* 81: 339-347.

NESER, F.W.C., VAN WYK, J.B., FAIR, M.D., LUBOUT, P. & CROOK, B.J., 2012. Estimation of genetic parameters for growth traits in Brangus cattle. *S. Afr. J. Anim. Scie.,* 42*:* 469–473.

OLTENACU, E.A.B., 1999. *Using math to see how well your goat is growing*. New York State 4HMeat goat project fact sheet 16. Cornell University, Ithaca, NY.

PORTOLANO, B., TODARO, M., FINOCCHIARO, R. & VAN KAAM, J.H.B.C.M., 2002. Estimation of the genetic and phenotypic variance of several growth traits of the Sicilian Girgentana goat. *Sma. Rum. Res.,* 45: 247–253.

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

SAFARI, E., FOGARTY, N.M. & GILMOUR, A.R., 2005. A review of genetic parameters estimates for wool, growth, meat and reproduction traits in sheep. *Liv. Prod. Scie.*, 92: 271-289.

SALHAB, S.A., ZARKAWI, M., WARDEH, M.F., AL-MASRI, M.R. & KASSEM, R., 2003. Characterisation and evaluation of semen in growing Awassi ram lambs. *Anim. Heal. Prod.*, 35: 455–463.

SHARMA, A.K. & DAS, N., 1995. Factors affecting growth of Jamunapari goat reared under intensive condition. *Ind. J. Anim. Scie.*, 50: 344-347.

SINGH, S.K., SOOD, S.B. & KHAN, B.U., 1992. Genetic analysis of growth traits in of Kutchi goats. *Ind. J. Anim. Scie.,* 78: 11.

SMITH, A.M.J., 2010. Genetic analyses of Growth traits for the Simbra Composite Breed. Masters thesis, Stellenbosch University.

SUSHMA, G., RAMESH GUPTA, B., VINOO, G.V., REDDY, N. & REDDY, S., 2006. Influence of genetic and non-genetic factors of body weights and body measurements of Ongole cattle. *Ind. J. Anim. Scie.,* 75: 228-235.

TALEKAR, A.E., 2015. Effects of various genetic and non-genetic factors affecting growth performance of Sangamnari kids. Masters thesis, Mahatma Phule Krishi Vidyapeeth, Maharashtra, India.

TOMAR, A.K.S., KUMAR, A., MEHTA, B.S. & JAISHANKAR, J., 2001. Factors affecting early express body traits in Sirohi goats. *Ind. J. Anim. Scie*., 71: 271–273.

UGUR, F., SAVAS, T., DOSAY, M., KARABAYIR, A. & ATASOGLU, C., 2004. Technical note growth and behavioral traits of Turkish Saanen kids weaned at 45 and 60 days. *Sma. Rum. Res.*, 52: 179–184.

WILSON, R.T., MURAYI, T. & ROCHA, A., 1989. Indigenous African small ruminant strains with potentially high reproductive performance. *Sma. Rum. Res.,* 2: 107-117.

YADAV, J.S., YADAV, M.C. & KHAN, B.U., 2008. The non-genetic factors affecting growth of Kutchi goats. *Ind. J.Anim. Scie.,* 78: 11.

https://doi.org/10.17159/2413-3221/2024/v52n4a16077

ZISHIRI, O.T., 2009. Genetic analyses of South African terminal sire sheep breeds. Masters thesis, University of Stellenbosch, South Africa.

S. Afr. J. Agric. Ext. Songca, Henning & Madende
Vol. 52 No. 4, 2024: 17-46
https://doi.org/10.17159/2413-3221/2024/v52n4a16686

Livelihood Assets Influence on Rural Youth Participating in Support Initiatives to Enhance Agricultural Participation

Songca, S.S.[1], Henning, J.I.F.[2] and Madende, P.[3]

Corresponding Author: S.S. Songca. Correspondence Email: Henningjif@ufs.ac.za

ABSTRACT

Government efforts to encourage youth participation in the agricultural sector through support initiatives have yet to realise the envisioned outcomes. With research primarily considering the factors influencing youth participation in the agricultural sector, involvement in agricultural support initiatives is rarely considered. The main aim of the research is to explore whether differences in access to assets within the Modified Sustainable Livelihood Framework influence youth participation in support initiatives. Data was collected between 2018 and 2021 from 369 randomly selected youth from QwaQwa and Thaba' Nchu in the Free State Province, South Africa. The regression results confirmed that participation in support initiatives is low. Already being involved in the sector, marital status, cooperative membership, and social grants were used for inputs as the exogenous factors and resilience and optimism as endogenous factors representing psychological capital were found to enhance participation in support initiatives. Youth need to draw on their endogenous capabilities to seek and access support initiatives while also seeking options to access livelihood assets. This will complement the efforts by governments and other institutions to enhance their participation in the sector. We recommend that policies consider that youth are not involved in the sector and have limited resource access. Secondly, the policies should motivate youth to achieve self-sustainability in their operations and not depend on unearned money such as grants.

[1] Postgraduate Student, Department of Agricultural Economics, University of the Free State, Free State 9301, South Africa. Henningjif@ufs.ac.za

[2] Senior lecturer, Department of Agricultural Economics, University of the Free State, Free State 9301, South Africa. Henningjif@ufs.ac.za. https://orcid.org/0000-0001-9468-4201

[3] Researcher, Department of Agricultural Economics, University of the Free State, Free State 9301, South Africa. MadendeP@ufs.ac.za. https://orcid.org/0000-0003-4520-0375

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

Keywords: Youth, Agricultural Development, Sustainable Livelihood, Psychological Capital, Agriculture

1. INTRODUCTION

Rural farmers usually farm on small pieces of land of about two to three hectares per family, if not less, and they mainly produce food for their household consumption, cultural reasons, and income (Naamwintome & Bagson, 2013). Rural farmers are considered old, non-productive, resistant to change, and backwards. They are willing to engage in farming owing to the households' food insecurity, which these older people are accustomed to (Nchabeleng, 2016). The rural farming sector is thus associated with older farmers. However, it is extensively highlighted that youth could play a dynamic role in rural development and agriculture (Pienaar, 2013). Nations could benefit from the opportunities youth can bring to the agriculture sector (Sikwela, 2013) and should thus be involved in this dynamic role. However, observations are that the youth are moving away from the rural areas and, consequently, the agricultural sector (Daudu *et al.*, 2023). Migration is mostly to urban areas in search of less backbreaking or labour-intensive jobs (Woolard, 2013; Girdziute *et al.*, 2022). This has led to lower youth participation in the agricultural sector, while poverty is increasing and income is decreasing (Zamxaka, 2015).

There has been a gradual decrease in the number of unemployed youth in South Africa, with 63.30% in the first quarter of 2021 (Trading Economics, 2021), to slightly lower for March 2023 at 62.1%. Despite the slight decrease, predictions forecast higher levels for the third quarter of 2023 at 66% (Trading Economics, 2023). This indicates that the youth are experiencing high levels of joblessness and have poor access to resources, which limits their opportunities to enhance their livelihoods. Agriculture is known to contribute towards a large part of livelihood development in most Sub-Saharan African (SSA) countries (Auta, Abdullahi & Nasiru, 2010), as the continuous growth of agriculture has led to a reduction of poverty in marginalised communities (Cheteni, 2016).

The South African public and private sectors have developed and implemented support initiatives in the agricultural sector aimed at helping different individuals and farmers, with some explicitly focusing on the youth. These initiatives include a broad spectrum of support programmes and training schemes that individuals can access, both general and others specifically focused on the agricultural sector. These initiatives were created and implemented

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

to improve livelihoods by creating employment and improving food security, among other things. Support initiatives are tools for enhancing youth participation in agriculture and agricultural-related activities, which results in job creation and improved livelihoods (Pienaar, 2013). Support focusing on youth aims to encourage and expand their willingness and interest to participate in the agricultural sector, not only in farming (primary agriculture) but also along the value chain. However, the participation by the youth in these initiatives is low (Auta *et al.*, 2010; Jammer, 2020; Henning, Jammer & Jordaan, 2022). This also contributes to low participation in agriculture, as some of the constraints that youth face, such as the lack of financial capital, land, and market access, hinder their active participation (Akpan *et al.*, 2015).

Livelihood capital refers to assets present in or accessible to individuals that enhance their ability and capacity to participate in various activities (Baffoe & Matsuda, 2018) consisting of human, social, natural, financial, and physical assets (Udoh, Akpan & Uko, 2017; Yang *et al.*, 2018). They form part of the Sustainable Livelihood Framework (SLF). Chipfupa (2017) stated that Psychological Capital (PsyCap) should be integrated into the SLF, as PsyCap represents how the mindset contributes to an individual's decision-making. PsyCap was therefore included as a sixth asset in an extension to the five livelihood assets by Chipfupa (2017) and is referred to as the Modified Sustainable Livelihood Framework (MSLF). PsyCap represents the personal psychological capacities and resources that guide individuals in conceptualising life experiences (Culbertson, Fullagar & Mills, 2010), and the addition concurs with research by Iwara *et al.* (2021) stating that more attention should be given towards endogenous factors of individuals. The mindsets of the youth have a significant influence on whether they participate in initiatives or agriculture. The access to and ownership of the assets included in the MSLF could contribute to the decision to join in support initiatives, ultimately enhancing youth participation in the agricultural sector.

While acknowledging that agriculture is an important sector in South Africa, involving youth in agriculture is paramount. The idea behind implementing the support initiatives is to recruit individuals, including the youth, to participate in these initiatives, ultimately increasing participation in agriculture and related activities (Adeyanju, 2019). This would assist in decreasing unemployment and increasing overall livelihoods and agricultural production (Mbanaso *et al.*, 2013). According to Adeyanju (2019), youth participation in support initiatives is still stunted, even though support initiatives are envisioned as stepping stones for increasing youth participation in agriculture. The factors contributing to the low involvement

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

in agricultural support initiatives include the youth's need for knowledge about and access to these support initiatives (Martey *et al.,* 2013; Khapayi & Celliers, 2016). Livelihood assets and PsyCap play a role in household decision-making and engagement in household livelihood strategies. Support initiatives such as farmer days, workshops and mentorship programmes are consistently recommended as solutions and policy recommendations (Chipfupa, Tagwi & Wale, 2021; Bahta, 2022; Henning *et al.,* 2022; Nyam *et al.,* 2022) to enhance or improve participation in the agricultural sector.

The question should be asked whether the envisioned returns can be accomplished when the youth do not participate in the initiatives. Support initiatives can only enhance agricultural participation once there is increased involvement. The influence of support initiatives to enhance youth's access to resources and the consequent desired positive impact on participation in agriculture and related activities has been limited. Therefore, this research endeavours to determine the influence of factors associated with the MSLF on youth participation in agricultural support initiatives. To achieve the objective of the research, the PsyCap dimensions of youth first need to be determined. Secondly, the PsyCap dimensions are included as part of the MSLF as independent variables in a binary logistic regression model to assess their influence on youth participation in support initiatives.

2. MATERIALS AND METHODS

2.1. Study Area

The study was conducted in the Free State province of South Africa, considering two districts, Thaba' Nchu and QwaQwa. The research formed part of a larger project in which the study area selection was based on the predetermined main criteria requiring rain-fed agricultural areas to be included. Details on the selection process can be found in Henning et al. (2024); however, the main criteria were then followed by selecting areas where (a) youth face a high unemployment rate, (b) governmental extension officers are willing to assist in the project, (c) limited research is available on youth participation in dryland (rain-fed) farming, and (d) farming is conducted on a rain-fed basis. The Free State Province, the third largest province of South Africa, is in the centre of South Africa. The province has an area of 129 825 km^2, with a population of 2 834 714 (5.1% of the South African population). The youth constitute almost a third of the population in South Africa. 4.7% of the youth reside in the Free State Province (Statistics South Africa, 2019). The language most spoken is Sesotho, followed by Afrikaans

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

and IsiXhosa. The economy is mainly dominated by agriculture, mining, and manufacturing industries.

2.2. Data

2.2.1. Sampling

A random sampling method was used for data collection, focusing on individuals between 18 and 35. The sampling method allowed the researchers to randomly select individuals within the identified youth age group (Gujarati, 2003). For the research team to be able to meet with the youth, the extension officers in the study areas were approached to assist in setting up meeting points where the youth and the research group could get together for interviews. For the convenience of the research group and the youth, meeting points for interviews were communicated to the youth in advance by the extension officers. The enumerators for the study were available to assist youth respondents in translating English to their language to ensure a better understanding of the questions. The data was captured in Excel and cleaned, where respondents who did not meet the age criteria were disregarded. Only complete questionnaires were considered, leading to a data set comprising 369 respondents.

The Statistical Package for Social Science (SPSS) was used to analyse the data. The research procedure was conducted in three steps. Firstly, descriptive statistics were used to understand better the youth who participated in the survey. The second step was to measure their Psycap. A Principal Component Analysis (PCA) was undertaken to determine indicators representing youth's PsyCap. In the third step, the indicators were used as independent variables of the MSLF in the binary logistic regression to explore these factors' influence on youth's participation in support initiatives. Ethical clearance of the project was received from the University of the Free State under clearance number UFS-HSD2018/0947. Participation of all youth was voluntary and with written consent.

2.3. Procedures

2.3.1. Determining Psychological Capital Indicators

PCA is a multivariate technique used to analyse observations representing independent variables known to be inter-correlated (Phakathi, 2016). The PCA reduces the size of the data set into smaller dimensions while retaining important information. This means that the PCA takes large amounts of data and filters the data to remove insignificant variable data, leaving

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

only the significant variables (Yeung & Ruzzo, 2001; Abdi & Williams, 2010). Certain steps are followed when performing a PCA. The first step is the generation of the correlation matrix from the variables. This is to examine the correlation between the variables in the analysis. The correlation matrix must have a minimum of three variables greater than 0.5 to continue with the PCA analysis (Nieuwoudt, Henning & Jordaan, 2017).

The second step in the analysis includes the Kaiser-Meyer-Olkin (KMO) and Bartlett Sphericity tests. KMO is the measure of the sampling adequacy, which should be greater than 0.5, while the Bartlett test of Sphericity should be less than the level of significance, 1%, for the research. The following step involves considering the anti-image matrices. On the diagonal line, all the correlation coefficients should be greater than 0.5, and variables that are less than 0.5 must be excluded to proceed with the PCA (Nieuwoudt *et al.,* 2017).

Lastly, before the final determination of the components, commonalities are considered, where variables with commonalities of 0.5 or greater are seen as strong and are used to continue with the analysis (Nieuwoudt *et al.,* 2017). Variables with commonalities of less than 0.5 are removed from further determinations. The eigenvalues of given variables calculate the generation of principal components. The correlation matrix and the relationship between variables determine eigenvalues. According to the Kaiser-Guttman Rule, determining the factors that must be included in the components is based on an expressed eigenvalue greater than one (Williams, Bown & Onsman, 2012). The varimax-rotated component matrix recognises complex structures through observation, making the solution more interpretable (Chipfupa, 2017). This stage involves examining components with eigenvalues equal to or greater than one and considering factor loadings of at least 0.4 in each component to explain the PCA results (Chipfupa, 2017).

2.3.2. Factors Influencing the Participation of Youth in Agricultural Support Initiatives

With the study's dependent variable being whether youth participate in support initiatives or not, a binary regression model is utilised, due to its simplicity to analyse the factors that influence youth participation in support initiatives. The binary logistic model is used when the dependent variable only has two possible responses: one (1) if the youth participated in agricultural support initiatives or zero (0) if otherwise (Gujarati, 2003). The dependent variable will be explored using a regression analysis, and the specified model equation (1) is as follows:

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

$$Y = \beta_0 + \beta_1 X_i + \beta_2 X_i + \beta_3 X_i \ldots\ldots \beta_{21} X_i + \mu i \quad (1)$$

Support initiatives include agricultural support programmes and training, as well as financial, input, and equipment support. The dependent variable is based on two questions: "Have you received any farming or agricultural business-related short-term training?", and "Are you a beneficiary of any government youth/agricultural/rural development support programmes?" β_0 is the coefficient (parameters) to be estimated, which measures the change in Y for a unit change in the explanatory variables, X_i represents the independent variables, and μ_i is the error term. The dependent and independent variables are reflected below in Table 1.

TABLE 1: Variable Descriptive and Hypothesis

Dependent variable	**Variable description**	**Hypothesised sign**	**Unit of measurement**
Support initiative participation	1 = Participated in initiatives		
Independent variables			
Human Capital			
Participation in Agriculture	1 if the youth participate in agriculture, 0 otherwise	+	**Dummy**
Household Size (HHS)	Household members	+/-	**Number**
Age	Age of the respondent	+	**Years**
Gender	1 = Male; 0 = Female	+/-	**Dummy**
Marital status	1 = Single; 0 = other	+	**Dummy**
Grade 12 and above	1 = Finished Grade 12; 0 = Not finished Grade 12	-	**Dummy**
Farming Experience (EXP)	Number of years	+	**Years**
Social Capital			
Extension Service	1 = Yes; 0 = No	+	**Dummy**
Cooperative Membership	1 = Yes; 0 = No	+	**Dummy**

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

Youth Club Membership	1 = Yes; 0 = No	+	**Dummy**
Social Media Membership	1 = Yes; 0 = No	+	**Dummy**
Natural Capital			
Land Size	Size of land access	+	**Ha**
Financial Capital			
Savings	Access to savings	+	**ZAR**
Access to Credit	1 = Yes; 0 = No	-	**Dummy**
Social Grants	Household access to Social grants 1 = Yes; 0 = No	+/-	**Dummy**
Physical Capital			
Livestock Ownership	1 = Yes; 0 = No	+	**Dummy**
Agricultural Equipment	Value of agricultural machinery and equipment ZAR	+	**ZAR**
Psychological Capital indicators			
Resilience	PCA Indicator	+	
Hope	PCA Indicator	+	
Self-confidence	PCA Indicator	+	
Optimism	PCA Indicator	+	

3. RESULTS

3.1. Descriptive Statistics

A total of 369 youth respondents were included in the research, comprising those participating in agricultural initiatives (84 or 23.2%) and those who had not participated in support initiatives (285 or 76.8%), as shown in Table 2. The participation statistics are consistent with and confirm previous indications of the low participation rate of youth in support initiatives (Jammer, 2020; Kising'u, 2016; Njenga, Mugo & Opiyo, 2013). Jammer (2020) reported a participation rate of 6% by respondents in government support programmes, while 12.9% had received training. An observation during the fieldwork for the research was that the youth's knowledge of the

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

available support initiatives was limited. The importance of access to training as a support initiative is also emphasised in the research of Mkuna and Wale (2023). They found that 92% of their respondents required further training on their participation in agriculture.

Participation in agriculture was indicated to be full-time farming as an individual, part of a cooperative, or partially through family farming activities, and it was seen that 85% of the youth who had participated in support initiatives were also, at the time of the survey, participating in agricultural activities. However, the data shows that, of the youth who had not participated in support initiatives, only 48% were involved in agricultural activities. This illustrates that, in most cases, the youth who engage in and become beneficiaries of support initiatives are those involved in some form of agriculture.

TABLE 2: Descriptive Analysis of Variables

	Not involved in support initiatives		**Involved in support initiatives**	
	Mean	**Std. Dev**	**Mean**	**Std. Dev**
Human Capital				
Participation in Agriculture	0.48	0.501	0.85	0.364
Household Size (HHS)	4.45	2.042	3.92	2.007
Age	25.46	4.577	27.55	4.9
Gender	0.54	0.499	0.61	0.491
Marital status	0.87	0.337	0.86	0.352
Grade 12 and above	0.6	0.49	0.73	0.449
Farming Experience (EXP)	2.225	3.804	4.381	5.539
Social Capital				
Extension Service	0.27	0.445	0.55	0.501
Cooperative Membership	0.11	0.307	0.39	0.491
Youth Club Membership	0.08	0.267	0.21	0.413
Social Media Membership	0.76	0.429	0.7	0.46
Natural Capital				
Land Size	2.984	35.618	6.193	23.638
Financial Capital				

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

Savings	553.129	2446.163	1193.631	5728.715
Access to Credit	0.06	0.231	0.08	0.278
Social Grants	0.12	0.325	0.31	0.465
Physical Capital				
Livestock Ownership	0.29	0.455	0.45	0.501
Agricultural Equipment	3812.47	42722.131	21450.9	75043.085

The data shows that more males who were slightly older and from smaller households had participated in support initiatives. Most respondents who had participated in the research were single at the time of the survey. Most of the youth respondents had finished their schooling, indicating that the youth who had completed Grade 12 and/or furthered their education had been more involved in the support initiatives. Farming and agriculture-related experience (Exp) indicate that the youth participating in support initiatives had, on average, four years of experience in the agricultural sector, compared to the two years of experience of their counterparts who did not participate. The results could indicate that those involved for longer in the agricultural environment had seen or experienced the advantages of participating in these initiatives and continued to participate.

3.1.1. Social Capital

Extension services provide information and knowledge to farmers (AL-Sharafat, Altarawneh & Altahat, 2012); thus, they have an important role in providing access to and spreading information. The survey found that the youth who had participated in support initiatives also had contact with extension services (56%) compared to 27% of the youth who had not participated in support initiatives. This could indicate that communicating with extension officers or receiving extension services increases the chance of the youth participating in support initiatives.

The data reveals that 39% of the youth in a cooperative participated or were involved in support initiatives. This indicates that the youth who are members of cooperatives are more likely to participate in support initiatives. Mhembwe and Dube (2017) alluded that cooperatives allow individuals with the same goal to pool their resources to achieve the same goal. Being in a cooperative thus increases the possibility of youth gaining access to or owning livestock or

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

land or starting with some form of production. It is, therefore, likely that the support initiatives will support the youth who are already engaged in agricultural activities.

Regarding youth club membership, only 21% of youth in youth clubs were currently participating in support initiatives at the time of the survey. In comparison, 7% of the youth in the youth clubs did not participate in support initiatives. These figures indicate that it is likely that the youth in youth clubs would participate, as opposed to those not in youth clubs. The variable for participating in social media shows that 70% of the youth would participate in support initiatives because of the general sharing of information and knowledge about the initiatives and agriculture. However, it is also indicated that 76% of youth participating in social media do not participate in support initiatives. This could result from youth lacking interest and knowledge about these initiatives. These social groups communicate and share knowledge and skills, increasing the possibility that the youth would seek and access support initiatives.

3.1.2. Financial Capital

Savings indicate the amount of money that the respondents can put aside and save for the future of their livelihoods or businesses. Savings can be done informally or formally (i.e., through financial institutions or stokvels). The data shows that an average of R1193.63 is saved by youth involved in support initiatives. In contrast, an average of R553.13 is saved by the youth who do not participate in support initiatives.

A small percentage of respondents were willing to take out a loan or credit, as only 8% took out a loan for those who participated in support initiatives, and only 6% of the non-participating youth participants. This indicates that most respondents participating in the initiatives were unwilling to take out credit or a loan and would participate in support initiatives instead. However, Etonihu (2010) states that it is difficult for the youth to access credit and loans due to their lack of collateral. Access to credit can impact the youth's ability to participate in support initiatives, as it could provide financial resources required to, for example, pay for transport to and from training.

An average of 30% of the youth who receive social grants and use the income for purchasing inputs participate in support initiatives, with only 11% not participating in support initiatives using social grants to buy inputs. These figures show that the respondents need assistance to

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

continue their production activities. It also indicates that the youth view using social grants as an encouragement to access these initiatives. Mthethwa and Wale (2020) also state that despite the positive contribution of social grants, they also have a negative contribution towards societies by creating a possible entitlement and expectation, while there is also no actual means available to ensure the grants received are used for their intended purpose.

3.1.3. Natural Capital

Access and ownership of land are seen as one of the main factors that encourage youth to participate in agriculture and an essential factor that the support initiatives should provide (Kidido, Bugri & Kasanga, 2017). Youth who have participated in support initiatives had access to more land than those who have not participated previously in support initiatives. This shows that those youth who are participating are likely to need to access support initiatives to increase their production land capacity. It is expected that access to land could potentially influence youth participation in support initiatives.

3.1.4. Physical Capital

The data indicates that 45% of the youth who own livestock participate in support initiatives, while only 29% of the youth who own livestock do not participate in support initiatives. This reveals that youth with assets that can be used to improve their livelihoods are willing to participate in support initiatives to increase their income and reduce food insecurity.

The youth participating in support initiatives indicate access to or ownership of agricultural equipment with an average value of R 21 450.90. On the other hand, the youth who do not participate in agricultural support initiatives own or have access to agricultural equipment, with an average value of R 3 812.47. This indicates why it is necessary for those participating in initiatives to do so, as the equipment required for production is expensive. Some agricultural support initiatives support their recipients by providing equipment. The equipment reported by the youth included water tanks, trailers, planters, ploughs, and tractors.

3.2. Determining Youth Psychological Capital indicators

PsyCap is part of the MSLF, as Chipfupa suggested (2017). It is hypothesised that youth with higher levels of positive PsyCap have higher levels of participation in support initiatives. The PsyCap indicators were determined using a PCA and are represented by the obtained Principle

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

Components (PCs), similar to the approach used by Chipfupa, Tagwi and Wale (2021). The PCA included Likert-scale responses (5-point) from eight questions, two each for Hope, Resilience, Self-efficacy and Optimism. Following the procedure explained in section 2.3.1, four components were extracted and retained using the eigenvalue rule. Given the eigenvalues rule of greater than one, the four extracted components explain 63.56% of the cumulative variance, as shown in Table 3. The PCA was found to be significant, as the KMO and the Bartlett Test of Sphericity were conducted, with the results showing that the KMO stands at 0.656 (66%), which is above the benchmark of 0.5. Therefore, the analysis can proceed, as the KMO complies with the PCA requirements. The Bartlett Test of Sphericity is significant, at a 1% significance level.

TABLE 3: Rotated Component Matrix of PsyCap of the Youth

Statements	**Components**			
	PC1	**PC2**	**PC3**	**PC4**
Continue with the business and consult advisors	0.893			
Continue with the business and change daily ways	0.833			
Consult peers already in business to find how they managed to obtain funding	0.664			
You still have potential to work through challenges and turn things around		0.809		
Talk to traditional leaders to check for possibility of acquiring land		0.772		
Government can address the issues		0.687		
Ask them to wait because you still want to think about it			-0.765	
Accept the deal			0.735	
Refuse to sell and continue with business				0.767
Continue with the business and see failure as temporary setback				0.751
Eigenvalues	**2.49**	**1.59**	**1.19**	**1.09**
% Variance explained	**24.90**	**15.86**	**11.93**	**10.87**
Cumulative % of variance explained	**63.56**			

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

The first principal component (PC1) explains 24.90% of the variance and has an eigenvalue of 2.49. This component was named *Resilience*. These statements indicate respondents' willingness and strength to continue with their business, with consulting peers or advisors or without consulting peers or advisors, and to change their ways of running the business rather than giving up the business. Similar results were obtained by Madende et al. (2023) and Chipfupa and Tagwi (2021), who found youth to be resilient in the face of adversity in business. Resilient youth tend to continue participating in activities, even without immediate success. This indicates that the youth who are resilient enough will find ways and opportunities, such as support initiatives, that would enhance their chances of success. Thus, resilience could influence youth to participate in support initiatives by giving youth the impetus to reduce risk factors and seek a way to avoid or overcome the challenges they might face.

Component two (PC2) explains 15.86% of the variance, with an eigenvalue of 1.59. This component is renamed *Hope.* The component represents self-reliant youth who believe that the government and traditional leaders can address the problems of acquiring land and easing other constraints. These statements indicate that the respondents see ways of avoiding challenges to continue with the business. It is a mindset that youth have that support initiatives are available to assist them, and they can apply the initiatives to overcome their challenges.

Furthermore, the respondents hope the traditional leaders will assist with their challenges. The youth who are hopeful have a belief that the challenges they face can be resolved. Therefore, hope could influence youth to participate in the support initiatives, as it allows individuals to create new paths to goals and keeps them motivated to continue believing that they can achieve their goals. It can further be seen that hopeful youth are more encouraged to participate in initiatives to improve their livelihoods.

The third component (PC3) has a variance of 11.93% and an eigenvalue of 1.19. The statements show that self-efficacy increases the chances of an individual taking opportunities such as becoming a cooperative leader. This component indicates whether a youth would think about a discussion of accepting or rejecting the opportunity given. This suggests that the youth who believe in themselves can take on any challenge and overcome obstacles, leading to this component being named *Self-confidence*. This mindset shows that the youth who believe in themselves and their businesses would be influenced to enquire about and acquire support through support initiatives. Self-confidence influences participation in initiatives based on the

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

youth's belief that they can carry out a course of action. It also encourages participation through performance-enhancing techniques.

The fourth component (PC4) explained 10.87% of the variance and had an eigenvalue of 1.09. The component was named *Optimism*. This implies accepting that there are times of failure, which could be temporary; instead of quitting and finding a new business, one can continue to anticipate positive outcomes. Although support initiatives might be available, the youth will not, in some cases, become beneficiaries of the initiatives, yet they still trust that they can be supported in the future. Furthermore, this indicates that the youth are optimistic and believe they can receive support from support initiatives. Optimism influences participation in support initiatives by enhancing an individual's self-esteem and giving encouragement to make difficult decisions. Optimistic youth have the attitude that their farms/businesses will succeed through participating in support initiatives.

3.3. Livelihood Assets and Psychological Capital Influence Towards Youth Participation in Agricultural Support Initiatives

This study used a binary logit model to evaluate the influence of youths' access to assets within the MSLF towards participating in agricultural support initiatives. The results show that exogenous factors and endogenous factors are important to consider, supporting the notion of Iwara *et al.* (2021). For inputs, exogenous factors such as agricultural participation, household size, marital status, cooperative membership, and social grants were used. In contrast, endogenous factors, resilience, and optimism significantly influenced youth participation in support initiatives.

Agricultural participation was positively significant, at 1%, implying that youth already involved or participating in the sector are more likely to participate in support initiatives than those not currently involved. Those participating in agricultural activities are more likely to understand the importance of support initiatives. Prah et al. (2023) and Khoza et al. (2019) found a positive relationship between a farmer's experience in farming activities and participation in farmer support programmes. This is consistent with the hypothesis that youth are more likely to participate in the available support initiatives if they are already involved in the sector and have access to at least some agricultural resources. The youth participating in agriculture are more likely to search for and access support initiatives as they know the type of support (resources) and training required. The other aspect that could influence access to

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

initiatives is the youth's communication with the local extension officers and networks. Although insignificant in the research, contact with extension services (0.475) suggests that regular contact with the services is required to attract youth to be involved in support initiatives. Frequent contact with extension bridges the information gaps on available support initiatives and can encourage participation (Prah et al., 2023). However, the support and training of the youth who do not participate in agriculture could differ from those who do, as these two distinct groups possess different attributes. These attributes range from experience, knowledge, mentorship, and general management skills. Therefore, support initiatives must also cater to youth not involved in agriculture, specifically regarding the relevant training and skills-transferring programmes.

TABLE 4: Factors that Influence Participation in Agricultural Support Initiatives

Independent Variables	**B**	**S.E**
Human Capital		
Participation in Agriculture	**1.031*** **	.393
Household Size	**-.171** **	.083
Age	.041	.035
Gender	-.161	.317
Marital Status	**.819***	.462
Grade 12 and above	.246	.335
Farm experience	.042	.032
Social Capital		
Extension services	.475	.320
Cooperative membership	**1.140*** **	.372
Youth club membership	.425	.434
Social media membership	-.332	.348
Financial Capital		
Savings	-.072	.149
Credit access	.133	.578
Social Grant used for buying inputs	**1.299*** **	.366
Natural Capital		
Land Size	.002	.004

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

Physical Capital		
Livestock ownership	.143	.317
Agricultural equipment	.163	.152
Psychological Capital Indicators		
PC 1 (Resilience)	**.369***	.184
PC 2 (Hope)	-.039	.149
PC 3 (self-confidence)	.163	.155
PC 4 (Optimism)	**.269****	.154
Constant	-3.905***	1.312

Note: Significance indications at 1%***,5%** and 10%*; **Chi-square 100.147; degrees of freedom 21; sign (p) = 0.000**

Household size was negatively significant, at 5%. This indicates that youth from larger households are less likely to participate in agricultural support initiatives. Household heads are less likely to allow the youth to make decisions in larger households, including participating in agricultural support initiatives. The number of people dependent on the household head increases with the household size, reducing the influence of the youth in making decisions and thereby reducing their chances of participating in agricultural support initiatives. Smaller rural households are more likely to participate in agricultural support initiatives, as having a garden was identified as their primary source of income and a form of reducing food insecurity. A reason for this could be the need for more financial and other household resources to sustain themselves. Therefore, they opt for agriculture as a means of sustenance. However, this indicates the possibility of the household head being responsible for the decisions, limiting opportunities for youth respondents to introduce new ideas, such as participating in or seeking assistance from agricultural support initiatives. This finding contradicts Mogano's (2018) finding that greater households are more likely to access support initiatives. However, that study's focus was not only on youth. It focused on all ages (the average age was 62 years). This potentially indicates that youth from larger households are less likely to participate in the initiatives than older household members. This aspect should be further researched to ensure that the youth from all households, regardless of size, have access to and participate in the available agricultural support initiatives.

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

Marital status is positively significant, at a 10% level of significance. Single rural youth tend to have dependents that require them to inject support into the family using their income. Therefore, it suggests that single youth will be more likely to participate in agricultural support initiatives. However, Martey *et al.* (2013) argue that married household heads have more responsibilities, increasing their probability of participating in support initiatives. This could show that married youth are more likely to participate in support initiatives than those who are unmarried. A study by Martey *et al.* (2013) states that married individuals in households have more responsibilities, encouraging them to seek and participate in support initiatives to relieve the pressure, especially if they are keen on continuing to participate in agriculture.

Additionally, the financial security of a married household is crucial to them, and farming is perceived to achieve some level of security. Thus, households with married individuals would seek support initiatives to sustain their farming activities and achieve financial or food security. On the other hand, this study found that single youth are more likely to participate in support initiatives. It may be that single youth have similar responsibilities as married youth, such as sustaining the household's livelihood and caring for the family, and this may encourage youth to participate in support initiatives. There is also a possibility that single youth may have responsibilities that their income cannot adequately meet, which enables them to seek relief from the support initiatives. This is possibly the case when assuming that single youth are limited to one income for the household. Financial security is also important to households comprised of single individuals as they seek to remain financially stable. They also see farming as a tool for achieving this financial security, encouraging them to participate in support initiatives. The influence of marital status should thus be further considered in future research to clarify the relationship between marital status and participation in support initiatives.

Cooperative membership was positively significant (1%), implying that being part of a cooperative increases the possibility of accessing and receiving support from initiatives. This shows that the support initiatives are more likely to support cooperatives than individuals. A possible reason could be that the existing resources of cooperatives are pooled together, which creates greater access to aspects such as markets, financial institutions, and knowledge. This is supported by Sikwela and Mushunje (2013), who state that forming groups and creating cooperatives are vital to receiving aid faster than applying for support individually in South Africa and Sub-Saharan Africa. Also, support initiatives are mainly implemented for groups rather than individuals to manage transaction costs (Madende, Henning & Jordaan, 2023). This

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

is consistent with Ortmann and King (2007), who state that cooperatives could be the instrument that would encourage youth to participate in support initiatives, specifically regarding training, which would be more beneficial for a group than an individual.

Conversely, youth not members of a cooperative would face the challenge of not having a formal structure through which to exchange information and knowledge about agriculture and, therefore, would have a lower prospect of accessing the support initiatives. Cooperatives could provide youth an advantage if they increase or enhance their participation in functional cooperatives to access support initiatives. Cooperatives are perceived to be more likely to achieve set goals than individuals, and therefore, cooperatives might be given preference for participating in support initiatives. Moreover, cooperatives are established as an initiative to help farmers overcome constraints, whereby they can show that they are willing to join forces to overcome potential challenges by pooling their resources (Ortmann & King, 2007). This, therefore, increases their possibility of being given preference for participating in support initiatives.

On the other hand, some disadvantages or problems identified by Ortmann and King (2007) might lead to cooperatives not being given preference for support initiatives. To illustrate, cooperatives in a state of internal conflict indicate a lack of unity among their members. This gives rise to the possibility that they would not be offered a place in support initiatives because of their internal conflict, which might arise due to older members not recognising younger individuals in the cooperative, leading to trust issues and, ultimately, withdrawal of the young members. The other disadvantage could be a negative track record of participation in support initiatives. This could be caused by their past misuse of resources and placing individual interests over the cooperative's interests. This raises the question of the role of cooperatives in attracting youth to participate in support initiatives and agriculture.

Social grants used to buy inputs were positively significant, at 1%. This result shows that households recognise social grants as a household income, which is unearned, according to Wale and Chipfupa (2018). These social grants are used to purchase agricultural inputs. This is consistent with August (2020), who stated that rural households use social grants to contribute to covering their farming costs. This indicates the need for support initiatives to be distributed to the youth dependent on social grants who are interested and willing to participate in agriculture and related activities. This further implies that the youth in households dependent

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

on social grants are more likely to participate in support initiatives. Although many rural households depend on government social grants as a fixed income, they acknowledge that the social grants received are limited and cannot sustain all their food needs throughout the month. Therefore, they supplement their food supplies with food grown in their gardens, requiring support. In rural areas, social grants are linked to purchasing agricultural inputs, which is crucial to the success of agricultural activities. Thus, the youth from households dependent on social grants are more likely to seek support from the initiatives, as the social grants might be insufficient to cover the household needs and the needs of their agricultural activities, even though the social grants are a consistent source of income. Literature about the exact role that social grants play in the youth participating in support initiatives is scant. Therefore, the study could not investigate the exact topic in further detail. Nevertheless, Henning *et al.* (2022) found that youth from households receiving social grants are less likely to participate in the agricultural sector. Thus, Receiving grants could influence youths' willingness to participate in support initiatives and agriculture since the grants provide easy access to unearned money, as Wale and Chipfupa (2018) explained.

Resilience was positively significant, at 10%. These results are consistent with the expectation that youth who are resilient in the face of obstacles are more likely to participate in support initiatives. The youth who can continue with their businesses, even when facing setbacks, are willing to consult those with better knowledge, thereby increasing the chances of them receiving assistance from support initiatives. Moreover, the youth already involved in agriculture would be more likely to be interested and encouraged to apply for support, as they are more aware of past challenges and what they require to overcome those obstacles. Luthans and Youssef (2004) stated that resilience shows how one creates coping resources to manage trying situations successfully, and the resources that could be useful to them could include accessing and participating in support initiatives. There are some potential explanations for this. Resilient youth can overcome challenges and are flexible in seeking solutions, continuously seeking ways to get involved in support initiatives. In other words, they are more likely to use the support initiatives effectively, even amid challenges.

Additionally, resilient youth are flexible in their methods to succeed in their agricultural operations. These methods might range from seeking mentorship and expanding existing networks to constantly looking for relevant opportunities, increasing their chances of participating in support initiatives. Furthermore, resilient youth tend to participate in

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

agriculture for longer, so they are likely to be preferred in support initiatives. This results in resilient youth being increasingly recognised by or involved in support initiatives.

A possible way to become resilient is to seek assistance from those who have overcome similar circumstances, who may thus provide the youth with assistance regarding any other challenges. In contrast, these results differ from those of Phakathi and Wale (2018), who argued that many rural farmers have high expectations of receiving handouts, resulting in them not trying to pursue the available opportunities. However, that study was not limited to youth, indicating that resilient youth could likely participate in support initiatives.

Optimism is positively significant, at a 5% level of significance. The result implies that the youth who are hopeful and confident about succeeding in the future are more likely to be willing to participate in support initiatives. This shows that, even if youth do not become beneficiaries of support initiatives, they stay positive and hopeful that, in the future, they will receive the support. As a result, they are persistent in seeking opportunities. Youth who are optimistic in search of opportunities become more exposed in terms of accessing information and networking with people who are exposed to the information and tend to be persistent even if they do not meet all the requirements of the support initiatives. These results are consistent with those of Etuk, Okorie, and Umoren (2018), whose findings indicate that a support programme improves self-belief and helps people stay optimistic.

Optimistic youth are more inclined to participate in support initiatives. This could be due to various reasons. For example, they should be hopeful and actively seek opportunities that increase their likelihood of receiving support. Additionally, their optimistic character exposes them to individuals and organisations with a broader network, enhancing their likelihood of gathering information about support initiatives. Since their optimistic nature allows them to expose themselves and their agricultural operations to a wider audience, the optimistic youth are more inclined to become members of associations. The increased exposure would benefit their growth, increasing their chances of engaging in support initiatives. As illustrated by Luthans *et al.* (2006), another aspect of optimistic youth is their persistent nature of being willing to participate in support initiatives, even though they do not meet the requirements for application. This also allows them to keep up with any changes (especially regarding the requirements) that may occur, thereby better positioning them to qualify for support later. Generally, optimism is a mindset that indicates how one reacts to failure and believes in

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

achieving all their goals. These two mindsets play a key role in participation in support initiatives and participation in agriculture. These mindsets present a tool for the youth's decision-making (as explained above) that will encourage them to seek and access support initiatives.

4. CONCLUSIONS

Indications are that youth are not participating in support initiatives available to attract and enhance their participation in the agricultural sector. The study confirms this observation, as only 23.2% of the youth respondents participated in support initiatives. This aligns with Njenga et al. (2013) and Henning *et al.* (2022). Mkuna and Wale (2023) further indicated that smallholder farmers, who are part of support groups, depend on support programmes. The authors mentioned that although many of their respondents (90%) were part of water governance groups, 92% needed access to irrigation training. Support initiatives thus provide participants in the agricultural sector with important assistance in entering or maintaining their operations within the agricultural sector.

Results from the research showed that agricultural participation and access to certain resources are closely linked to accessing support initiatives. The results guide where efforts should be aimed to enhance or attract youth participation in the agricultural sector. Certain support initiatives precondition access to or ownership of resources such as land and financial capital to accept individuals or groups as beneficiaries of the initiatives. Thus, youth engaged in agriculture or related activities are more likely to participate in the available initiatives. This places the youth not involved in agriculture at a disadvantage as the limited participation in agricultural activities might be attributed to a lack of these preconditioned resources. Using agriculture for employment and poverty reduction is counterproductive if youths who are not involved are excluded from support initiatives. Therefore, these initiatives should also consider the youth not involved in the sector and their lack of resources, allowing them to access the much-needed support to engage in agricultural activities. This will enhance overall participation in the sector and reduce unemployment. There is a need for initiatives for youth who would like to start new endeavours in the agricultural sector and currently have minimal to no resources. Secondly, it is also suggested that the youth should not rely only on the support provided. Instead, they should take their future into their own hands, using their endogenous resources, and consider self-help strategies to access certain resources while complimenting

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

their efforts with possible support from these initiatives. This could include showcasing the agricultural sector as an innovative, technological-driven sector with opportunities to establish its own businesses, as Girdziute et al. (2022) suggested.

Income and dependency are influential in affirming that large households are less likely to engage in support initiatives. To illustrate, previous research (e.g., Sinyolo, Mudhara & Wale, 2016) shows that larger households have the potential (given a good situation) to offer more resources in terms of income, reducing their need for support initiatives. One aspect being considered is the occupations of the various household members that contribute to the household size. It could prove detrimental to youth seeking support from the initiatives if they are in large households that consist of people who are unemployed or less interested in agriculture. If the opposite is true, the need for support initiatives also increases. Few studies have been found that explore household size in terms of the family dynamics that could influence the lower participation of large households in agricultural support initiatives. Therefore, it is imperative to understand whether household size impacts youth participating in support initiatives, as larger households also have the potential for more income from grants. Receiving grant money from households was found to contribute towards participating in support initiatives. This could be due to the youth from these households being aware of and using the unearned income to support their farming operations. As Wale and Chipfupa (2018) mentioned, unearned income could hinder enhancing participation in the agricultural sector. This is, however, also an aspect which requires further investigation. The findings from the research suggest interventions should be developed to specifically address the needs of youth not involved in the sector with limited access to resources. Secondly, the policies should motivate youth to achieve self-sustainability in their operations and not depend on unearned money such as grants. These will contribute towards achieving the overall objective of reducing youth unemployment through youth participation in the agricultural sector.

5. USE OF AI TOOLS DECLARATION

The authors declare they have not used Artificial Intelligence (AI) tools in creating this article.

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

6. ACKNOWLEDGEMENTS

This research was funded by the Water Research Commission (WRC) of South Africa and the Department of Agriculture, Land Reform and Rural Development (DALRRD), grant number K5/2789//4.

7. INSTITUTIONAL REVIEW BOARD STATEMENT

The study protocol was approved by the Institutional Review Board (or Ethics Committee) of the University of the Free State (UFS-HSD 2018/0947).

8. INFORMED CONSENT STATEMENT

Informed consent was obtained from all subjects involved in the study.

9. CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

ABDI, H. & WILLIAMS, L.J., 2010. *Principal Component Analysis*. Wiley Interdisciplinary Reviews: Computational Statistics.

ADEYANJU, D.F., 2019. Impact of agricultural training programmes on youth agripreneurship performance and empowerment in Nigeria. Master's thesis. University of Nairobi.

AKPAN, S.B., PATRICK, I.V., JAMES, S.U. & AGOM, D.I., 2015. Determinants of decision and participation of rural youth in agricultural production: A case study of youth in southern region of Nigeria. *Russ. J. Agric. Soc.Econ. Sci., 43*(7): 35-48.

AL-SHARAFAT, A., ALTARAWNEH, M. & ALTAHAT, E., 2012. Effectiveness of agricultural extension activities. *Am J Agric Biol Sci., 7*(2): 194-200.

AUGUST, M.M., 2020. Youths' Aspirations and perceptions towards agricultural participation: A Case of Two Free State Regions. Master's thesis. University of the Free State, South Africa.

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

AUTA, S., ABDULLAHI, Y. & NASIRU, M., 2010. Rural youths' participation in agriculture: Prospects, challenges and the implications for policy in Nigeria. *J. Agric. Educ. Ext.*, 16(3): 297-307.

BAFFOE, G. & MATSUDA, H., 2018. A perception-based estimation of the ecological impacts of livelihood activities: The case of rural Ghana. *Ecol. Indic., 93*: 424-433.

BAHTA, Y.T., 2022. Social vulnerability to agricultural drought: Insights from Northern Cape, South Africa. *Sci. Afr., 17*: e01324.

CHETENI, P., 2016. Youth participation in agriculture in the Nkonkobe District Municipality, South Africa. *J Hum Ecol.*, 55(3): 207-213.

CHIPFUPA, U., 2017. Entrepreneurial development pathways for smallholder irrigation farming in KwaZulu-Natal: typologies, aspirations and preferences. Doctoral dissertation. University of KwaZulu-Natal.

CHIPFUPA, U. & TAGWI, A., 2021. Youth's participation in agriculture: A fallacy or achievable possibility? Evidence from Rural South Africa. *S. Afr. J. Econ. Manag. Sci., 24*(1): 1-12.

CHIPFUPA, U., TAGWI, A. & WALE, E., 2021. Psychological capital and climate change adaptation: Empirical evidence from smallholder farmers in South Africa. *Jamba: J. Disaster Risk Stud.*, 3(1): a1061.

CULBERTSON, S.S, FULLAGAR, C.J. & MILLS, M.J., 2010. Feeling good and doing great: The relationship between psychological capital and well-being. *J. Occup. Health Psychol.*, 15(4): 421.

DAUDU, A.K., ABDOULAYE, T., BAMBA, Z., SHUAIB, S.B. & AWOTIDE, B.A. 2023. Does youth participation in the farming program impact farm productivity and household welfare? Evidence from Nigeria. *Heliyon., 9*(4).

ETONIHU, I.K., 2010. Farmers' Accessibility to Agricultural Credit for Crop Production in Doma Local Government Area of Nasarawa State, Nigeria. Unpublished B. Agric Project, Faculty of Agriculture. Nasarawa State University, Keffi, Nigeria.

ETUK, U.R., OKORIE, N. & UMOREN, E., 2018. Analysis of youth participation in community development activities of West Africa agricultural productivity programme in Akwa Ibom State Nigeria. *Niger. J. Rural. Sociol.,* 18(1). 10.22004/ag.econ.287617

GIRDZIUTE, L., BESUSPARIENE, E., NAUSEDIENE, A., NOVIKOVA, A., LEPPALA, J. & JAKOB, M., 2022. Youth's (un) willingness to work in Agriculture Sector. *Front Public Health.,* 10: 937657.

GUJARATI, D., 2003. *Basic econometrics*. 4th edn. New York: The McGrowth Hill Companies.

HENNING, J.I.F., JAMMER, B.D. & JORDAAN, H., 2022. Youth participation in agriculture, accounting for entrepreneurial dimensions. *South. Afr. J. Entrep. Small Bus. Manag., 14*(1): 14.

HENNING, J.I.F., JORDAAN, H., MADENDE, P., JAMMER, B.D., AUGUST, M.M. & SONGCA, S.S., 2024. *Entrepreneurial development for establishing small farming businesses and employment by youth in rain-fed crop farming: Free State Province Case Study*. WRC Report No. 2789/2/23.January 2024. Pretoria: Water Research Commission.

HENNING, J.I.F., MATTHEWS, N., AUGUST, M. & MADENDE, P., 2022. Youths' perceptions and aspiration towards participating in the agricultural sector: A South African Case Study. *Soc. Sci. (Basel).*, 11(5): 215.

IWARA, I.O., KILONZO, B.M., ZUWARIMWE, J. & NETSHANDAMA, V.O., 2021, 'Entrepreneurs' endogenous attributes necessary for small enterprise success in Vhembe Rural Areas, South Africa'. *South. Afr.J. Entrep. Small Bus. Manag.,* 13(1): a331.

JAMMER, B.D., 2020. Determining youth entrepreneurial competencies in two rural areas of the Free State Province. Master's thesis. University of the Free State, South Africa.

KHAPAYI, M. & CELLIERS, P., 2016. Factors Limiting and Preventing Emerging Farmers to Progress to Commercial Agricultural Farming in the King William's Town Area of the Eastern Cape Province, South Africa. *S. Afr. J.Agric. Ext.,* 44(1): 25-41.

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

KHOZA, T.M., SENYOLO, G.M., MMBENGWA, V.M., SOUNDY, P. & SINNETT, D., 2019. Socio-Economic factors influencing smallholder farmers' decision to participate in agro- processing industry in Gauteng Province, South Africa. *Cogent Soc. Sci.*, 5(1): 1–14.

KIDIDO, J.K., BUGRI, J.T. & KASANGA, R.K., 2017. Dynamics of youth access to agricultural land under the customary tenure regime in the techiman traditional area of Ghana. *Land Use Policy.*, 60: 254–266.

KISING'U, J.M., 2016. Factors influencing youth participation in agricultural value chain projects in Kenya: A case of Kathiani Sub-county, Machakos County, Kenya. Master's thesis. University of Nairobi.

LUTHANS, F. & YOUSSEF, C.M., 2004. Human, social, and now positive psychological capital management: Investing in people for competitive advantage. J. *Organ. Dyn*., 33(2): 143–160.

LUTHANS, F., AVEY, J.B., AVOLIO, B.J., NORMAN, S.M. & COMBS, G.M., 2006. Psychological capital development: Toward a micro-intervention. *J. Organ. Behav.*, *27*(3): 387-393.

MADENDE, P., HENNING, J.I.F. & JORDAAN, H., 2023. Accounting for heterogeneity among youth: A missing link in enhancing youth participation in agriculture—A South African Case Study. *Sustain.*, *15*(6): 4981.

MARTEY, E., WIREDU, A.N., ASANTE, B.O., WILSON, K., ATTOH, D.C. & AL-HASSAN, R.M., 2013. *Factors influencing participation in rice development projects: The case of smallholder rice farmers in Northern Ghana*. UK: European Centre for Research Training and Development.

MBANASO, E.O., AJAYI A.R., IRONKWE, A.G. & ONUNKA, N.A., 2013. Appraisal of young farmers' club programme in Abia State, Nigeria. *J. Agric. and Social Res*., 13(1): 31-38.

MHEMBWE, S. & DUBE, E., 2017. The role of cooperatives in sustaining the livelihoods of rural communities: The case of rural cooperatives in Shurugwi District, Zimbabwe. *Jamba: J. Disaster Risk Stud.*, 9(1): 1-9.

MKUNA, E. & WALE, E., 2023. Smallholder Farmers' choice of irrigation systems: Empirical Evidence from Kwazulu-Natal, South Africa and its implications. *Sci. Afr.*, *20*: e01688.

MOGANO, M.W., 2018. Socio-economic factors as determinants of access to input subsidy: The case of smallholder farmers of Polokwane Municipality. Master's thesis. University of the Free State, South Africa.

MTHETHWA, S. & WALE, E., 2020. Household vulnerability to food insecurity in rural South Africa: Evidence from a nationally representative survey data. *Int. J. Environ. Res. Public Health.*, 18(4): 1917.

NAAMWINTOME, B.A. & BAGSON, E., 2013. Youth in agriculture: Prospects and challenges in the Sissala area of Ghana. *Net Journals*., 1(2): 60-68.

NCHABELENG, M.J., 2016. Assessing the impact of the department of agriculture farm together programme on development and growth of selected agricultural cooperatives in Capricorn District Municipality in Limpopo Province. Master's thesis. University of Limpopo, South Africa.

NIEUWOUDT, S., HENNING, J.I.F. & JORDAAN, H., 2017. Entrepreneurial competencies and financial performance of farmers in South Africa. *S. Afr. J. Econ. Manag. Sci.*, 20(1): a1640.

NJENGA, P., MUGO, F. & OPIYO, R., 2013. *Youth and women empowerment through agriculture in Kenya. Nairobi: Voluntary Service Overseas (VSO Jitolee).* Available from: https://agritech.tnau.ac.in/ta/women_in_agri/pdf/articles/youth-and-women-empowerment-through-agriculture-2013.pdf.

NYAM, Y.S., BAHTA, Y.T., ODUNIYI, O.S. & MATTHEWS, N., 2022. Smallholder sheep farmers' perception of production constraints and competitiveness strategies in South Africa. *Sci. Afr.*, *16*: e01192.

https://doi.org/10.17159/2413-3221/2024/v52n4a16686

ORTMANN, G.F. & KING, P., 2007. Agricultural cooperatives I: History, theory and problems. *Agrekon*., 46(1): 40-68.

PHAKATHI, S. & WALE, E., 2018. Explaining variation in the economic value of irrigation water using psychological capital: A case study from Ndumo B and Makhathini, KwaZulu-Natal, South Africa. *Water SA.*, 44(4): 664-673.

PHAKATHI, S., 2016. Small-scale irrigation water use productivity and its role in diversifying rural livelihood options: Case Studies from Ndumo B and Makhathini Irrigation Schemes, KwaZulu-Natal, South Africa. Master's thesis. University of KwaZulu-Natal.

PIENAAR, P.L., 2013. Typology of smallholder farming in South Africa's former homelands: Towards an appropriate classification system. Doctoral thesis. Stellenbosch University, South Africa.

PRAH, S., ASANTE, B.O., AIDOO, R., MENSAH, J.O. & NIMOH, F., 2023. Impact of agricultural policy intervention on yield and profitability of maize farmers: The case of planting for food and jobs (PFJ) programme in Ghana. C*ogent Food Agric.*, *9*(1): 2249928.

SIKWELA, M.M. & MUSHUNJE, A., 2013.The impact of farmer support programmes on household income and sustainability in smallholder production: A case study of Eastern Cape and KwaZulu-Natal, South Africa. *Afr. J. Agric. Res.*, 8(21): 2502-2511.

SIKWELA, M.M., 2013. The impact of farmer support programmes on market access of smallholder farmers in the Eastern Cape and KwaZulu-Natal Provinces, South Africa. Doctoral thesis. University of Fort Hare, Alice.

SINYOLO, S., MUDHARA, M. & WALE, E., 2016. Assessing the impact of social grant-dependency on participation of KwaZulu-Natal rural households in farming: Application of the generalised propensity score method. *J. Agric. Rural Dev. Trop. Subtrop.*, *118*(2): 233-244.

STATISTICS SOUTH AFRICA., 2019. *Mid-year Population Estimates*. Available from: https://www.statssa.gov.za/publications/P0302/P03022019.pdf.

TRADING ECONOMICS., 2021. *South African Youth Unemployment Rate*. Available from: radingeconomics.com/south-africa/youth-unemployment rate#:~:text=Youth%20Unemployment%20Rate%20in%20South%20Africa%20averaged%2054.21%20percent%20from,the%20fourth%20quarter%20of%202014.

TRADING ECONOMICS., 2023. *South African Youth Unemployment Rate*. Available from: https://tradingeconomics.com/south-africa/youth-unemployment-rate.

UDOH, E.J., AKPAN, S.B. & UKO, E.F., 2017. Assessment of sustainable livelihood assets of farming households in Akwa Ibom State, Nigeria. *J. Sustain. Dev*., 10(4).

WALE, E.Z. & CHIPFUPA, U., 2018. *Appropriate entrepreneurial development paths for homestead food gardening and smallholder irrigation crop farming in KwaZulu-Natal Province.* WRC Report No. 2278/1/18. Pretoria: Water Research Commission.

WILLIAMS, B., BROWN, T. & ONSMAN, A., 2012. Exploratory factor analysis: A five-step guide for novices. *Australas. J. Paramed*., 8(3): 01.

WOOLARD, I., 2013. *The youth unemployment problem in South Africa within the international context*. SALDRU, University of Cape Town.

YANG, L., LIU, M., MIN, Q. & LI, W., 2018. Specialization or diversification? The situation and transition of households' livelihood in agricultural heritage systems. *Int J Agric Sustain.*, 16(6): 455-471.

YEUNG, K.Y. & RUZZO, W.L., 2001. Principal component analysis for clustering gene expression data. *Bioinformatics.*, 17(9): 763-774.

ZAMXAKA, X., 2015. Factors affecting participation rates in farming in the rural areas of South Africa. Case of Amathole District Municipality. Master's thesis. University of Fort Hare Alice, South Africa.

S. Afr. J. Agric. Ext. Von Maltitz, Van Niekerk & Davis
Vol. 52 No. 4, 2024: 47-65
10.17159/2413-3221/2022/v50n1a14407

The Digital Readiness of Agricultural Advisory Professionals: A South African Case Study

Von Maltitz, L.[1], Van Niekerk J.A.[2] and Davis, K.[3]

Corresponding Author: L. Von Maltitz. Correspondence Email: vonmaltitzL@ufs.ac.za

ABSTRACT

Agricultural advisory services link producers, the government, the research community, and credit and input supply organisations. This vital role can be enhanced through the efficient use of digital platforms, especially in South Africa, where the advisor-to-producer ratio was last recorded to be 1:1019. According to the last census conducted in South Africa, 92.1% of households own a mobile phone, and only 21.1% do not have access to the internet, providing the platform for timeous interaction between advisors and their clients. The affordability of technology and data services, network coverage, and digital literacy are obstacles in the country that need to be addressed if access to ICTs is to be improved. This article focuses on the readiness of South African agricultural advisors to use digital platforms. Survey research was used to collect data from professionals, and the data was evaluated using a survey instrument that was developed based in part on similar work done in Rwanda. The results show that although most advisors are ready to use digital platforms, many obstacles must be addressed for efficient application.

Keywords: Agricultural Advisory Services, Digital Platforms, Digital Access, Digital Readiness, Digital Competency

1. INTRODUCTION

[1] Department of Agricultural Economics, University of the Free State, 205 Nelson Mandela Avenue, Bloemfontein, vonmaltitzL@ufs.ac.za, Orcid 0000-0002-7175-2344

[2] Associate Professor: Department of Sustainable Food Systems and Development, University of the Free State, 205 Nelson Mandela Avenue, Bloemfontein, vniekerkJA@ufs.ac.za, Orcid 0000-0001-9842-0641

[3] Senior Research Fellow, International Food Policy Research Institute, Washington, USA. K.Davis@cgiar.org

Vol. 52 No. 4, 2024: 47-65
https://doi.org/10.17159/2413-3221/2024/v52n4a16851

The importance of progressive socio-economic development in South Africa and, more specifically, rural South Africa is indisputable. Persistent poverty, excessive unemployment, sub-standard living conditions, and failing public infrastructure are just a few of the issues prevalent in the country (Wall, 2021; Habiyaremye *et al*., 2022). Amidst these circumstances, many households become involved in agriculture to enhance food security. The last census by Statistics South Africa (StatsSA) reported that 13.8% of all households in the country were classified as agricultural households involved in food production. The majority (89.2%) of these households were producing in their backyard to increase their food security and procure income for the household (StatsSA, 2023). Supporting these farmers in sustainably enhancing their production and progressing from subsistence to small commercial farmers is one of the critical roles that agricultural advisors fulfil. However, several factors impede advisory efficiency, of which a lack of funding is prominent. Lack of funding contributes to the current high extensionist-to-farmer ratio, last recorded to be 1:1019 by the Department of Agriculture, Land Reform & Rural Development (DALRRD, 2020). The deteriorating road conditions in the country are another factor increasingly hindering efficient service delivery in rural areas (Nyawo & Mashau, 2019). The culmination of these two issues highlights the need for an innovative approach to service delivery that includes using information and communication technologies (ICTs) and digital platforms (Antwi-Agyei & Stringer, 2021).

The call for participatory agricultural advisory processes, where farmers actively formulate solutions with and provide information to advisors, has been at the forefront of dialogues for decades (Chambers, 1997; Minh *et al*., 2010; Knook *et al*., 2018). This is opposed to the top-down linear approach, where the assumption is made that extension services know best, which has failed globally (Anderson & Feder, 2004). The participatory process contributed to the agricultural innovation systems approach where all stakeholders (farmers, researchers, government, NGOs, value chain institutions, etc.) collaborate to formulate solutions and enhance innovative developments (Hellin, 2012). The innovation system approach's efficiency significantly relies on successful networking amongst roleplayers (Davis *et al*., 2008). The increasing digitalisation of information and communication technologies (ICTs), including radio, television, computers, the internet, and mobile phones, has exponentially expanded the horizon for networking (Blum *et al*., 2020).

Access to digital platforms has drastically increased since the fourth industrial revolution was first coined in 2016 by the Founder and Executive Chairman of the World Economic Forum

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

(WEF), Klaus Schwab (Lavopa & Delera, 2021; Ndung'u & Signé, 2020). It created new pathways entrepreneurs harnessed, resulting in increased income levels and improved quality of life (Xu *et al*., 2018). Productivity improvements stemmed from, amongst others, increased efficiencies related to decreasing communication costs, better supply chain interaction, and low-cost logistics (Schwab, 2017). The COVID-19 pandemic forced society to enhance the development and use of ICTs to communicate and educate in all sectors, including agricultural advisory services (Chivers *et al*., 2023).

According to the last census conducted in 2022 in South Africa, 92.1% of the population owns or has access to a mobile phone compared to 32.3% in 2001. A mobile phone was also the household item of preference, followed by a stove (86.9%), a refrigerator (83.2%), and a television (79%) (StatsSA, 2023). Only 21.1% of households did not have access to the internet either via mobile phones, Wi-Fi at home or the workplace, libraries, internet cafés, etc., and the majority (60.5%) of users accessed the internet through mobile phones or other mobile devices (StatsSA, 2023). Affordability of technology and data services, network coverage, and digital literacy are obstacles in the country that need addressing if access to ICTs is to be improved (Aruleba & Jere, 2022; Born *et al*., 2021).

Many scholars have expressed the advantages and possibilities digital platforms bring to agricultural advisory services (Tsan *et al*., 2019; Oyinbo *et al*., 2020; Fabregas *et al*., 2022; Klerkx *et al.,* 2019). The complex communication flow in the entire food system can be facilitated by digital platforms, improving access to timeous information (Steinke *et al*., 2021). Farmers rely on up-to-date information concerning technological developments, market information, and weather forecasts on a near-daily basis to manage their production efficiently. Communicating relevant information to farmers is central to agricultural extension and advisory services, which digital technology can facilitate and expedite (Blum *et al*., 2020; Fabregas *et al*., 2022). Some studies have reported video content to be more helpful to farmers than written information, especially when farmers have time constraints or, in some cases, low literacy. Viewing practical demonstrations rather than reading a manual was reported to be beneficial and preferred by many farmers as it saves time and also counters illiteracy (Chivers *et al*., 2023). Many mobile phone applications that can assist farmers in managing crops, livestock, and weather data are available on the market. Cook and colleagues divide digital technologies in agriculture into four categories: 1. Data (collecting, measuring, storing, and reporting relevant statistics), 2. Control (assisting in managing specific tasks, such as GPS

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

systems, electronic tracking, and livestock fencing), 3. Modelling (analysis and comparison of recorded data), and 4. Networking and communications (sharing information, diagnosing, problem-solving) (Cook *et al.,* 2022). Another digital platform that has been shown to benefit farmers is digital financial inclusion (DFI). DFI allows farmers in remote areas better access to financial services, contributing to sustainable development and food security (Zhai *et al.,* 2023).

The Department of Agriculture, Land Affairs, and Rural Development (DALRRD) in South Africa has reiterated the importance of using ICTs in agricultural advisory services. The last departmental review affirmed the importance of equipping advisors with appropriate tools and skills to use ICTs efficiently (DALRRD, 2020).

The abundance of available digital platforms can overwhelm both advisors and farmers. According to Saravanan and colleagues (2015), the essential factors to consider when using ICTs for advisory services are:

- Relevant content: A thorough needs assessment must ensure that content shared with farmers caters to their needs.
- Appropriate: A highly technical application that requires a lot of time and data from the consumer might not be applicable in areas lacking data availability and limited digital literacy.
- Integrated: ICTs must complement existing extension practices, not replace them.
- Institutionalising: For ICT development and use to be sustainable, continuous support is needed from the institutions endorsing it.

Digital platform usage in advisory services is not without challenges. Besides the technological aspects and challenges, it is essential to consider social science elements (Klerkx *et al.,* 2019). For example, from a farmer's perspective, lack of digital literacy, data availability, internet coverage, and smartphone ownership create a digital divide, and generic content is not always relevant (Coggins *et al*., 2022; McCampbell *et al*., 2021). On the other hand, the ability and motivation of advisory professionals to efficiently utilise digital platforms are also vital to the success thereof (Olangunju *et al*., 2021). Spielman and colleagues (2021) provide a conceptual framework for using ICTs in agricultural advisory services. It displays the complexity of the multiple roleplayers and the many elements involved in using ICTs. These include the contextual political and policy framework, empowerment and equity issues, organisational

Vol. 52 No. 4, 2024: 47-65
https://doi.org/10.17159/2413-3221/2024/v52n4a16851

capacity, and individual competencies (Spielman *et al*., 2021). Much of the research on digital technology usage has focused on farmers and their ability and willingness to use it. However, the mindset, attitude, and competency of agricultural advisors to utilise, formulate, and construct ICT platforms also play a vital role in the successful application thereof (Spielman *et al*., 2021).

This research study focused on the readiness of agricultural advisory agents in South Africa to use digital platforms to provide support services to producers. Readiness in this context describes how users are prepared to actively use digital technologies in executing their work. Factors that contribute to preparedness are the mindsets and attitudes of users, availability and access to said technologies, and institutional support related to them (Gfrerer *et al*., 2021).

2. METHODOLOGY

2.1. Data Collection and Analysis

As part of the research conducted and reported in the South African Extension Agent Competencies and Attitudes for the Future Research Report of the CGIAR Research Program on Policies Institutes and Markets (Davis *et al*., 2021), this study sought to understand South African advisory professionals competency levels, perceptions, and attitudes, especially toward digital advisory services. Questions focused on advisors' attitudes toward using different digital technologies and accessing and using various digital tools.

Survey research was used to collect data from extension professionals. Sector, experience, position in the workplace, and demographic information such as gender, age, and education levels were collected. A survey instrument was developed based partly on Spielman and colleagues' work in Rwanda (Spielman *et al*., forthcoming). The instrument was tested for face and content validity using a panel of experts from South Africa. The survey was in English.

The Alchemer survey platform was used for the online survey, which allows for secure communication between the surveyor, the respondent, and the survey database to ensure that data stay protected and are not accessible to other respondents or unauthorised entities. The service also allows for a restriction on the survey or sections that only enables respondents to proceed with the survey once they have completed certain sections or accepted specific terms and conditions.

Vol. 52 No. 4, 2024: 47-65
https://doi.org/10.17159/2413-3221/2024/v52n4a16851

Working with the DALRRD sub-programme National Extension Services, the quarterly Public Sector Forum meeting on 6 August 2021 was used for awareness creation with the Provincial Departments of Agriculture. Background was provided to the meeting members to get buy-in and support. When the survey was ready in September 2021, the provincial extension heads were approached to distribute it to their constituencies. For non-public staff from commodity organisations, agricultural unions, and private sector firms, lists were developed to obtain publicly available contact details. Information was shared widely through social media and follow-up emails to provincial and non-public organisations. All communication complied with the Protection of Personal Information Act (POPIA).

In addition, the annual South African Society for Agricultural Extension (SASAE) conference in Paarl, Western Cape, held 11-14 October 2021, was utilised to promote the survey. The event was compliant with all local COVID protocols. Study leads attended the conference and asked participants to fill out the survey. Paper copies were distributed. All face-to-face contact between the researcher and respondents aligned with South African COVID-19 protocols. Data collection took place between 30 September and 15 November 2021.

Data were analysed using descriptive statistics and tests of significance, using appropriate software (Excel and SPSS) for the data collected. The mean, variance, and correlates of three key indicator sets—technical skills, functional capacities, and digital readiness—among public and private sector extension agents were assessed using response data collected from an online survey. Indices derived from the data that capture the multidimensionality of these capabilities and econometric specifications appropriate to the nature of the data were used.

2.2. Study Population

The sampling frame for this survey was the entire population of agricultural advisors in South Africa. That includes all individuals who work as agricultural advisory professionals: crop advisors, livestock advisors, and other individuals working in agricultural advisory services in the public, private, and non-profit sectors in South Africa.

According to the latest figures, there are 2652 public sector agricultural extension professionals (Table 1) and roughly 1500 private sector officials.

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

TABLE 1: Distribution of Public Advisory Professionals in South Africa and Ratio to Producers

Province	Number of staff in advisory services, including managers, advisors, and specialists	Estimated number of household producers	Extension to farmer ratio (excluding managers)
Eastern Cape	571	491 000	1:941
Free State	120	153 000	1:1378
Gauteng	124	192 000	1:1613
KwaZulu Natal	750	526 000	1:734
Limpopo	538	584 000	1:1321
Mpumalanga	228	317 000	1:1524
Northern Cape	56	31 000	1:674
North West	193	112 000	1:622
Western Cape	72	47 000	1:746
TOTAL	2652	2 453 000	1:1019

(Source: DALRRD, 2022.)

3. RESULTS

Three hundred and seventy respondents provided consent and completed the survey. An overview of the respondents is provided in Table 2 below:

TABLE 2: Descriptive Information About Respondents

Variable	Indicator	Frequency (n = 370)	Percentage (%)
Gender	Male	192	52.3
	Female	173	47.1
	Unknown	2	0.5
Education	Diploma & advanced certificate	13	3.6
	Bachelor's degree and advanced diploma	116	31.8

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

	Honours degree and postgraduate diploma	116	31.8
	Masters degree	99	27.1
	Doctoral Degree	19	5.2
District	Eastern Cape	61	16.7
	Free State	43	11.7
	Gauteng	31	8.5
	Kwazulu Natal	49	13.4
	Limpopo	35	9.6
	Mpumalanga	21	5.7
	Northern Cape	35	9.6
	Northwest	11	3
	Western Cape	72	19.7
	Multiple provinces	8	2.2
Sector of employment	Public sector/government	292	79.8
	Private sector	36	9.8
	Non-profit/NGO's	23	6.2
	Other	15	4.1
Position	Frontline staff or field staff working mainly with clientele	224	62.2
	Manager of advisory staff	47	13.1
	Manager of staff in other disciplines, including agricultural advisors	16	4.4
	Subject matter specialists	34	9.4
	Other	39	10.8

The respondents answering "other" regarding their position in their job were all involved in agricultural advisory services but did not fit into the provided descriptives.

3.1. The Importance of Different Areas of Knowledge and Skills For Extension/Agricultural Advisory Services in the Future

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

Respondents were asked to rate the importance of different topics according to the following Likert scale:

1 = I strongly disagree; 2 = I somewhat disagree; 3 = I neither disagree nor agree; 4 = I somewhat agree; 5 = I strongly agree

The results are illustrated in Figure 1.

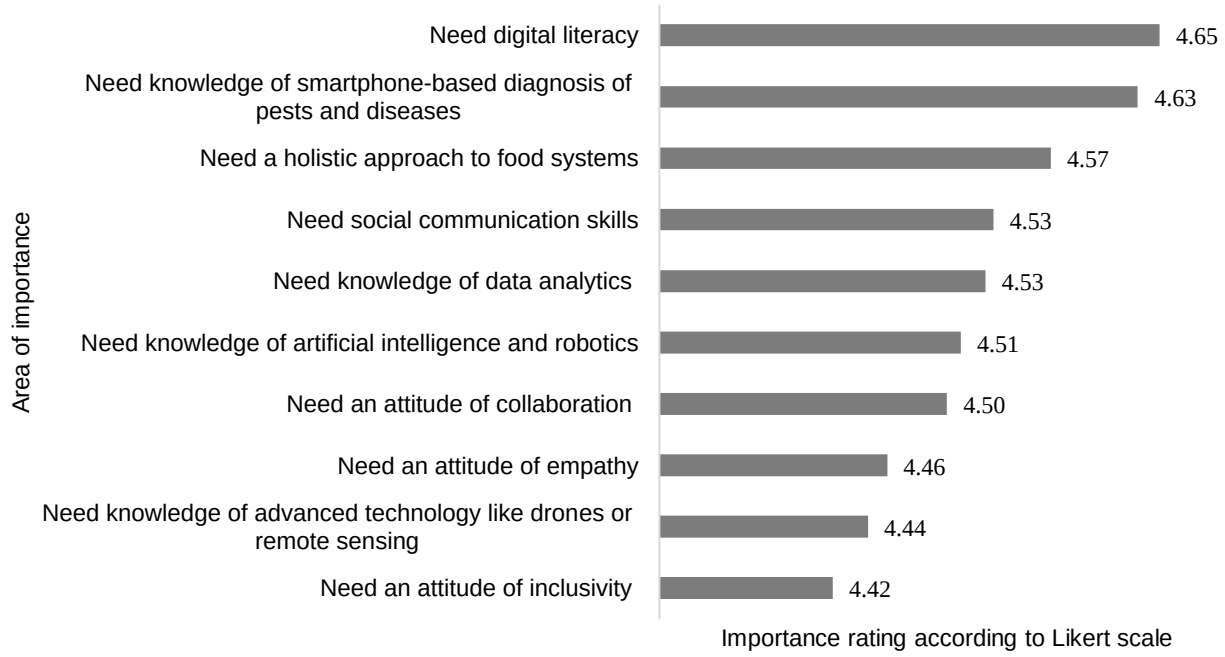

FIGURE 1: The Importance of Different Agricultural Advisory Services Needed in the Future

The results show that advisory professionals agreed with all the statements given to some extent, indicating that using and knowing different digital platforms is vital for the future. Digital literacy was ranked most important, followed by the smartphone-based diagnosis of pests and diseases. Other skills and competencies related to ICTs included knowledge of data analytics, artificial intelligence and robotics, and advanced technology like drones or remote sensing.

Respondents were asked to include additional topics not listed in the questionnaire, and the responses are summarised in Table 3.

TABLE 3: Other Skills and Competencies Important For Agricultural Advisory Services in the Future

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

Topic	Frequency (n=370)	Percentage (%)
Analytical thinking/personal development	27	7.3
Climate-smart management	18	4.9
Precision agriculture	12	3.2
App development	9	2.4
Project management	8	2.2
Webinars/demonstrations	7	1.9
Market Intelligence	7	1.9
Research and article writing	5	1.4
Chemical usage	2	0.5
Youth development	2	0.5

3.2. Attitudes Towards Digital Agricultural Advisory Services

In this section, respondents were asked to indicate their attitudes and preferences toward using digital technologies in their work. Digital technologies were limited to smartphones, tablets, computers, and phone applications. Respondents could answer "yes" or "no" along each topic. The results are shown in Figure 2.

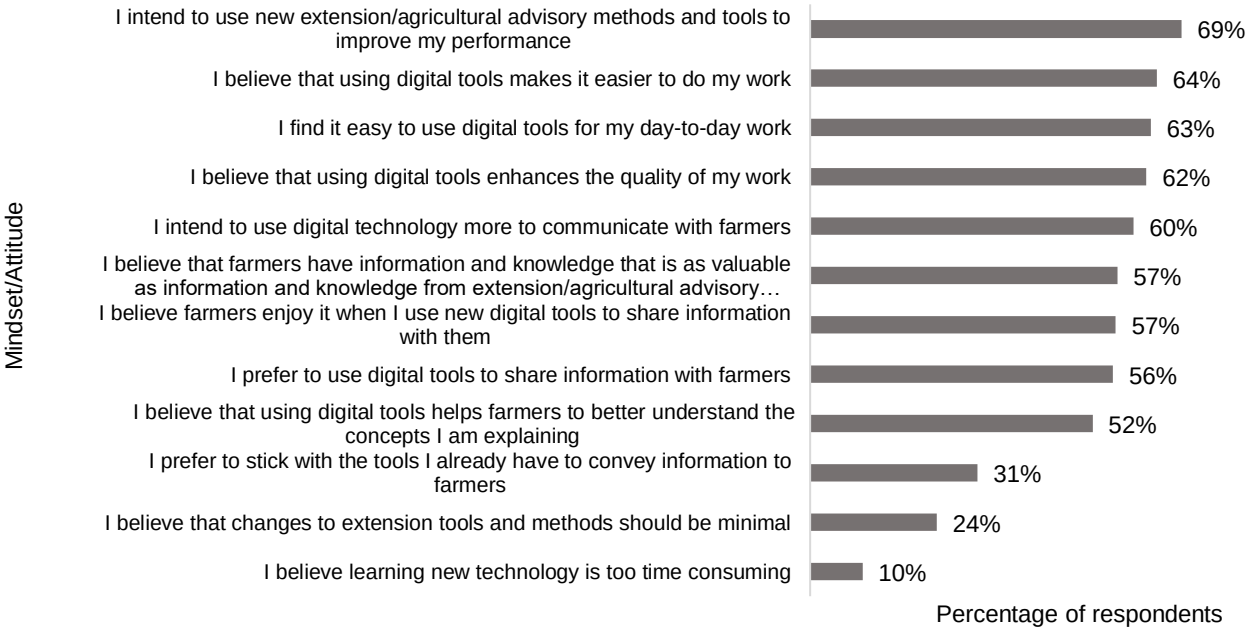

FIGURE 2: Mindsets and Attitudes of Advisory Professionals Toward Digital Platforms

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

Although encouraging, the results above indicate that there is still some hesitance among agricultural advisory professionals to use digital technologies to perform their duties, which could be attributed to the country's lack of existing digital programs.

More than half (57%) of survey respondents agreed with or had a yes response to the question, "I believe that farmers have information and knowledge that is as valuable as information and knowledge from extension/agricultural advisory officers", reflecting an attitude of superiority that is still present in some cases, which is detrimental to participatory approaches in agricultural advisory services. This agrees with the findings of a study by Davis and colleagues in 2019 (Davis *et al*., 2019).

3.3. Access to Digital Tools and Usage

Respondents were asked to identify the digital tools they have access to and if they are provided to them by their employer or if they use their personal ones for work. They were also questioned on data sufficiency to perform their job and then asked which digital tool they used most regularly in performing their work.

The results are illustrated in Figure 3.

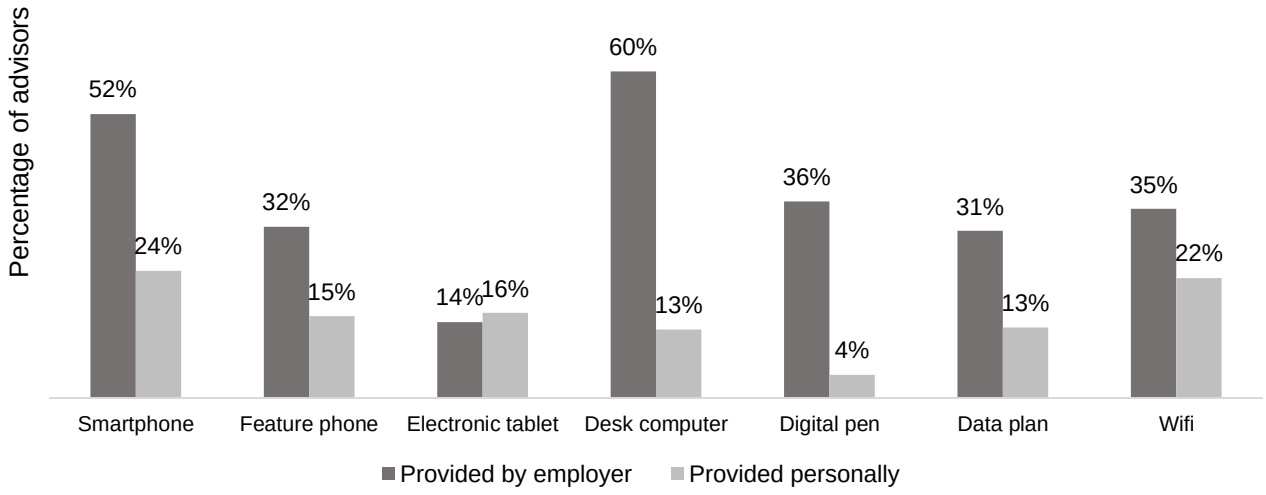

FIGURE 3: Digital Devices Provided By Employers Vs Provided Personally and Used For Work

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

When performing a sector comparison of digital devices provided by employers, there was a significant difference between the public and private sectors. Their employers better supported public sector employees regarding providing digital devices than private sector employees.

Regarding data sufficiency for work, 45.9% of respondents answered "no," and 54.1% answered "yes". There was a significant difference between public and private sector respondents, with 48.6% of public sector respondents and 81.1% of private sector respondents indicating that they usually have sufficient data to carry out their work on a smart device. Device usage is illustrated in Figure 4**.**

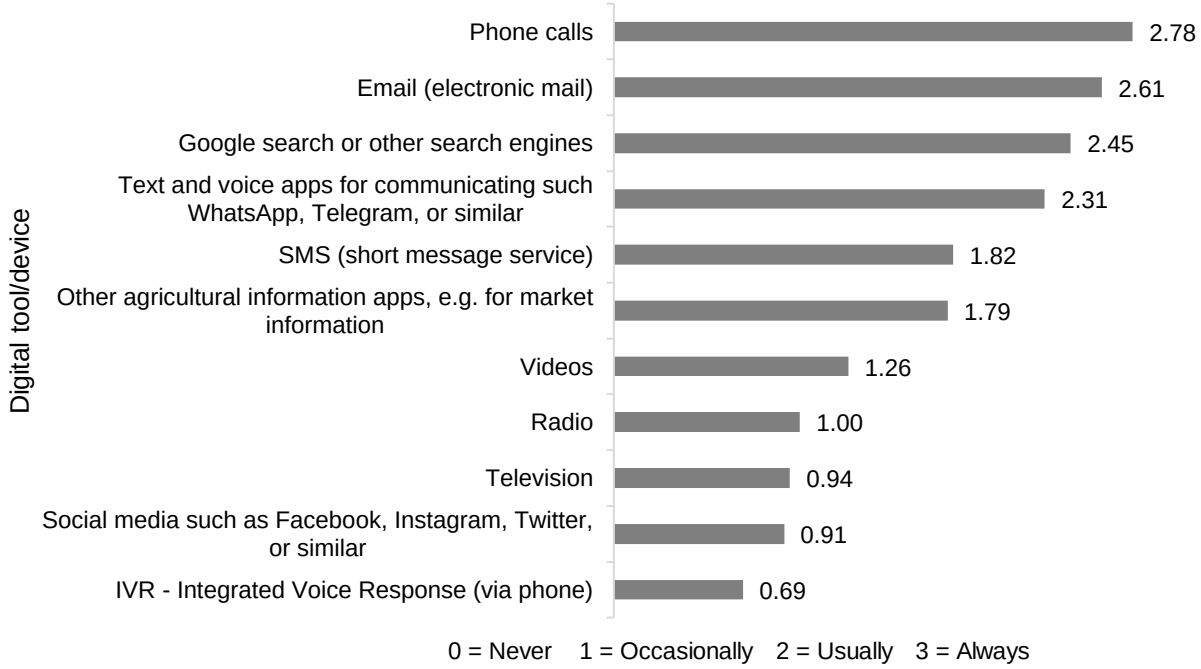

FIGURE 4: Frequency of Device Usage Amongst Respondents (Based on the Mean)

Phone calls, emails, search engines, and text and voice applications were the tools utilised most frequently by respondents. When comparing, there was a significant difference between male and female usage of search engines and emails, with females using these more frequently than males to conduct their work. Public sector agents also used phone calls, text messages, radio, and television more than private sector agents. Phones, desktop computers, digital pens, and Wi-Fi are more frequently used by agents older than 35 than agents below 35.

Vol. 52 No. 4, 2024: 47-65
https://doi.org/10.17159/2413-3221/2024/v52n4a16851

4. DISCUSSION

The study revealed that agricultural advisory professionals in South Africa realise the importance of using different digital tools and platforms in agricultural extension. This is consistent with a study conducted among advisory practitioners in the North West province in 2015, which indicated that digital advisory services play a vital role in accessing and sharing agricultural information and providing quality information on time (Oladele, 2015).

The mindset toward digital technologies indicated that most agricultural advisors were ready to use digital platforms, but some professionals still hesitated. Only 52.4% of respondents answered that using digital tools helps farmers better understand concepts, and 60% said they intend to use them more to communicate. This could be attributed to several factors, including the results in the section that indicated that only 52% of respondents were provided with a smartphone and only 35% with Wi-Fi by their employer. Only 54.1% of respondents indicated they usually have sufficient data to carry out their work. Successful execution of digital extension can only be performed if equipped with appropriate tools and adequate data. Lack of support will negatively impact advisors' mindsets toward digital technology (Gfrerer *et al*., 2021).

Regarding device usage, the results showed that extensionists hardly use social media and videos, focusing more on phone calls, email, and text messages. Using videos in support has been effective in many studies and should be considered (Gandhi *et al*., 2007; Ibeawuchi *et al*., 2021; Van Campenhout *et al*., 2016). Spielman and colleagues (2019) highlight social media's role in improving information sharing through social networking. Information can be customised to suit the needs of specific farmers, and data can be collected through the algorithms that social media employs (Spielman *et al*., 2019). Avenues other than phone calls, emails, and text messages must receive prioritised attention from policymakers and other stakeholders.

Public-sector agricultural advisors in South Africa are often criticised for being incompetent (Manoko, 2022). Taking advantage of the possibilities that ICTs offer, the South African public agricultural extension sector can access, design, and distribute innovative solutions to their clients and increase the quality of service provided. By providing and maintaining a conducive environment to ensure progress and development in digital agriculture, the public sector can

Vol. 52 No. 4, 2024: 47-65
https://doi.org/10.17159/2413-3221/2024/v52n4a16851

ensure that agricultural development receives the necessary priority to safeguard food security (Cook *et al.,* 2022).

5. CONCLUSION AND RECOMMENDATIONS

The need and scope for developing customised digital agricultural advisory tools in South Africa are substantial. The existing digital agricultural applications mainly focus on the commercial farming sector that pays for the service (Born *et al*., 2021). To support the smallholder and subsistence farming sector, the government should engage with private sector roleplayers to assist in developing appropriate platforms or use existing platforms for digital agricultural extension. Content has to be context-specific according to location and commodity.

Farmers must be consulted, and their needs must be catered to in formulating efficient digital platforms. Efficient implementation of digital agricultural advisory services can assist in overcoming funding issues in the public sector. Instead of endeavouring to appoint more advisors given the budget constraints, digital communication can be supported and facilitated instead of endeavouring to appoint more advisors, saving costs but still enhancing service delivery. Agricultural advisors must be equipped, trained, and supported to engage digital platforms so that farmers can benefit and food security is enhanced in the process.

The Global Forum for Rural Advisory Services (GFRAS) continuously researches digital advisory services in different countries. The latest report, "Digital advisory services: Global lessons in scaling up solutions", has just been published on their website (Larsen *et al.,* 2023). The recommendations made should be incorporated into the formal training of advisory staff. Higher education institutions offering qualifications in agricultural advisory services must ensure that their modules are regularly updated to equip agricultural students with the digital tools they will use in their workplace. A recent study found that the available agricultural advisory undergraduate degree qualifications in South Africa had very little digital training content or none at all (Von Maltitz *et al.*, 2023).

6. ACKNOWLEDGEMENTS

The research to support this article was conducted as part of the International Food Policy Research Institute (IFPRI) CGIAR Research Program on Policies, Institutions, and Markets.

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

REFERENCES

ANDERSON, J.R. & FEDER, G., 2004. Agricultural extension: Good intentions and hard realities. *World Bank Res Obser.*, 19(1): 41–60.

ANTWI-AGYEI, P. & STRINGER, L.C., 2021. Improving the effectiveness of agricultural extension services in supporting farmers to adapt to climate change: Insights from northeastern Ghana. *Clim. Risk Manag.,* 32: 1-13.

ARULEBA, K. & JERE, N., 2022. Exploring digital transforming challenges in rural areas of South Africa through a systematic review of empirical studies. *Sci. Afr.,* 16: 2468-2276.

BLUM, M.L., COFINI, F. & SULAIMAN, R.V., 2020. *Agricultural extension in transition worldwide: Policies and strategies for reform.* Rome: FAO.

BORN, L., CHIRINDA, N., MABAYA, E., AFUN-OGIDA, O., GIRVETZ, E., JARVIS, A. & KROPFF, W., 2021. *Digital Agriculture Profile: South Africa*. Rome: FAO.

CHAMBERS, R., 1997. *Whose reality counts? Putting the last first*. London, UK: Intermediate Technology Publications.

CHIVERS, C., BLISS, K., DE BOON, A., LISHMAN, L., SCHILLINGS, J., SMITH, R. & ROSE, D.C., 2023. Videos and podcasts for delivering agricultural extension: achieving credibility, relevance, legitimacy and accessibility. *J. Agric. Edu. Ext.,* 29(2): 173-197.

COGGINS, S., MCCAMPBELL, M., SHARMA, A., SHARMA, R., HAEFELE, S.M., KARKI, E., HETHERINGTON, J., SMITH, J. & BROWN, B., 2022. How have smallholder farmers used digital extension tools? Developer and user voices from Sub-Saharan Africa, South Asia and Southeast Asia. *Glob Food Secur.,* 32: 1-10.

COOK, S., JACKSON, E.L., FISHER, M., BAKER, D. & DIEPEVEEN, D., 2021. Embedding digital agriculture into sustainable Australian food systems: pathways and pitfalls to value creation. *Int. J. Agric. Sustain.,* 20(3): 346-367.

DAVIS, K., EKBOIR, J. & SPIELMAN, D.J., 2008. Strengthening agricultural education and training in sub-Saharan Africa from an innovation systems perspective: A case study of Mozambique. *J. Agric. Edu. Ext.,* 14(1): 35-51.

DAVIS, K., LANDINI, F., VAN NIEKERK, J.A., GREEN, K. & TERBLANCHE, S.E., 2019. Extension officers' perceptions of extension and innovation in South Africa. *S Afr. Jnl. Agric. Ext.,* 47(4): 152-161.

DAVIS, K., VON MALTITZ, L., DE BRUYN, M., VAN NIEKERK, J.A. & NGOMANE, T., 2021. *South African extension agent competencies and attitudes for the future: Results of a survey.* Washington, D.C: CGIAR, International Food Policy and Research Institute.

DEPARTMENT OF AGRICULTURE, LAND REFORM AND RURAL DEVELOPMENT (DALLRD)., 2020. *Draft review of the national framework for the minimum norms and standards for extension and advisory services in agriculture.* Pretoria: Republic of South Africa.

FABREGAS, R., HARIGAYA, T., KREMER, M. & RAMRATTAN, R., 2022. Digital agricultural extension for development. In T. Madon, A.J. Gadgil, R. Anderson, L. Casaburi, K. Lee & A. Rezaee (eds.), *Introduction to development engineering*. Cham: Springer.

GFRERER, A., HUTTER, K., FÜLLER, J. & STRÖHLE, T., 2021. Ready or not: Managers' and employees' different perceptions of digital readiness. *Calif. Manag. Rev.,* 63(2): 23-48.

GANDHI, R., VEERARAGHAVAN, R., TOYAMA, K. & RAMPRASAD, V., 2007. Digital green: Participatory video for agricultural extension. In *2007 International Conference on Information and Communication Technologies and Development*, Bangalore, India, pp. 1-10.

HABIYAREMYE, A., KING, N.A. & TREGENNA, F., 2022. *Innovation and socio-economic development challenges in South Africa: An overview of indicators and trends*. SARChI Industrial Development Working Paper Series WP 2022-03. The South African Research Chair in Industrial Development (SARChI), University of Johannesburg, South Africa.

HELLIN, J., 2012. Agricultural extension, collective action and innovation systems: Lessons on network brokering from Peru and Mexico. *J. Agric. Edu. Ext.,* 18(2): 141-159.

IBEAWUCHI, B.O., ADISA, P.T., GBEDE, O.I., BILISUMA, K.W., DERARA, S.F. & AMINU, H.A., 2021. Review of the usage of video in agricultural extension to increase the adoption of agricultural innovation. *J. Commun. Communication. Res.,* 6(2): 110-118.

KLERKX, L., JAKKU, E. & LABARTHE, P., 2019. A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS – Wageningen J. Life Sci.,* 90-91: 1-16.

KNOOK, J., EORY, V., BRANDER, M. & MORAN, D., 2018. Evaluation of farmer participatory extension programmes. *J. Agric. Edu. Ext.*, 24(4): 309-325.

LARSEN, C.E.S., NIELSON, D., OLIVEIRA, S.K. & PAYNE, J., 2023. *Digital advisory services: Global lessons in scaling up solutions*. Lausanne, Switzerland: GFRAS.

LAVOPA, A. & DELERA, M., 2021. *What is the fourth industrial revolution?* Industrial Analytics Platform, UNIDO. Available from: https://iap.unido.org/articles/what-fourth-industrial-revolution.

MANOKO, T., 2022. *"We want competent extension officers, please."* Food for Mzansi. Available from: www.foodformzanzi.co.za.

MCCAMPBELL, M., ADEWOPO, J., KLERKX, L. & LEEUWIS, C., 2023. Are farmers ready to use phone-based digital tools for agronomic advice? Ex-ante user readiness assessment using the case of Rwandan banana farmers. *J. Agric. Edu. Ext.,* 29(1): 29-51.

MINH, T.T., ERIK, C., LARSEN, S. & NEEF, A., 2010. Challenges to institutionalising participatory extension: The case of farmer livestock schools in Vietnam. *J. Agric. Edu. Ext.*, 16(2): 179-194.

NJUGUNA, N. & SIGNÉ, L., 2020. *The fourth industrial revolution and digitisation will transform Africa into a global powerhouse*. *Capturing the Fourth Industrial Revolution. A regional and national agenda.* Washington D.C: The Brookings Institution.

NYAWO, J.C. & MASHAU, P., 2019. The development of the rural roads network for sustainable livelihoods in South African local municipalities. *Gender and Behaviour.,* 17: 12553-12568.

OLADELE, O.I., 2015. Effect of Information Communication Technology (ICT) on agricultural information access among extension officers in North West Province South Africa. . *S Afr. Jnl. Agric. Ext.,* 43(2): 30-41.

OLANGUNJU, O., HASSAN, S., SAMAD, M.Y.A. & KASIN, R., 2021. Enhancing work performance of extension agents among cocoa farmers in Malaysia: The influence of human resource development skills. *Walailak J. Sci. & Tech.,* 18(5): 1-15.

OYINBO, O., CHAMBERLIN, J. & MAERTENS, M., 2020. Design of digital agricultural extension tools: Perspectives from extension agents in Nigeria. *J. Agric. Econ.*, 71(3): 798–815.

SARAVANAN, R., SULAIMAN, R.V., DAVIS, K. & SUCHIRADIPTA, B., 2015. *Navigating ICTs for Extension and Advisory Services*. GFRAS Good Practice Notes for Extension and Advisory Services, Note 11. Lindau, Switzerland: GFRAS.

SCHWAB, K., 2017. *The fourth industrial revolution*. London, UK: Portfolio Penguin.

MINISTRY OF FINANCE., 2021. *The national budget speech*. Republic of South Africa.

SPIELMAN, D., ROSENBACH, G., MAKHIJA, S. & DAVIS, K., (Forthcoming). *Assessing Agricultural Extension Agent Digital Readiness: Results of a Representative Survey in Rwanda.* Rwanda Strategy Support Program Working Paper.

SPIELMAN, D., LECOUTERE, E., MAKHIJA, S. & VAN CAMPENHOUT, B., 2021. Information and communication technology (ICT) and agricultural extension in developing countries. *Annu. Rev. Resour. Econ.,* 13: 177-201.

STATISTICS SOUTH AFRICA (STATS SA)., 2023. *Census 2022.* Statistical release: P03014. Pretoria: Republic of South Africa.

STEINKE, J., VAN ETTEN, J., MÜLLER, A., ORTIZ-CRESPO, B., VAN DE GEVEL, J., SILVESTRI, S. & PRIEBE, J., 2021. Tapping the full potential of the digital revolution for agricultural extension: an emerging innovation agenda. *Int. J. Agric. Sustain.,* 19(5-6): 549-565.

https://doi.org/10.17159/2413-3221/2024/v52n4a16851

TSAN, M., TOTAPALLY, S., HAILU, M. & ADDOM, B.K., 2019. *The Digitalisation of African Agriculture Report 2018–2019*. Wageningen, The Netherlands: CTA/Dalberg Advisers.

VAN CAMPENHOUT, B., VANDEVELDE, S., WALUKANO, W. & VAN ASTEN, P., 2016. *Agricultural extension messages using video on portable devices: Increase knowledge about seed selection and seed storage and handling among smallholder potato farmers in southwestern Uganda.* IFPRI Discussion Paper 1573. Washington, D.C: International Food Policy Research Institute (IFPRI).

VON MALTITZ, L., DAVIS, K., SUVEDI, M., CHANZA, C., AGWU, A.E., SASIDHAR, P.V.K., DIMELU, M.U., LIVERPOOL-TASIE, L.S.O., ANUGWA, I.Q. & TCHUWA, F., 2023. *Strengthening agricultural extension training: process skills and competency gaps in undergraduate agricultural extension curriculum in South Africa.* Partnerships for Innovative Research in Africa (PIRA) Research Report. East Lansing, Michigan, USA: Alliance for African Partnership, Michigan State University. https://aap.isp.msu.edu/index.php?cID=452

WALL, K., 2021. The right to functioning urban infrastructure – A review. *Town and Regional Planning.,* 79: 55-66.

XU, M., DAVID, J.M. & KIM, S.H., 2018. The fourth industrial revolution: Opportunities and challenges. *Int. J. Financ. Res.,* 9(2): 90-95.

ZHAI, S., PENG, C. & SHENG, Y., 2023. Assessing the impact of digital financial inclusion on agricultural total factor productivity in China. *Int. Food Agribus. Manag. Rev.,* 26(3): 519-533.

S. Afr. J. Agric. Ext. Bodiba, Letsoalo, Teele & Legodu
Vol. 52 No. 4, 2024: 66-82
https://doi.org/10.17159/2413-3221/2024/v52n4a17160

Rangeland Management Practices and Perceptions of Communal Livestock Farmers' Towards Rangeland Degradation in the North West Province of South Africa

Bodiba, K.C.[1], Letsoalo, N.L.[2], Teele, T.[3] and Legodu, G.L.[4]

Corresponding Author: K.C. Bodiba. Correspondence Email: bodibakb@gmail.com

ABSTRACT

This study assessed rangeland management practices and perceptions of livestock farmers towards rangeland degradation in the Moretele communal areas of North West Province, South Africa. Understanding these issues is crucial for developing interventions to improve rangeland productivity and sustainability. A semi-structured questionnaire surveyed 106 randomly selected communal farmers across four villages (Lebalangwa, Mmakgabetlwane, Noroki, & Swartdam). Data analysis was conducted using SPSS software. The majority of participants were males. Most farmers had less than years of farming experience, and most were farming with mixed livestock (cattle, sheep, and goats). Based on the farmers' perceptions, over 70% of the farmers agreed that rangelands are overgrazed and considered the condition of the rangelands to have declined dramatically over time. The most important traditional rangeland management strategy adopted by the farmers was mobility. Better pastures and water access were common reasons for mobility across all areas. The study suggests that, in future, development agencies and government must work closely with local communities to train and empower them in rangeland management skills.

Keywords: Rangelands, Communal Land, Livestock Farmers, Sustainable Practices

[1] Mr. KC Bodiba. Agricultural Advisor: Northwest Department of Agriculture and Rural Development, Agricentre Building Cnr Dr James Moroka Drive & Stadium Road Mmabatho Tel. 018 389 5111; E-mail: bodibakb@gmail.com ORCID: 0000-0003-4285-0575

[2] Mr. NL Letsoalo. Research Technician: Agricultural Research Council – Animal Production, Private Bag X 2, Irene, 0062, South Africa. Tel. 012 672 7370; Email Letsoalonl@arc.agric.za ORCID: 0000-0001-5083-1054

[3] Dr. T Teele: Postdoctoral Researcher: Post Graduate Studies in Education, Faculty of Humanities, Central University of Technology, Free State Tel. 081 214 8397; Email tspoteele@gmail.com ORCID: 0000-0001-5267-7652

[4] Dr. G.L Legodu. Lecturer: Department of Mathematics Natural Sciences and Technology Education Faculty: Education PO Box 339, Bloemfontein 9300, Republic of South Africa; Tel. 051 401 2406 Email LegoduGL@ufs.ac.za ORCID: 0000-0001-7118-6787

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

1. INTRODUCTION

Generally, rangelands are natural or semi-natural vegetation areas supporting livestock grazing and wildlife (O'Connor & van Wilgen, 2020). About 74% of the total land surface of South Africa is arid and semi-arid rangelands (Mudau *et al*., 2022). Over the past few decades, the impact of rangeland degradation has been a major challenge faced, especially by communal farmers in most developing countries, including South Africa (Reed *et al*., 2015; Zerga, 2015; Bolo *et al*., 2019). An estimated 25% of South Africa's natural arid and semi-arid rangelands are already degraded (Kellner & de Wet., 2021; Marquart *et al*., 2023). Kassahun *et al*. (2008) and Diogo *et al*. (2021) stated that poor grazing practices, land-use intensification, and livelihood diversification, particularly in communal areas, cause rangeland degradation. Furthermore, the increasing number of communal livestock farmers and livestock in South Africa has led to challenges in rangeland management (Selemani, 2014). Mismanaged access to rangeland and variations in livestock owners' intentions result in poor rangeland conditions and overgrazing (Beyene *et al*., 2014; Mphinyane & Omphile, 2016).

According to Marquart *et al*. (2020) and Yousefi *et al*. (2021), overgrazing significantly threatens rangelands. It can lead to reduced biodiversity, loss of palatable species, and degradation of soil physical properties. Cai *et al*. (2020) further stated that other negative consequences of overgrazing could also lead to the proliferation of woody plants and decreased water infiltration. Overgrazing compacts the topsoil, making it denser and less porous. Numerous studies, such as those by Belayneh and Tessema (2017) and Maphanga *et al*. (2022), have demonstrated that bush encroachment primarily affects savanna ecosystems and is considered an environmental problem. Mani *et al*. (2021) indicated that communal land degradation in South Africa has been mainly characterised by woody plant encroachment, whether this phenomenon is more prevalent in communal areas with unrestricted open grazing or conservation areas with restricted closed grazing (Mangani, 2021).

Communal farmers in developing countries possess valuable indigenous knowledge of rangeland management, which should be considered when planning rangeland management practices (Finca *et al*., 2023; Baloyi, 2023). Sandhage *et al*. (2015) stated that the lack of resources available to communal farmers is a significant challenge for rangeland management in South Africa. Despite limited access to advanced technologies, these farmers have successfully maintained livestock for generations. Their ecological knowledge can contribute to the development of effective rangeland management programs.

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

This study aimed to assess rangeland management practices and perceptions of livestock farmers towards rangeland degradation in Moretele Local Municipality. This information is considered vital for possible interventions to improve these rangelands' productivity and sustainable use.

2. MATERIALS AND METHODS

2.1. Description of Study Area

The study was conducted in Moretele Local Municipality, located under the Bojanala Platinum district in the North West Province of South Africa. The area is located at the following coordinates: latitudes 25.142°S to 25.285°S and longitudes 27.970°E to 28.253°E above sea level. It covers an area of about 1 369km2 km^2 of land. The area has an average annual rainfall of 565 mm, with rain falling in the summer months between October and March. The maximum monthly average temperatures in summer range from 27 to 34 °C and 20 to 23 °C in winter, and the respective minimum temperatures range from 15 to 16 °C in summer and 3 to 6 °C in winter (DIGES, 2012). Mixed Bushveld, Kalahari Thornveld, and Springbok Flats Turf Thornveld (Letsoalo *et al*., 2000) are the veld types. The vegetation type comprises open to dense low thorn savanna, dominated by *Acacia* species recently divided into two genera, namely Vachellia and Senegalia. The common woody species include *Vachellia karoo*, *Vachellia tortilis*, *Vachellia, nilotica*, *Senegalia, mellifera*, *Vachellia, luederitzii*, and *Ziziphus mucronata* (Mucina & Rutherford, 2006). The following grasses dominate the herbaceous layer: *Ischaemum afrum*, *Dichanthium annulatum*, *Aristida bipartita*, and *Brachiaria eruciformis* (Mucina & Rutherford, 2006).

2.2. Data Collection

The data for the study was collected from a sample of 106 livestock farmers in four villages: Lebalangwa (n = 24), Mmakgabetlwane (n = 26), Noroki (n = 21), and Swartdam (n = 35), which are among the largest communal areas in Moretele. These included male and female farmers with a minimum of 10 Large Stock Units (LSU) or animal/s unit equivalent, as long as they were ruminants (goats, sheep, and/or cattle). A meeting was held with North West Department of Agriculture and Rural Development officials to introduce the study's purpose before selecting farmers. The questionnaires were administered by well-trained enumerators proficient in the local language (Setswana), and face-to-face interviews were conducted. This ensured that the farmers could understand the questions and provide accurate answers. Primary

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

data obtained included 1) demographic information, 2) rangeland management practices, and 3) causes of degradation.

Ethical clearance was obtained from the University of the Free State for conducting the survey. A briefing was then held with extension officers, community leaders, and communal livestock farmers to explain the purpose of the study and schedule dates for interviews. The questionnaire survey was pre-tested in 10 households to improve clarity and reliability. A structured questionnaire was randomly administered to 106 communal livestock farmers of the four selected villages in Moretele Local Municipality.

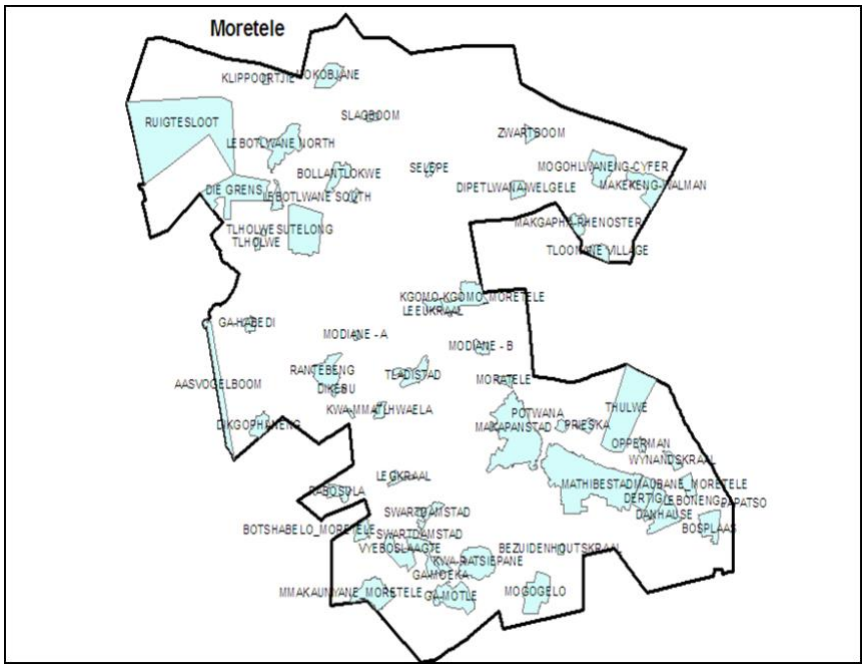

FIGURE 1: Map of the Study Area

2.3. Data Analysis

The Microsoft Office Excel 2022 software package was used to capture the coded data and to test the reliability of the information gathered from the questionnaires. The data was analysed using SPSS.

3. RESULTS

3.1. Demographic Information of the Farmers

Table 1 illustrates the demographics of the farmers who participated in this study. The gender of most respondents who participated in this study were male farmers (60%) and female farmers (40%). The study found that many respondents had formal education, with only 14%

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

of farmers having no formal education in Noroki. Mmakgabeltwane had the highest percentage of farmers with primary education (31%), while Lebalangwa had the highest percentage with high school education (25%). Swartdam had the highest percentage of farmers with post-matric education (63%). Most farmers in all four areas had less than five years of farming experience.

TABLE 1: Demographic Information of the Farmers

Demographics				
Area	**Lebalangwa**	**Mmakgabetlwane**	**Noroki**	**Swartdam**
Gender/area (%)				
Female	38	46	38	37
Male	62	54	62	63
Education level (%)	**Lebalangwa**	**Mmakgabetlwane**	**Noroki**	**Swartdam**
No-formal Educ	8.0	4.0	14	3.0
Primary	21	31	10	23
High school	25	12	19	11
Post matric	46	54	57	63
Years of experience	**Lebalangwa**	**Mmakgabetlwane**	**Noroki**	**Swartdam**
< 5 years	46	46	43	31
6-10 years	29	27	33	37
11-20 years	8.0	12	14	29
> 20 years	17	15	10	3.0

TABLE 2: Livestock Production Types Among Farmers on Rangeland

Variables	**Frequency (*n*=106)**	**Percentage (%)**
Type of livestock owned		
Large stock	24	23
Mixed livestock (large and small stock)	54	51

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

Small stock	28	26

n=number; %=percentage

The most common livestock production system was mixed livestock, with 51%. The second most common livestock production system was small stock (26%), followed by large stock (23%).

Table 3 outlines the livestock farmers' understanding of rangeland farming practices. This study shows a high level of variation in the perception of overgrazing in communal lands among livestock farmers. This is reflected in Mmakgabetlwane, of which most respondents (85%) believe that communal grazing lands are overgrazed. In comparison, several respondents (4%) believe they are not overgrazed, and some (12%) are unsure.

TABLE 3: The Livestock Farmers' Perspective on Rangeland Practices

Variables (%)					
Communal lands are overgrazed by livestock.	**Yes**	**No**	**Not sure**		
Area					
Lebalangwa (*n*=24)	79	13	8.0		
Mmakgabetlwane (*n*=26)	85	4.0	12		
Noroki (*n*=21)	76	19	5.0		
Swartdam (*n*=35)	80	9.0	11		
Animals graze according to the grazing plan.					
Lebalangwa (*n*=24)	21	71	8.0		
Mmakgabetlwane (*n*=26)	8.0	50	42		
Noroki (*n*=21)	14	52	33		
Swartdam (*n*=35)	20	66	14		
Reasons for the mobility of livestock from one area to the other	**Pasture**	**Pasture + water**	**Water**	**Because others are doing it**	**Other**
Lebalangwa (*n*=24)	8.0	42	42	4.0	4.0

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

Mmakgabetlwane (*n*=26)	4.0	31	46	15	-
Noroki (*n*=21)	5.0	33	52	10	-
Swartdam (*n*=35)	3.0	37	51	6.0	3.0

Type of grazing system	**Rotational grazing**	**Seasonal grazing**	**Other**	**Not sure**
Lebalangwa (*n*=24)	42	33	-	25
Mmakgabetlwane (*n*=26)	35	31	-	35
Noroki (*n*=21)	38	19	5.0	38
Swartdam (*n*=35)	60	23	-	17

Plants have adequate time to recover.	**Yes**	**No**	**Not sure**
Lebalangwa (*n*=24)	21	33	46
Mmakgabetlwane (*n*=26)	12	31	58
Noroki (*n*=21)	19	29	52
Swartdam (*n*=35)	20	40	40

n=number; %=percentage

The study found that the Lebalangwa farmers (71%) do not have a rangeland management plan, while only several (21%) believe that they do, and some (8%) are not sure. In contrast, Swartdam has the highest level of compliance with grazing plans, with several respondents (20%) indicating that animals graze according to grazing plans.

Pasture and water are the most common reasons for livestock mobility by livestock farmers in all researched sites. The majority of livestock owners by farmers in Lebalangwa (42%) cited pasture and water as the reason for their animals' mobility, followed by some (37%) in Swartdam, others (33%) in Noroki, and the least (31%) in Mmakgabetlwane.

The reason for livestock movements from area to area is common in all four villages, with better pasture being the most common reason for animals to move. In Lebalangwa, the majority of the livestock owners (8%) cited pasture and water as the reason for livestock mobility, followed by some (5%) in Noroki, others (4%) in Mmakgabetlwane and the least (3%) in Swartdam.

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

The majority of the farmers indicated livestock mobility is a common practice in the area, with the majority of livestock farmers in Mmakgabetlwane (15%), followed by some (10%) in Noroki, others in Swartdam (6%) and the least in Lebalangwa (4%) using this system. The decision to move livestock, because others are doing it, has shown to be a relatively rare reason for livestock mobility, with a percentage of (4%) in Lebalangwa and Swartdam (3%) only livestock farmers.

The majority of farmers in all the research sites, Mmakgabetlwane (58%), Noroki (52%), Lebalangwa (46%) and Swartdam (40%), indicated not being sure about the recovery time of natural plants.

4. DISCUSSIONS

Results from this current study are in line with those of Letsoalo (2019), Mapiliyao *et al*. (2019) and Letsoalo *et al*. (2023), who reported male participation dominance in agricultural activities. A study conducted by Adedeji *et al*. (2013) and Obayelu *et al*. (2020) in Nigeria further noted that men had a higher proportion than women in agriculture. Charles (2014) suggests that this difference in gender distribution may be due to the different roles that men and women play in traditional agriculture in these areas. For example, in Tunisia, women often experience additional challenges due to gender norms and cultural practices, which exclude them from agri-training, rangeland governance, and owning land on par with men (Najjar, 2020). Gcumisa *et al*. (2016) reported that men generally owned cattle, goats and sheep.

Regarding education, our results are similar to those of Letsoalo (2019), who found that most farmers in Gauteng Province had formal education. Educated farmers are more likely to adopt sustainable rangeland management practices are significant because they suggest that education can be an effective tool for improving rangeland health.

Mixed livestock was the most common livestock production system in this study; these results agree with Martin *et al*. (2020) and Rowntree *et al*. (2020), who found that multi-species livestock farming can enhance the sustainability of livestock farming systems. Moreover, it is essential to properly integrate different livestock species and manage pasture and livestock enterprises effectively.

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

The second most common livestock production system in this study was small stock; a similar trend was reflected by Rinehart (2018). The study conducted by Rinehart (2018) shows that mixed grazing (cattle and sheep) improves productivity by 20 to 25% and carrying capacity. Additionally, goats, which are browsers, are used to control woody plants and use biologically efficient agents (O'Connor *et al*., 2014; Hare *et al*., 2020). Moreover, sheep can help prevent parasite populations and improve pasture quality (Kumar *et al*., 2013; Dettenmaier *et al*., 2017).

The least common livestock kept by farmers was large stock. A similar trend is reflected in Mapiye *et al*. (2018) findings that beef cattle production is a crucial and multipurpose survival practice in rural areas, particularly in remote and distant places with degraded lands and few socioeconomic possibilities. This may be due to the recent trend towards smaller-scale livestock farming. Multi-species livestock farming and the movement of livestock can benefit sustainability. Still, it is important to carefully consider the factors influencing the decision to adopt these practices.

Ravhuhali's (2018) work reports findings consistent with this study, which found that large portions of the communal grazing areas in the North West Province rangelands are not effectively managed. Bolo *et al*. (2019) and Kellner *et al*. (2021) also indicated that excessive grazing by domestic livestock leads to overgrazing because of overcrowding and unmanaged grazing, which can lead to the degradation of rangelands. This suggests that overstocking and overgrazing are widespread problems in these areas. However, most farmers indicated that they have a rangeland management plan. This is likely because some farmers have 11-20 years of experience, which has given them a better understanding of the importance of grazing plans and how to implement them effectively.

The results of this study are consistent with the findings of Behnke (2018), Turner and Schlecht (2019), and Owen-Smith *et al*. (2020), who asserted that grazers do not follow a fixed pattern of movement but rather move opportunistically in search of food and water. This is because livestock must graze on fresh grass for daily nutritional needs. The area will become overgrazed if the grazing pressure is too high due to overstocking.

Water was also an important factor in the decision to move livestock. The results of this study are consistent with the findings of Franke and Kotzé (2022) and Fust (2022), who found that the behaviour of grazers does not follow a fixed pattern and is mainly opportunistic, driven by

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

the availability of water, linked to highly variable precipitation in the semi-arid to arid regions of the savannahs and grasslands. This indicates that some livestock farmers may sometimes decide where to move their livestock based on what other farmers are doing. This can be a way to ensure that livestock have access to good grazing and water, but it can also lead to overgrazing and other environmental problems.

This type of grazing system is where livestock is moved to different pastures regularly, allowing the pasture time to recover and prevent overgrazing. However, these results contradict the point made by Kellner *et al*. (2021), which stated that reducing grazing pressure by grazing exclusion is difficult in rural areas that are managed communally. Moreover, on this note, Angassa (2014), Reid *et al*. (2018) and Mcdonald *et al*. (2018) warned that continuous grazing practice reduces biodiversity and ecosystem functions, promoting bush encroachment.

Lamidi and Ologbose (2014) found that the availability of natural pasture varies seasonally in Nigeria, with a peak in the rainy season (May–November) and a decline in the dry season (November–April). The rainy-season pasture is more succulent, highly nutritious, and abundant, while the dry-season pasture is fibrous, scarce, and devoid of essential nutrients. Rotational grazing is the most effective grazing system for preventing overgrazing and promoting biodiversity in communally managed grazing lands. This is because rotational grazing allows the pasture to recover and regenerate while providing livestock access to fresh grass and water. These findings provide a better understanding of the challenges of managing communal lands and the impact of overgrazing on rangeland management practices.

5. CONCLUSIONS

This study investigated rangeland management practices and perceptions among communal livestock farmers in the Moretele Local Municipality, South Africa. The findings highlight a critical need for interventions to address rangeland degradation and promote sustainable rangeland management.

Our results revealed a disconnect between farmer perceptions and the potential severity of rangeland degradation. The limited experience and knowledge of sustainable practices among farmers, particularly regarding rotational grazing effectiveness and plant recovery times, suggests a crucial role for educational programs. Furthermore, the dominance of opportunistic livestock movement due to dependence on readily available pasture and water sources

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

underscores the need for improved grazing plans considering stocking rates and carrying capacity. Additionally, collaborative management strategies involving farmers, government agencies, and research institutions hold promise for knowledge sharing and fostering sustainable practices.

By implementing the proposed interventions, including educational programs, community-based grazing plans, improved water access infrastructure, and collaborative management initiatives, this study paves the way for improved rangeland management in Moretele. These interventions have the potential to enhance livestock production, conserve vital ecosystems, and ensure the long-term sustainability of these rangelands for future generations.

Further research is warranted to delve deeper into the specific causes of overgrazing in Moretele. Additionally, evaluating the effectiveness of different grazing management strategies in communal settings is crucial for optimising rangeland utilisation. Finally, developing culturally appropriate methods for disseminating knowledge on sustainable rangeland management practices among communal farmers is essential for long-term success. This study provides a valuable foundation for understanding Moretele's rangeland management practices and perceptions. By addressing the identified knowledge gaps and implementing the proposed interventions, along with the suggested areas for future research, we can contribute significantly to the sustainable management and conservation of these critical ecosystems.

6. ACKNOWLEDGEMENT

The authors would like to sincerely thank Moretele, North West Province's livestock farmers, for sharing their valuable perspectives on rangeland management practices. Their insights were essential to the development of this research.

The authors would also like to thank the Department of Agriculture, Land Reform, and Rural Development for providing financial and logistical support for this study. This support made it possible to conduct the research promptly and efficiently.

Finally, the authors would like to thank colleagues for their assistance with data analysis. Their expertise was invaluable in ensuring the accuracy and reliability of the results.

https://doi.org/10.17159/2413-3221/2024/v52n4a17160

REFERENCES

ADEDEJI, O.S., AKANDE, T.O., AKINWUMI, A.O., OKUNLOLA, D.O. & SHITTU, M.D., 2013. Ethnoveterinary practices among sheep rearers in Ona-Ara Local Government of Oyo state, Nigeria. *Sokoto J. Vet. Sci.*, 11(1): 38-44.

ANGASSA, A., 2014. Effects of grazing intensity and bush encroachment on herbaceous species and rangeland condition in southern Ethiopia. *Land Degrad Dev.*, 25(5): 438-451.

BALOYI, T.P.M., 2023. Communal-based strategies for bush encroachment management in a savannah rangeland in Mafarana village in the Greater Tzaneen Local Municipality of Limpopo Province, South Africa. Doctoral dissertation. Cape Peninsula University of Technology.

BEHNKE, R., 2018. Open access and the sovereign commons: A political ecology of pastoral land tenure. *Land Use Policy.*, 76: 708-718.

BELAYNEH, A. & TESSEMA, Z.K., 2017. Mechanisms of bush encroachment and its inter-connection with rangeland degradation in semi-arid African ecosystems: A review. *J. Arid Land*., 9: 299-312.

BEYENE, S.T., MLISA, L. & GXASHEKA, M., 2014. Local perceptions of livestock husbandry and rangeland degradation in the highlands of South Africa: Implication for development interventions. *J Hum Ecol.*, 47(3): 257-268.

BOLO, P.O., SOMMER, R., KIHARA, J.M., KINYUA, M., NYAWIRA, S. & NOTENBAERT, A.M.O., 2019. *Rangeland degradation: Causes, consequences, monitoring techniques and remedies. Working Paper. CIAT Publication No. 478*. Nairobi, Kenya: International Center for Tropical Agriculture (CIAT).

CAI, Y., YAN, Y., XU, D., XU, X., WANG, C., WANG, X., CHEN, J., XIN, X. & ELDRIDGE, D.J., 2020. The fertile island effect collapses under extreme overgrazing: Evidence from a shrub-encroached grassland. *Plant. Soil*., 448: 201-212.

CHARLES, B., 2014. Assessment of the youth in agriculture programme in Ejura-Sekyedumase District. Master's thesis. Kwame Nkrumah University of Science and Technology, Ghana.

DETTENMAIER, S.J., MESSMER, T.A., HOVICK, T.J. & DAHLGREN, D.K., 2017. Effects of livestock grazing on rangeland biodiversity: a meta-analysis of grouse populations. *Ecology & Evolution*., 7(19): 7620-7627.

DIOGO, R.V.C., DOSSA, L.H., VANVANHOSSOU, S.F.U., ABDOULAYE, B.D., DOSSEH, K.H., HOUINATO, M., SCHLECHT, E. & BUERKERT, A., 2021. Farmers' and herders' perceptions on rangeland management in two agroecological zones of Benin. *Land*., 10(4): 425.

FINCA, A., LINNANE, S., SLINGER, J., GETTY, D. & IGSHAAN SAMUELS, M., 2023. Implications of the breakdown in the indigenous knowledge system for rangeland management and policy: A case study from the Eastern Cape in South Africa. *Afr. J. Range Forage Sci.*, 40(1): 47-61.

FRANKE, A.C. & KOTZÉ, E., 2022. High-density grazing in southern Africa: Inspiration by nature leads to conservation?. *Outlook on Agric*., 51(1): 67-74.

FUST, P., 2022. *Grazing effects and resource use by large herbivores in arid and semi-arid rangelands: Advancements of analysis through high resolution spatio-temporally dynamic modelling*. BoD–Books on Demand.

HARE, M.L., XU, X., WANG, Y. & GEDDA, A.I., 2020. The effects of bush control methods on encroaching woody plants in terms of die-off and survival in Borana rangelands, southern Ethiopia. *Pastoralism*., 10(1): 1-14.

KASSAHUN, A., SNYMAN, H.A. & SMIT, G.N., 2008. Impact of rangeland degradation on the pastoral production systems, livelihoods and perceptions of the Somali pastoralists in Eastern Ethiopia. *J. Arid Environ*., 72(7): 1265-1281.

KELLNER, K., MANGANI, R.T., SEBITLOANE, T.J., CHIRIMA, J.G., MEYER, N., COETZEE, H.C., MALAN, P.W. & KOCH, J., 2021. Restoration after bush control in

selected range-land areas of semi-arid savannas in South Africa. *Bothalia-Afr. Biodiv. Conser.*, 51(1): 1-13.

KUMAR, N., RAO, T.K.S., VARGHESE, A. & RATHOR, V.S., 2013. Internal parasite management in grazing livestock. *J. Parasitic Dis.*, 37(2): 151-157.

LAMIDI, A.A. & OLOGBOSE, F.I., 2014. Dry season feeds and feeding: A threat to sustainable ruminant animal production in Nigeria. *J. Agric. Soc. Res.,* 14(1): 17-30.

LETSOALO, S., KRECEK, R., BOTHA, C. & NGETU, X., 2000. Animal husbandry in Moretele 1 of North-West Province: Implications for veterinary training and research. *J S Afr Vet Assoc*., 71(2): 92-96.

LETSOALO, N.L., 2019. Rangeland management practices among emerging livestock farmers in Gauteng province, South Africa. Masters dissertation. University of South Africa.

LETSOALO, N., SAMUELS, I., CUPIDO, C., NTOMBELA, K., FINCA, A., FOSTER, J., TJELELE, J. & KNIGHT, R., 2023. Coping and adapting to drought in semi-arid Karoo rangelands: Key lessons from livestock farmers. *J. Arid Environ.,* 219: 105070.

MANGANI, R.T., 2021. Restoration after bush control and impact on ecosystem services in the Lephalale municipality, Limpopo Province. Doctoral dissertation. North-West University, South Africa.

MANI, S., OSBORNE, C.P. & CLEAVER, F., 2021. Land degradation in South Africa: Justice and climate change in tension. *People & Nature*., 3(5): 978-989.

MAPHANGA, T., DUBE, T., SHOKO, C. & SIBANDA, M., 2022. Advancements in the satellite sensing of the impacts of climate and variability on bush encroachment in savannah rangelands. *Remote Sens. Appl.: Soc. Environ*., 25: 100689.

MAPILIYAO, L., PEPE, D., CHIRUKA, R., MARUME, U. & MUCHENJE, V., 2013. Production practices and constraints to sheep productivity in two ecologically different and resource-poor communal farming systems of South Africa. *Sci. Res. Essays*., 7: 3209-3217.

MAPIYE, O., MAKOMBE, G., MAPIYE, C. & DZAMA, K., 2018. Limitations and prospects of improving beef cattle production in the smallholder sector: A case of Limpopo Province, South Africa. *Trop. Anim. Health Prod*., 50: 1711-1725.

MARQUART, A., ELDRIDGE, D.J., GEISSLER, K., LOBAS, C. & BLAUM, N., 2020. Interconnected effects of shrubs, invertebrate-derived macropores and soil texture on water infiltration in a semi-arid savanna rangeland. *Land Degrad Dev*., 31(16): 2307-2318.

MARQUART, A., VAN COLLER, H., VAN STADEN, N. & KELLNER, K., 2023. Impacts of selective bush control on herbaceous diversity in wildlife and cattle land use areas in a semi-arid Kalahari savanna. *J. Arid Environ.*, 208: 104881.

MARTIN, G., BARTH, K., BENOIT, M., BROCK, C., DESTRUEL, M., DUMONT, B., GRILLOT, M., HÜBNER, S., MAGNE, M.A., MOERMAN, M. & MOSNIER, C., 2020. Potential of multi-species livestock farming to improve the sustainability of livestock farms: A review. *Agric. Sys.*, 181: 102821.

MCDONALD, S.E., REID, N., WATERS, C.M., SMITH, R. & HUNTER, J., 2018. Improving ground cover and landscape function in a semi-arid rangeland through alternative grazing management. *Agric. Ecosyst. Environ*., 268: 8-14.

MPHINYANE, N.W. & OMPHILE, U.J., 2016. Influence of policy on the transformation of range management from traditional management: A perspective of the history of range management in Botswana. *Botsw. J. Agric. Appl. Sci*., 11(1): 20-28.

MUCINA, L. & RUTHERFORD, M.C., 2006. *The vegetation of South Africa, Lesotho and Swaziland*. Pretoria: South African National Biodiversity Institute.

NAJJAR, D., 2023. *Women's contribution to rangeland cultivation: A policy blind spot*. Available from: https://www.icarda.org/media/blog/womens-contribution-rangeland-cultivation-policy-blind-spot?utm_source=European+GDPR+law&utm_campaign=02af1500cf-Desertification+and+Drought+Day+2023&utm_medium=email&utm_term=0_-9783f31595-%5BLIST_EMAIL_ID%5D

OBAYELU, A.E., OGBE, A.O. & EDEWOR, S.E., 2020. Gender gaps and female labour participation in agriculture in Nigeria. *Afr. J. Econ. Manag. Stud*., 11(2): 285-300.

O'CONNOR, T.G., PUTTICK, J.R. & HOFFMAN, M.T., 2014. Bush encroachment in southern Africa: Changes and causes. *Afr. J. Range Forage Sci*., 31: 67-88.

O'CONNOR, T.G. & VAN WILGEN, B.W., 2020. The impact of invasive alien plants on rangelands in South Africa. *Biological Invasions SA*., 14: 459-487.

OWEN-SMITH, N., HOPCRAFT, G., MORRISON, T., CHAMAILLÉ-JAMMES, S., HETEM, R., BENNITT, E. & VAN LANGEVELDE, F., 2020. Movement ecology of large herbivores in African savannas: current knowledge and gaps. *Mammal Review*., 50(3): 252-266.

RAVHUHALI, K.E., 2018. Spatial variation in density, species composition and nutritive value of vegetation in selected communal areas of the North West province. Doctoral dissertation. North-West University, South Africa.

REED, M.S., STRINGER, L.C., DOUGILL, A.J., PERKINS, J.S., ATLHOPHENG, J.R., MULALE, K. & FAVRETTO, N., 2015. Reorienting land degradation towards sustainable land management: Linking sustainable livelihoods with ecosystem services in rangeland systems. *J Environ Manage*., 151: 472-485.

REID, H., BOURNE, A., MULLER, H., PODVIN, K., SCORGIE, S. & ORINDI, V., 2018. A framework for assessing the effectiveness of ecosystem-based approaches to adaptation. In Z. Zommers & K. Alverson (eds.), *Resilience*. Elsevier, pp. 207-216.

RINEHART, L., 2018. *Multi-species Grazing: A Primer on Diversity*. Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://attradev.ncat.org/wp-content/uploads/2022/06/multispeciesgrazing.pdf

ROWNTREE, J.E., STANLEY, P.L., MACIEL, I.C., THORBECKE, M., ROSENZWEIG, S.T., HANCOCK, D.W., GUZMAN, A. & RAVEN, M.R., 2020. Ecosystem impacts and productive capacity of a multi-species pastured livestock system. *Front. Sustain. Food Syst*., 4: 544984.

SANDHAGE-HOFMANN, A., KOTZÉ, E., VAN DELDEN, L., DOMINIAK, M., FOUCHÉ, H.J., VAN DER WESTHUIZEN, H.C., OOMEN, R.J., DU PREEZ, C.C. & AMELUNG, W., 2015. Rangeland management effects on soil properties in the savanna biome, South Africa: A case study along grazing gradients in communal and commercial farms. *J. Arid Environ.,* 120: 14-25.

SELEMANI, I.S., 2014. Communal rangelands management and challenges underpinning pastoral mobility in Tanzania: a review. *Livestock Res Rural Dev*., 26(5): 1-15.

TURNER, M.D. & SCHLECHT, E., 2019. Livestock mobility in sub-Saharan Africa: A critical review. *Pastoralism*., 9(1): 1-15.

YOUSEFI, S., POURGHASEMI, H.R., AVAND, M., JANIZADEH, S., TAVANGAR, S. & SANTOSH, M., 2021. Assessment of land degradation using machine-learning techniques: A case of declining rangelands. *Land Degrad Dev.*, 32(3): 1452-1466.

ZERGA, B., 2015. Rangeland degradation and restoration: A global perspective. *Point J. Agric. Biotechn. Res*., 1(2): 37-54.

S. Afr. J. Agric. Ext. Gwala, Yusuf, Loki, Bontsa, Mdiya & Rani
Vol. 52 No. 4, 2024: 83-96
https://doi.org/10.17159/2413-3221/2024/v52n4a18365

Perceptions of Communal Farmers on Extension Support Services Accessibility in the Port St Johns, Eastern Cape Province

Gwala, L.[1], Yusuf, F.S.G.[2], Loki, O.[3], Bontsa, N.V.[4], Mdiya, L.[5] and Rani, Z.T.[6]

Corresponding Author: L. Gwala. Correspondence Email: Lgwala@ufh.ac.za

ABSTRACT

Communal farming is mainly practised in most rural areas of South Africa, and agricultural production plays a significant part in rural livelihoods. Lack of access to adequate resources has led to high vulnerability. Farmers' understanding, awareness, and experience of extension services are important. Extension services are vital in supporting farmers in acquiring information, gaining knowledge and skills, and engaging in agricultural production to solve farming-related problems. Therefore, the paper seeks to determine farmers' perceptions of extension services accessed. The study used a cross-sectional research design to collect data using a 5-Likert scale questionnaire. A snowball sampling method was used to select 115 communal farmers from Ntsimbini village in Port St Johns Local Municipality. Descriptive statistics and principal component analysis were used to analyse the collected data. The study's findings revealed that production challenges associated with limited access to support services affect crop and livestock production. Findings on farmers' perceptions revealed poor access to production inputs and infrastructural support. Therefore, extension services accessibility

[1] Senior Lecturer, Department of Agricultural Economics and Extension, Faculty of Science and Agriculture University of Fort Hare, Alice, South Africa. Email: gwala@ufh.ac.za ORCID: 0000-0002-0186-050X

[2] Lecturer, Department of Agricultural Economics and Extension, Faculty of Science and Agriculture University of Fort Hare, Alice, South Africa. Email: 4layusuf@gmail.com ORCID: 0000-0002-4156-1221

[3] Lecturer, Department of Agricultural Economics Extension and Rural Development, University of Pretoria, Pretoria, South Africa. Email: o.loki@up.ac.za ORCID: 0000-0003-4187-3345

[4] Lecturer, Department of Agricultural Economics and Extension, Faculty of Science and Agriculture University of Fort Hare, Alice, South Africa. Email: nbontsa@ufh.ac.za ORCID: 0000-0002-6320-4559

[5] Lecturer, Department of Sustainable Food Systems and Development, Faculty of Natural Sciences and Agriculture University of the Free State, South Africa. Email: MdiyaL@ufs.ac.za ORCID: 0000-0002-2207-9261

[6] Lecturer, Animal and Poultry Science, School of Agriculture, Earth and Environmental Science University of Kwa-Zulu Natal, Pietermaritzburg, South Africa. Email: RaniZ@ukzn.ac.za ORCID: 0000-0002-5118-3658

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

affects production inputs and infrastructural support. The study recommends that access and use of extension support services be improved through communication strategies conducive to all stakeholders involved in communal farming, as this will help improve access to support services for farmers.

Keywords: Access and Use of Support Material, Communication Strategies, Infrastructure, Perceptions

1. INTRODUCTION

In the Eastern Cape Province of South Africa, the communal farming system comprises villages with residential areas, cropping and grazing areas, and grazing lands shared by different livestock (Goni et al., 2018). Most farmers keep indigenous animals because of their potential adaptability to the local environment (Mthi et al., 2017). Communal livestock farming provides great potential for job creation, food producers, and income generation and continues to be an essential rural livelihood source in the province (Taruvinga et al., 2022; Duncan et al., 2020; Mmbengwa et al., 2015; Yitayew et al., 2013; FAO, 2009; Miao et al., 2005). However, the practice of crop-livestock farming in South Africa is susceptible to climate-related events, income fluctuation, social-related shocks, overgrazing, poor infrastructure, water scarcity, low productivity, diseases, limited access to information, poor adaptive capacity and limited extension services (Debie & Ayele, 2023; Gwala et al., 2022; Hajdu et al., 2020; Oduniyi et al., 2020). Access to extension services is important because it provides farmers with information on farming techniques, raises their awareness of several challenges and changing climate conditions, and also helps them learn about management practices that can help sustain agricultural production (Bontsa et al., 2023; Loki, Aliber, & Sikwela, 2021; Gwala et al., 2016). However, "addressing rural farmers' challenges often ignores farmers' perceptions and experiences (Chambers, 1988; Francis & Sibanda, 2001).

Perception is how organisms interpret and organise sensations to produce a meaningful experience (Lindsay & Norman, 1977; Ndamani & Watanabe, 2015; Pickens, 2005). Understanding smallholder farmers' perceptions of extension services could be vital for a better understanding the strategies that would be most effective in reducing challenges faced in agricultural production (Popoola et al., 2019). Perception is influenced and shaped by, among other things, the characteristics of the person, their experiences, the information they receive,

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

and the cultural and geographical context in which they live (Van der Linden, 2015; Whitmarsh & Capstick, 2018). Farmers' susceptibility to challenges and uncertainties is sometimes intensified by a lack of knowledge and poor access to information (Mittal & Mehar, 2012). Akpotosu et al. (2017) and Jones et al. (2023) argued that the timely availability of relevant information is critical in agricultural enterprises to facilitate successful learning and social change. Understanding farmers' perceptions can help identify potential barriers to access support services and develop strategies or awareness design programs to address farmers' specific concerns. There is a need for extension support services aimed at addressing challenges associated with crop-livestock farming practices to enhance farmers' knowledge and access to support services and improve production (Gwala et al., 2022). Hence, this study aims to determine communal farmer's perceptions of extension services accessed.

2. STUDY METHODOLOGY

2.1. Study Site

The study was conducted in Port St. Johns (PSJ), a local municipality in the Eastern Cape Province of South Africa. Two communities, Thombo and Ntsimbini, were selected. The population size of farming households is 18190 (Stats SA, 2011). The household head is a sampling unit in this study because the household head is solely responsible for most socioeconomic activities and significant decisions (Ahmad, 2023). The communities were selected because most households practise farming, so access to extension services is vital. PSJ Local Municipality has a moderate, humid, and subtropical coastal climate. The climate is ideal for growing vegetables during summer and winter. Temperatures in the area vary from a maximum of 25 degrees Celsius in summer to a minimum of 20 degrees Celsius in winter.

In comparison, the maximum is 21 degrees Celsius, and the minimum is 8 degrees Celsius (Kambanje et al., 2018). Rainfall is received mainly in summer, from October to March. Port St. Johns gets between 1100 and 1400 ml of rain annually. The area generally experiences favourable weather conditions, but droughts and floods occur occasionally, although not frequently (Obi & Maya, 2021).

2.2. Research Approach

The study aimed to determine the quality of extension services accessed by communal livestock farmers using quantitative research methods. The sample size was calculated using Yamane's

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

formula n= $N/(1+N(e)^2$ i.e. n= 18190/1+18190 (0.05) ^{2}= 395. Based on the willingness and availability of household heads during the study, a cross-sectional survey of 115 farmers was attained using the snowball sampling technique.

A Likert scale questionnaire was developed (based on a review of the relevant literature on extension support services) comprising 18 statements to which respondents had to agree or disagree. Statements covered the farmers' perceptions on 1) production inputs, infrastructural support and challenges; 2) quality and relevance of the support material; and 3) communication strategies between stakeholders. The Likert scale questions allowed for responses that varied from strongly disagree (5), disagree (4), don't know (3), agree (2) to strongly agree (1). Total and mean perception scores were computed for each support item, after which a cut-off mean score of 3.5 [(5+4+3+2+1) /5+0.5)] was used to differentiate between the various levels of perceptions (support services provided to farmers, quality and relevance of the support material, communication strategies of accessing support service) for the farmers. A rating of ≥1.5 indicated ineffective extension support services and poor access, while <1.5 indicated effective extension support services and good access. The content and face validity of the questionnaire were also calculated. The Cronbach's alpha reliability coefficient was 0.82. Descriptive statistical analysis was done, while an exploratory Principal Component Analysis (PCA) (Orthogonal rotation technique) was performed on the data collected for the communal farmers, using SPSS version 2 (2021).

3. RESULTS AND DISCUSSION

3.1. Demographics

The demographic characteristics of communal livestock farmers revealed that more males (68.7%) were involved in communal farming than females and that 47.8% were between 60-69 years old. About 39.1% of the respondents had primary school as their highest level of education. A significant number (54.8%) of respondents were married. Only 5% of farmers were between 30 and 39 years old. The results show that communal farming was popular amongst elderly male farmers compared to female and youth farmers. As shown in the table, the majority (88.7%) of the respondents had up to five occupants per household. This showed that some household members would likely provide family labour for crop and livestock farming.

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

TABLE 1: Characteristics of Survey Respondents (n=115)

Attribute	Category	Frequency	Percentage
Gender	Male	79	68.7
	Female	36	31.3
Age	30-39	5	4.3
	40-49	16	13.9
	50-59	20	17.3
	60-69	55	47.8
	70-79	10	8.6
	80-89	9	7.8
Marital status	Single	33	28.7
	Married	63	54.8
	Divorced	3	2.6
	Widowed	16	13.9
Highest level of education	No formal education	28	24.3
	Primary	45	39.1
	Secondary	33	28.7
	Tertiary	9	7.8
Household size	1-5	102	88.7
	6-10	13	11.3

3.2. Communication and Advisory Services

Farmers obtained information from different sources through several channels. Research results in Table 2 reveal that 55.6% of farmers received information from other farmers, and 18.2% indicated that they received information from extension officers. After other farmers, media was most frequently used as an information source (26.2% of farmers). Only 10.4% of farmers indicated receiving information from community meetings, and most (58.6%) highlighted media as the common communication channel. Only 8.7% and 7.8% of farmers received dip and vaccines, respectively.

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

Additionally, 14.8% and 11.3% of farmers received water and fodder support services during drought seasons. Such support services were reported to assist farmers in coping with drought and low feed. However, the services are accessed quarterly. The latter affects agricultural production as the crop and livestock produce will be at its lowest status. The majority (57.4%) of farmers reported that they did not receive any advisory support services. These findings imply that farmers/neighbours were the study area's primary information source. This could be because farmers in the community used the local language to share information (Bontsa et al., 2023). Unlike media, where information might be communicated in a foreign language, using a one-way communication approach could result in information distortion given the level of education of most farmers in the study.

TABLE 2: Communication and Advisory Support Services

Communication, advisory support services and frequency	**Frequency**	**Percentage**
Sources of information		
Community/ other farmers	64	55.6
Extension officers	21	18.2
Media	30	26.1
Communication channel		
Media	67	58.3
Field visit	22	19.1
Meetings	12	10.4
Phone call	14	12.2
Type of advisory support services		
Dip	10	8.7
Vaccines	9	7.8
Water	17	14.8
Fodder feed	13	11.3
No support services	66	57.4

3.3. Quality of Extension Services

About 19% and 9% of farmers rated extension services as good, moderate quality and relevant to the farming practices. However, the majority (28%) of farmers from those who indicated

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

access to extension services (Table 3) reported poor quality and irrelevance of extension services. Advisory support services (fodder, water and dip) are provided quarterly; by that time, most crops had been lost, and there had been more livestock deaths. Timely and frequent provision of support services to farmers before production losses is important to prevent various challenges. A study by Bontsa et al. (2023) also identified the extension advisory services accessed by farmers in rural areas as being non-helpful and of poor quality.

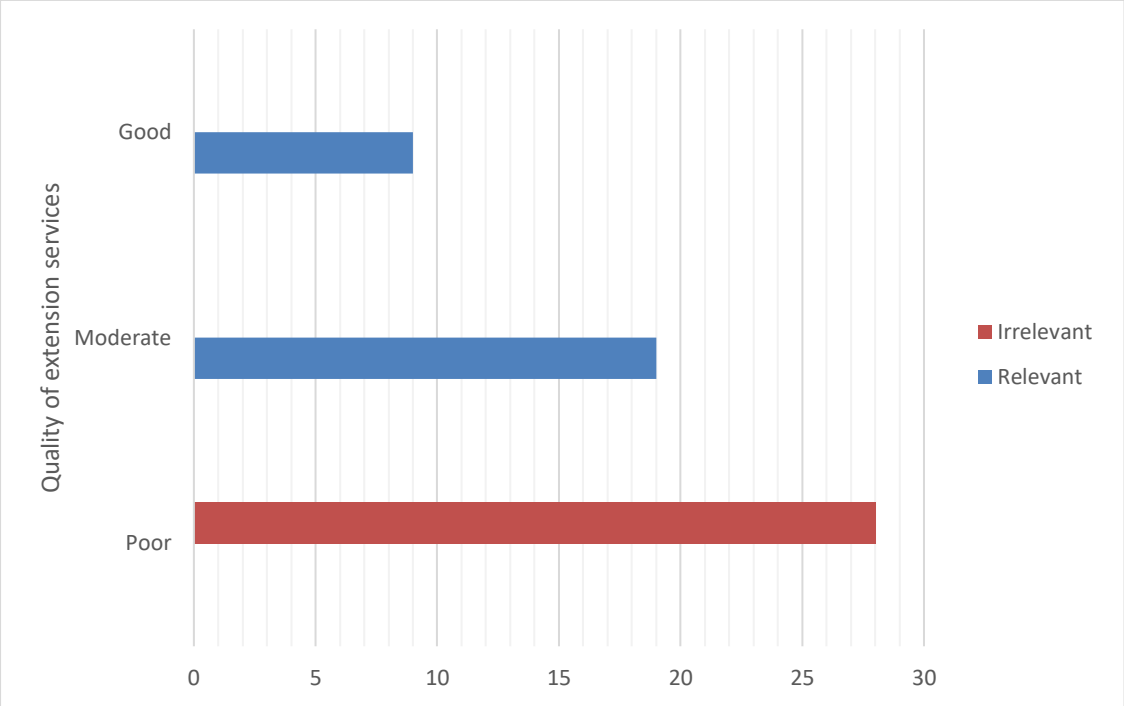

FIGURE 1: Quality and Relevance of Extension Support Services

3.4. Perceptions of Farmers on Production Inputs, Infrastructural Support and Challenges

The study assessed the perceptions of communal farmers regarding accessing support services and production challenges in the study area. Seven variable factors were analysed (see Table 3); all the variables yielded a result of <1.5. The findings confirm poor infrastructure and limited and inadequate access to support services.

3.5. Perceptions of Communication Strategies for Providing Support Services

Table 4 presents communication strategies used when providing the support services. Results on: The procedure for communicating with extension advisors was spelt out clearly to farmers in training; there are massive education and training workshops by the government for communal farmers on farm management, farmers field workshops to ensure that they are

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

registered on the government database so that they benefit and be updated on relevant information, establishment of relevant association that assists with information sharing, yielded a result of more than 1.5. All other variables were below 1.52. The findings indicate inadequate or poor use of relevant communication strategies (workshops, training, farmer's field visits and consultations) to provide and/or access extension services.

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

TABLE 3: Perceptions of the Farmers on Production Inputs, Infrastructural Support and Challenges (n=115)

Support material	SA	A	NE	D	SD	%	Mean scores	Std Dev.
Farmers were encouraged to keep fodder banks and crop residues for animal feed	8	9	36	22	39	100	1.52	.261
Farmers were only supported with poor attention to crop-livestock production	3	59	309	13	4	100	0.53*	.173
Support services (feed, water, fertiliser, seedlings, dip, medication, machinery) were inadequate	0	5	18	32	60	100	0.49*	.311
Inadequate actions were taken to reduce poor information access, water services, tertiary services	41	54	264	18	11	100	0.92*	.268
There was poor infrastructure for farming practices to take place	64	27	10	10	3	100	0.52*	.369
Limited training of farmers by department officials on farming techniques	56	31	17	5	6	100	0.69*	.236
Poor development of farmers' skills in the identification of crop deficiencies and livestock diseases	95	15	5	0	0	100	0.43*	.224

Strongly Agree (SA), Agree (A), Neutral (NE), Disagree (D), Strongly Disagree (SD)

- * = Significant if the mean score is <3.5.

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

TABLE 4: Perceptions of Communication Strategies for Providing Support Services

Perceptions	**SA**	**A**	**NE**	**D**	**SD**	**%**	**Mean scores**	**Std Dev.**
There is massive education and training workshops by the government for communal farmers on farm management	5	9	3	29	69	100	1.51	0.345
The procedure for communicating with extension advisors was spelled out clearly to farmers in training	3	11	3	19	79	100	1.52	.289
Government focuses only on large-scale farmers	0	0	111	2	8	100	0.47*	.261
Limited training of farmers on the use and interpretation of information during field days	61	32	13	5	4	100	0.47*	.231
There was a lack of training for crop-livestock farmers on how to keep fodder banks and conserve crop residues as animal feed and how to store seeds for the next growing season	70	30	7	3	5	100	0.45*	.209
Farmers field workshops to ensure that they are registered on the government database so that they benefit and be updated on relevant information	3	6	15	12	79	100	1.50	.286
Establishment of a relevant association that assists with information sharing	3	3	9	39	62	100	1.53	.239
Farmers receive relevant information about their farming practices through meetings	0	1	5	36	73	100	0.41*	.218
Workshops or consultations assist in coordinating the application for support material on face-to-face consultations	30	19	44	93	22	100	0.48*	.321
Farmers always apply best farming practices to prevent and mitigate future disasters	50	12	25	17	11	100	0.68*	.223
Farmers are encouraged by extension advisors to acquire insurance plans in case of emergencies	10	10	95	0	0	100	0.49*	.293

Strongly Agree (SA), Agree (A), Neutral (NE), Disagree (D), Strongly Disagree (SA)

* = Significant if the mean score is <3.5.

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

4. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The study pursued to investigate the perception of farmers on extension support services. Research findings revealed that farmers had limited access to support services, with a few indicating access to extension support. The extension services have been reported to be of poor quality and irrelevant and do not address farmer's needs. Poor communication strategies, limited access to resources, inputs and access to relevant information, lack of awareness, lack of capacity and effective communication channels affect communal farmers. The study recommends that the responsible stakeholders enhance their capacity and clarify their roles in this regard. Extension services should be accessible to farmers, and communication strategies be improved for effective information exchange. The consideration of farmers' needs should be a priority so that the support services provided align with the farmers' interests and needs. Communal farmers need to be capacitated in farming techniques to improve agricultural production. Mass media, particularly radio and social media, should be incorporated into awareness campaigns, in which reporting channels and contact numbers should be made clear so that farmers are aware of approaching conditions and can transmit the relevant information to others.

REFERENCES

AHMAD, N., ASHRAF, M., MURTAZA, G., MUKHTAR, U. & AINUDDIN, S., 2023. Farmers' perception about drought and climate change in north-west region of Balochistan, Pakistan. *Journal of ilin University*, 42(2): 510-521.

AKPOTOSU, B.W., ANNOR-FREMPONG, F. & BOSOMPEM, M., 2017. Determinants of agricultural extension agents' internet competencies in Eastern Region of Ghana. *Int. J. Res. St. Comp.*, 6(1): 1-7.

BONTSA, N.V., GWALA, L., NGARAVA, S., MDIYA, L. & ZHOU, L., 2023. Quality of climate change extension services provided to smallholder farmers in Raymond Mhlaba Local Municipality, Eastern Cape Province. *S. Afr. J. Agric. Ext*., 51(2): 114-127.

CHAMBERS, R., 1988. Farmer-first: A practical paradigm for the Third Agriculture, England. In M. Altieri & S. Hecht (eds.), *Agroecology and Small Farm Development*. CRC Press.

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

DEBIE, E. & AYELE, A.W., 2023. Perceived determinants of smallholder households' resilience to livelihood insecurity in Goncha District, Northwest Highlands of Ethiopia. *SAGE Open.*, *13*(3).

DUNCAN, A.J., TARAWALI, S.A., THORNE, P., VALBUENA, D., DESCHEEMAEKER, K. & HOMANN– KEETUI, S., 2020. *Integrated crop-livestock systems: A key to sustainable intensification 225 in Africa*. Available from: https://uknowledge.uky.edu/igc/22/1–15/5/

FOOD AND AGRICULTURAL ORGANISATION (FAO). 2009. *The State of Food and Agriculture. Livestock, Food Security and Poverty Reduction.* Rome: FAO.

FRANCIS, J. & SIBANDA, S., 2001. Participatory action research experiences in smallholder dairy farming in Zimbabwe. *Liv. Res. Rur.Dev.*,13(3).

GONI, S., SKENJANA, A. & NYANGIWE, N., 2018. The status of livestock production in communal farming areas of the Eastern Cape: A case of Majali Community, Pelton. *Applied Animal Husb. & Rural Dev*., 11: 34-40.

GWALA, L., YUSUF, S.F.G. & MONDE N., 2022. Characteristics of livestock production systems in some communal areas of the Eastern Cape Province, South Africa. *J. Crit. Rev.*, 9(2): 17-28.

GWALA, L., MONDE, N. & MUCHENJE, V., 2016. Qualitative data analysis of extension services for Nguni cattle project beneficiaries in Nkonkobe local municipality, South Africa. *Int. J. Dev. Sustain.*, 5(11): 553-563.

HAJDU, F., NEVES, D. & GRANLUND, S., 2020. Changing livelihoods in rural Eastern Cape, South Africa (2002–2016): Diminishing employment and expanding social protection. *J. of S. Afr. Stud.*, 46(4): 1–30.

JONES, E.O., THAM-AGYEKUM, E.K., FRED ANKUYI, F., ANKRAH, D.A., AKABA, S., SHAFIWU, A.B. & RICHARD, F.N., 2023. Mobile agricultural extension delivery and climate-smart agricultural practices in a time of a pandemic: Evidence from Southern Ghana. *Env. Sust. Ind.*,19: 100274.

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

KAMBANJE, A., NGARAVA, S., MUSHUNJE, A. & TARUVINGA, A., 2018. Labour dynamics in climate and techno-reliant small scale maize production. *J. Econ. Beh. St.,* 10(4): 262-276.

LINDSAY, P.H. & NORMAN, D.A., 1977. *Human information processing: An introduction to psychology*. 2nd edn. New York: Academic Press.

LOKI, O., ALIBER, M. & SIKWELA, M.M., 2021. Assessment of socioeconomic characteristics that determine farmers' access to agricultural extension services in Eastern Cape, South Africa. *S. Afr. J. Agric. Ext.,* 49(1): 198-209.

MIAO, Z.H., GLATZ, P.C. & RU, Y.J., 2005. Free-range poultry production. A review. *Asia Astr. J. An. Sc.,* 18(1): 113–132.

MITTAL, S. & MEHAR, M., 2012. How mobile phones contribute to growth of small farmers? Evidence from India. *Quart. J. Int. Agric.,* 51: 227-244.

MMBENGWA, V., NYHODO, B., MYEKI, L., NGETHU, X. & VAN SCHALKWYK, H., 2015. Communal livestock farming in South Africa: Does this farming system create jobs for poverty-stricken rural areas? *Syl.,* 159(10): 76–192.

MTHI, S., SKENJANA, A. & FAYEMI, P.O., 2017. Characteristics of small-scale sheep production systems in some communal areas of the Eastern Cape Province, South Africa. *Int. J. Livest. Prod.,* 8(12): 199-206.

NDAMANI, F. & WATANABE, T., 2015. Farmers' perceptions about adaptation practices to climate change and barriers to adaptation: a micro-level study in Ghana. *Water.*, 7(9): 4593– 4604.

OBI, A. & MAYA, O., 2021. Innovative climate-smart agriculture (CSA) practices in the smallholder farming system of South Africa. *Sust.,* 13(12): 6848.

ODUNIYI, O.S., RUBHARA, T.T. & ANTWI, M.A., 2020. Sustainability of livestock farming in South Africa. Outlook on production constraints, climate–related events, and upshot on adaptive capacity. *Sust.,*12(7): 2582.

PICKENS, J., 2005. Attitudes and perceptions. *J. Organ. Behav*., 4(7): 43-76.

https://doi.org/10.17159/2413-3221/2024/v52n4a18365

POPOOLA, O.O., MONDE, N. & YUSUF, S.F.G., 2019. Perception and adaptation responses to climate change: An assessment of smallholder livestock farmers in Amathole District Municipality, Eastern Cape Province. *S. Afr. J. Agric. Ext.*, 47(2): 46-57.

STATISTIC SOUTH AFRICA., 2011. *Census*. Pretoria, South Africa.

TARUVINGA, A., KAMBANJE, A., MUSHUNJE, A. & MUKARUMBWA, P., 2022. Determinants of livestock species ownership at household level: Evidence from rural OR Tambo District Municipality, South Africa. *Pastoralism.*, 12(1): 1–11.

VAN DER LINDEN, S., 2015. The social–psychological determinants of climate change risk perceptions: Towards a comprehensive model. *J. of Env. Psy.*, 41: 112–124.

WHITMARSH, L. & CAPSTICK, S., 2018. Perceptions of climate change. In S. Clayton & C. Manning (eds.), *Psychology and climate change*. Academic Press, pp. 13-33.

S. Afr. J. Agric. Ext. Maziya, Nkonki-Mandleni & Van Niekerk
Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Smallholder Farmers' Choice of Climate Change Adaptation Strategies in the uMkhanyakude District in KwaZulu-Natal, South Africa

Maziya, M.[1], Nkonki-Mandleni, B.[2] and Van Niekerk, J.A.[3]

Corresponding Author: M. Maziya. Correspondence Email: Mbongeni.maziya@univen.ac.za

ABSTRACT

Climate change poses a considerable risk to sustaining smallholder farming in developing countries and hinders efforts to reduce poverty and food insecurity. One way to mitigate and counter the adverse effects of climate change is through adaptation. This study aimed to investigate the climate change adaptation strategies adopted by smallholder farmers in the uMkhanyakude district of KwaZulu-Natal, South Africa. A stratified random sampling procedure collected data from 400 smallholder farmers. Focus group discussions were used to gather in-depth knowledge about climate change adaptation. A multinomial regression model (MNL) was used to analyse the adaptation strategies and their determinants. The results of the MNL model revealed that factors such as access to extension services, Tropical Livestock Units, gender of the household head, age, land size and market access play an important role in farmers' adaptation to climate change. The study recommends that programmes and initiatives aimed at supporting smallholder farmers should facilitate their access to both formal and informal sources of credit. By addressing this key factor, policymakers can contribute to building the adaptive capacity of farmers and strengthening their ability to cope with climate change challenges.

Keywords: Climate Change; Smallholder farmers; Adaptation; uMkhayakude District

[1] Senior Lecturer : Institute for Rural Development, University of Venda, Thohoyandou, South Africa. Email: mbongeni.maziya@univen.ac.za. https://orcid.org/0000-0001-5374-3260

[2] Professor: Community Engagement and Development Directorate, Mangosuthu University of Technology, Durban, South Africa. Email: mandleni@mut.ac.za. https://orcid.org/0000-0001-9908-8504

[3] Associate Professor: Department of Sustainable Food Systems and Development, University of the Free State, 205 Nelson Mandela Avenue, vniekerkJA@ufs.ac.za. https://orcid.org/0000-0001-9842-0641

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

1. INTRODUCTION

Climate change and variability are among the biggest threats to agricultural production for current and future generations. Scenarios on the vulnerability of world agriculture suggest that smallholder farmers in developing countries are the most affected by the negative effects of climate change because of their overreliance on a rainfed agricultural system and limited adaptive capacity due to poor resource endowments (Hitayezu, Zegeye & Ortmann, 2014; Jiri, Mafongoya, Mubaya & Mafongoya, 2015; Kassie, Hengsdijk, Ro¨tter, Kahiluoto, Asseng & Ittersum, 2013). As the African populace strives to outstrip poverty and improve economic growth, the production risks associated with climate change will deepen vulnerabilities and seriously undermine the prospect of development (Ojo & Baiyegunhi, 2020). As a result, climate change will likely hinder global efforts to achieve the 2030 agenda on sustainable development, especially sustainable goals that aim to end poverty and hunger (SDG 1 and SDG 2).

Agriculture is important in sustaining the livelihoods of many smallholder farmers in South Africa. There are over 240 000 market-oriented smallholder farmers and an estimated two to four million subsistence-oriented farmers (Ncube & Fanadzo, 2017). Most of these farmers reside in communal areas where agriculture is dominant (Maziya, Mudhara & Chitja, 2017).

The adoption of agricultural innovations in the context of climate change is currently a prominent conversation among development economists and has become a primary focus of policymakers (Gebrehiwot & Van der Veen, 2013). Adaptation to climate change in the context of smallholder agriculture pertains to the capacity of farm households to devise and implement pragmatic strategies aimed at mitigating the adverse consequences of climate change-induced events, including but not limited to drought, floods, hailstorms, heat waves, and strong winds (Grothmann & Patt, 2005; Mugambiwa, 2018). Successful adaptation necessitates the confluence of the requisite skill and a willingness to engage in adaptive measures. Adaptation can be responsive (against current occurrences) or planned in anticipation of future climatic events.

Adaptation to climate change is a two-step process; the first step requires the individual to recognise that climate change is occurring, and the second step requires the individual to act, i.e., to implement adaptation strategies to reduce human or economic losses. The second step requires both the ability and willingness of the smallholder farmer. Mugambiwa (2018) asserts

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

that the extent to which climate change's negative effects are felt depends on the extent of adaptation. As a result, the adverse effects of climate change tend to be severe where there is no adaptation. In addition, demographic, socio-cultural, and institutional variables influence the selection and implementation of adaptation strategies (Hitayezu, Wale & Ortmann, 2017).

There are a plethora of studies that have documented climate change adaptation in the African continent (Komba & Muchapondwa, 2018; Asfaw, Simane, Bantider & Hassen, 2019; Marie, Yirga, Haile & Tquabo, 2020) and area-specific studies that have focused on South Africa (Lottering, Mafongoya & Lottering, 2021; Shisanya & Mafongoya, 2016; Kom, Nethengwe, Mpandeli & Chikoore, 2020). The continental and local-level studies generally agree that local-level climate change adaptation can play an important role in improving the resilience of smallholder farmers (Abegunde, Sibanda & Obi, 2019; Awazi, Tchamba & Avana, 2019). Adaptation to climate change, for example, has been shown in studies to improve crop productivity in drought-prone areas (Abate, Cosmos, Amsal & Peter, 2015; Fisher et al., 2015; Lunduka, Mateva, Magorokosho & Manjeru, 2017). The common adaptation strategies in agriculture include planting drought-resistant crops, introducing livestock species adaptable to harsh climatic conditions, changing planting dates, mixed farming, irrigation and adopting mixed cropping systems (Wale, Nkoana & Mkuna, 2022; Asfaw *et al*., 2019; Marie *et al*., 2019; Lottering *et al*., 2021).

The study aimed to investigate smallholder farmers' adaptation strategies and their determinants. 'Farmers' adaptation strategies and determinants in the uMkhanyakude district are little known. Understanding farmer's choice of climate change adaptation and their determinants will facilitate a better understanding of how smallholder farmers adapt to climate change.

2. MATERIALS AND METHODS

2.1. Study Area

UMkhanyakude District municipality is in the northern part of the KwaZulu-Natal (KZN) province in South Africa (32, 014489; -27, 622242) (uMkhanyakude District Municipality, 2019). The district borders the Indian Ocean in the east, Mozambique to the north, the Kingdom of Eswatini in the northwest and King Cetshwayo and Zululand districts in the south and west. There are five local municipalities in the uMkhanyakude district: Jozini, uMhlabuyalingana, Hlabisa, Mtubatuba and Big Five False Bay. UMkhunyakude is a rural district with Mtubatuba

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

and Jozini as major local towns. The district covers a surface area of 12 818 km^2 and has about 625 846 people with a population density of 46 per km^2 (uMkhanyakude District Municipality, 2019). In terms of size, uMkhanyakude is the second-largest district in KZN. Out of 11 districts in KZN, uMkhanyakude district was purposively chosen. UMkhanyakude district is one of the poorest municipalities in KZN, and the area is highly devastated by climate-induced changes (Ntsaluba, 2014).

2.2. Sampling

Israel (1992) provides guidelines for determining sample sizes based on population size, the margin of error and confidence levels. The selected local municipalities (LMs) have 84 198 households; based on the guidelines, population sizes of 10 000, 100 000 and 500 000 have corresponding sample sizes of 370, 383 and 388, where the margin of error is 5%, and the confidence level is 95%. A sample size of 400 households was considered adequate for this study. A multi-stage random sampling procedure was used to select participants. In the first stage, 50% of the wards in each local municipality were randomly selected. In the second stage, farming households were randomly selected within the wards. Jozini LM has 20 wards, while uMhlabuyalingana LM comprises 18 wards. Data was collected in two LMs, i.e., Jozini and uMhlabuyalingana. Jozini LM has a population of 198 215 and 44 584 households, while uMhlabuyalingana LM has a population of 172 077 and 39 614 households (Stats SA, 2020).

2.3. Data Collection

A structured questionnaire was used to collect quantitative data between November and December 2020. The survey questionnaire was designed to capture data on demographics, crop production, household assets, livestock ownership, support services and farmer training, land ownership, food security, climate change perception and adaptation. The study focused on smallholder farmers engaged in both crop and animal production. Enumerators visited the sampled households and interviewed the household head.

This study used focus group discussions to gather in-depth information on farmers' experiences of climate change, adaptation strategies and the perceived effect of climate change and variability on their livelihoods. Qualitative data obtained from the focus groups was used to supplement quantitative data in the questionnaires. As Tang and Davis (1995) recommended,

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

each focus group consisted of a maximum of 12 farmers, which is considered appropriate for maximum participation.

2.4. Data Analytical Methods

The multinomial logit regression (MNL) model was employed to analyse the determinants of farmers' choice of adaptation strategies. The MNL model offers several advantages, such as analysing decisions involving multiple categories and estimating choice probabilities for each category (Madalla, 1983). The model has been widely used in studying crop and livestock choices for climate change adaptation (Ubisi *et al*., 2017; Hassan & Nhemachena, 2008).

Using an MNL model has the benefit of being computationally simple for determining analytically expressible decision probabilities (Tse, 1987). It provides a straightforward closed form for calculating choice probabilities without requiring multivariate integration, facilitating the assessment of choice scenarios with multiple alternatives (Tse, 1987). In addition, the likelihood function of the MNL model specification is globally concave, which reduces computational complexity (Hausman & McFadden, 1984). However, the MNL model has a weakness known as the Independence of Irrelevant Alternatives (IIA) property. This property assumes that the ratio of the probability of selecting any two choices is independent of any other attribute in the decision set (Hausman & McFadden, 1984).

During preliminary site visits, it was established that smallholder farmers were using four main distinct adaptation strategies. They included planting -resistant crops, shifting planting dates, practising mixed farming, and using irrigation. It was also established that some farmers did not adopt any climate change adaptation strategy. Consistent with previous climate change adaptation studies (Saguye, 2016; Debela, 2017), the dependent variables in this study are binary and were assigned a value of 1 if the farmer implemented the specific adaptation strategies and 0 if the farmer did not employ them. This approach was adopted to distinguish between farmers who successfully adapted to climate change and those who did not. For this study, a farmer is considered to have adapted to climate change if they implemented at least one of the following adaptation strategies: planting drought-resistant crops, adjusting planting dates, practising mixed farming methods, or utilising irrigation. The MNL logit model is expressed as follows:

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

The dependent variable is the adaptation strategy adopted by the farmer (1= Drought-resistant crops; 2= Shifting planting dates; 3= Mixed farming; 4= Irrigation; 5= No adaptation). Let A_j= (j= 1, 2, 3, 4, 5) be the probability of each smallholder farmer being in each adaptation strategy and j=5 being the base category (no adaptation). According to Greene (2003), the MNL model for choice of adaptation strategies expresses the relationship between the probability of a farmer being in a particular adaptation option and a set of explanatory variables. The model is expressed as follows:

$A_j = I_n (A_j / A_5) = \beta_0 + \beta_1 X_1 + \ldots\ldots \beta_{12} X_{12} + ei$

where:

A_j = adaptation strategy (1= Drought resistant crops; 2= Shifting planting dates; 3= Mixed farming; 4= Irrigation)

In= the natural logarithm

A_5= base category (no adaptation)

β_0 = constant term;

$\beta_1, \beta_2 \ldots \beta_{12}$ = regression coefficients of the explanatory variables;

$X_1 , X_2 \ldots\ldots X_{12}$ = explanatory variables;

e_i= error term.

According to Deressa *et al.* (2009), the parameter estimates derived from the MNL model indicate only the direction of the influence of independent variables on the dependent variable. These estimates do not quantify the actual magnitude of change or probabilities. Marginal effects are used to analyse the impact of the explanatory variables on probabilities. The marginal effects are calculated as follows:

$$\partial_j = \frac{\partial A_j}{\partial X_i} = A_j\left[\beta_j - \sum_{k=0}^{j} A_j \beta_k\right] = A_j\left(\beta_j - \beta^-\right)$$

According to Greene (2000), marginal effects measure the anticipated change in the probability of a specific adaptation strategy being chosen in response to a unit change in an explanatory variable. Some statistical concerns, such as multicollinearity, were assessed for the hypothesised independent variables. The variance inflation factor (VIF) was employed to detect multicollinearity among continuous explanatory variables. The correlation matrix approach was used to determine the degree of relationship between dummy explanatory variables. Variables are considered collinear if the coefficient correlation matrix exceeds 0.4.

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Multicollinearity is also present when the correlation coefficient exceeds 0.4 (Long & Freese, 2006).

The model incorporates a range of explanatory variables hypothesised to influence farmers' choice of adaptation strategies. These variables include various factors, such as demographic, socio-economic and institutional characteristics that shape the farming landscape. Table 1 provides details of the variable names, descriptions, and anticipated signs within the model.

TABLE 1: Variables Used in the Multinomial Logit Regression Model

Variable code	Variable name	Variable descriptionand measurement	Expected sign
AGE	Age	Age of household head in years (continuous)	+/-
GENDER	Gender	1= male and 0 otherwise (dummy)	+/-
EDUCAT	Education	Years of schooling (continuous)	+
LAND_SIZE	Land size	Land size in hectares (continuous)	+
TOTAL_INCOME	Farm and off-farm income	Total amount of money received by the household in the previous year (continuous)	+
H_HADULTS	Number of adult equivalents	Number of people above 18 years who reside in the household and assist in farming (continuous)	+
EXTENSION	Access to extension	1 if the farmer has access to extension services and otherwise (dummy)	+
TLU	Tropical Livestock Units	Livestock size per household (TLUs) (continuous)	+
MARKET_ACCESS		1 if the farmer has access to markets and 0 otherwise (dummy)	+
CREDIT	Access to credit	1 if the farmer received credit in the previous year and 0 otherwise (dummy)	+

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

3. RESULTS AND DISCUSSION

3.1. Socio-Economic Characteristics of the Sampled Farmers

Data was analysed using STATA version 15. Descriptive statistics were employed to analyse the variables used in the model and the barriers to adaptation. Table 2 presents the variables included in the MNL model and their respective means and proportions. The findings indicate that 32% of the sampled farmers were males, whereas 68% were females. These results align with previous studies conducted in the KwaZulu-Natal province (Lottering *et al*., 2021) and Limpopo province (Kom *et al*., 2020) of South Africa. These findings imply that women constitute the majority of smallholder farmers in South Africa, suggesting that they are particularly susceptible to the adverse impacts of climate change.

The average age of smallholder farmers is 55.77 years, indicating that the study area predominantly consists of older individuals engaged in smallholder farming. This demographic composition raises concerns about the sustainability of smallholder farming in the uMkhanyakude district. Nevertheless, the reliability of the results is bolstered by the fact that the average age of smallholder farmers is 55.77, as this study focused on a 20-year reference period. Moreover, in Nigeria, Obayelu *et al*. (2014) found that older people were more active in farming compared to younger people. On average, households in the uMkhanyakude district had approximately five adults during the study. These results conform to earlier findings about the composition of agricultural households in KwaZulu-Natal (Hitayezu *et al*., 2017).

On average, smallholder farmers had attained 7.14 years of schooling, implying that most farmers in the local area did not go beyond primary education. The low levels of education (EDUCAT) in the study area may potentially hinder the adoption of agricultural innovations. Studies (Muzangwa *et al*., 2017; Marenya et *al*., 2017) have shown that education is critical in enhancing understanding and facilitating the uptake of adaptation strategies.

The findings indicate inadequate levels of institutional support provided by the government. Approximately 19% of smallholder farmers received extension services between November 2019 and November 2020. The limited access to extension services (EXTENSION) has broader implications for their ability to adopt innovative climate change adaptation strategies that could mitigate the adverse effects of climate change. These results align with previous studies that reported only 13.6% of agriculturally active black households in the KZN province received agricultural support in 2017 (Stats SA, 2018).

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

More than half (53%) of the sampled smallholder farmers reported having access to some form of credit (CREDIT). However, previous studies conducted in South Africa (Myeni *et al*., 2019; Khapayi & Celliers, 2016) have highlighted the limited access to credit among households due to low income, advanced age and low levels of education. Focus group discussions revealed that most farmers in the uMkhanyakude district had access to informal credit sources such as stokvels, friends and family members. These findings emphasise the significant role of social networks as essential sources of credit, providing much-needed funding for smallholder farmers.

The average land size (LAND_SIZE) controlled by farmers was 1.31 hectares. This result aligns with previous studies that reported that most smallholder farmers in South Africa own less than 2 hectares of land (DAFF, 2012; Mpandeli & Maponya, 2014; Von Loeper *et al*., 2016). The study results indicate that market access (MARKET_ACCESS) was not a problem in the uMkhanyakude district. Those involved in the two irrigation schemes in the Jozini local municipality sold their produce to bakkie traders who were mainly from Richards Bay and the port city of Durban. However, farmers lamented in the focus groups that they mostly get orders in winter since they can plant summer crops in winter because of the warm temperatures.

TABLE 2: Variables Used in the MNL Model

Variable code	Variable name	Mean	SD
AGE	Age of household head in years	55.77	12.36
GENDER	Gender of the household head	0.32	-
EDUCAT	Years of schooling	7.14	4.74
LAND_SIZE	Land size in hectares (ha)	1.31	1.20
MARKET_ACCESS	Access to output markets	0.62	-
H_HADULTS	Number of adult equivalents	4.25	3.76
TLU	Tropical Livestock Units	8.13	12.23
CREDIT	Access to credit	0.53	-
TOTAL_INCOME	Total annual income (Rands)	55674.49	32568.76
EXTENSION	Access to extension services	0.19	-

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Smallholder farmers in the uMkhanyakude district implemented various climate change adaptation strategies to mitigate climate risk. Figure 1 depicts the prevalent adaptation strategies employed by smallholder farmers. Mixed farming was the most widely used adaptation strategy. About 37.25% of the sampled farmers practised mixed farming. Figure 1 shows that 16.5% of the surveyed farmers were adjusting planting dates as an adaptation strategy against the adverse impacts of climate change. Similar findings have been reported in South Africa (Taruvinga *et al*., 2016; Ubisi *et al*., 2017) and Togo (Gadédjisso-Tossou, 2015). Approximately 17.25% of the smallholder farmers planted drought-resistant crops to adapt to climate change. Previous studies (Kom *et al*., 2020; Vilakazi *et al*., 2019) conducted in South Africa have shown that farmers living in harsh climatic conditions are shifting to drought-resistant crops. In the focus group discussions, farmers indicated they were also planting crops such as cassava and sweet potatoes since they have minimal water requirements. Irrigation is one way of enhancing crop production by reducing dependency on rainfed agriculture. A small proportion (4.5%) of the smallholder farmers used irrigation to adapt. Extension officers in the area echoed this result. They agreed that irrigation is not well developed and the support received by smallholder farmers regarding irrigation infrastructure was limited and insufficient to adequately support irrigation as a widely used adaptation strategy.

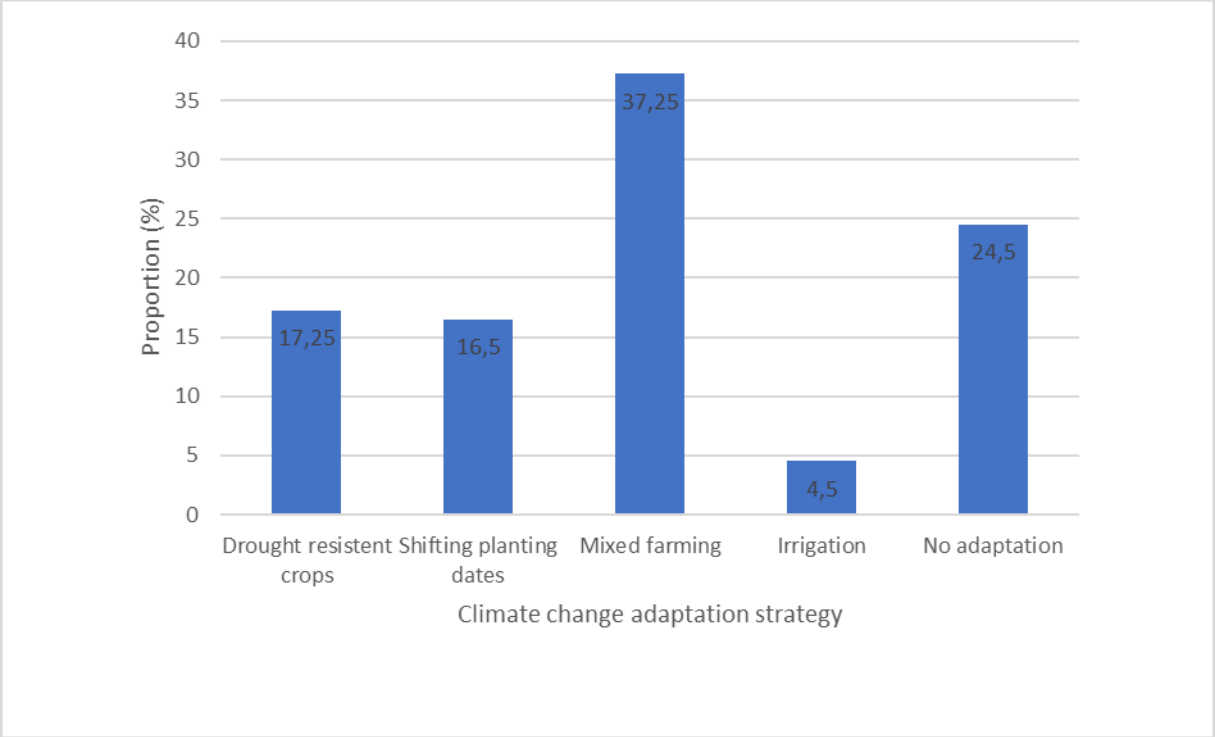

FIGURE 1: Climate Change Adaptation Strategies

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

The study further explored the barriers hindering climate change adaptation. Figure 2 shows that farmers identified lack of information, insufficient financial resources, scarcity of labour and limited availability of land as the barriers to climate change adaptation. Among the surveyed farmers, a significant proportion (70%) cited a lack of information as a significant barrier to climate change adaptation. Around 60% of the farmers identified a lack of financial resources as a constraint impacting their ability to adapt to climate change. In addition, 23% of the sampled farmers reported labour shortages, while 20% mentioned limited land as a limiting factor. These findings align with the results of Wale *et al*. (2022), who reported that lack of information, financial constraints, and labour shortages were the main factors impeding climate change adaptation in the KwaZulu-Natal province of South Africa. In the focus groups, some farmers echoed the sentiment that they had not interacted with extension agents between November 2019 and November 2020. This explains the high proportion (70%) of farmers who indicated a lack of information as a barrier to climate change adaptation.

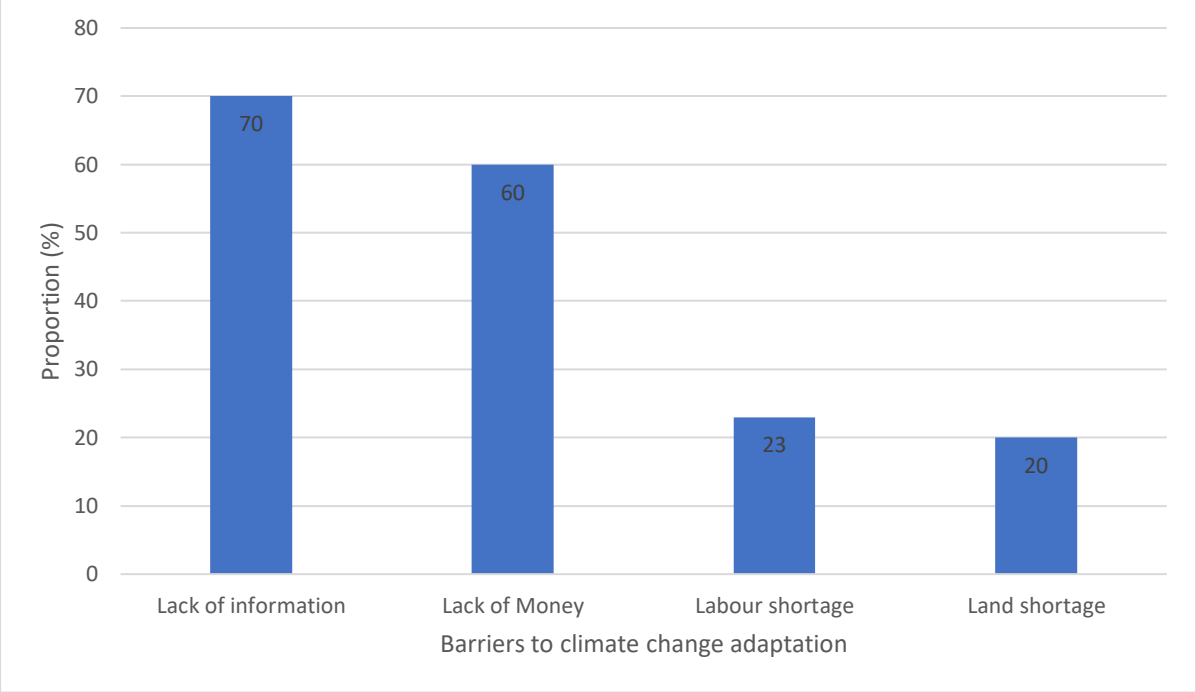

FIGURE 2: Barriers to Climate Change Adaptation

3.2. Determinants of Farmers' Choice of Adaptation Methods

The MNL model was used to analyse the factors influencing farmers' adaptation strategies. The MNL model in this study was employed by normalising one category, also called the base or the reference category. In addition, the Ordinary Least Squares (OLS) model was applied to

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

assess multicollinearity using the Variance Inflation Factor (VIF) and highly correlated variables were removed from the regression model. Appendix 1 presents the VIF values for the variables included in the MNL model. With a mean VIF of 1.10, multicollinearity was not a problem, and the remaining variables were considered appropriate for the model. Correlations were also performed, and the remaining variables had coefficients of less than 0.4, which is regarded as appropriate.

Table 3 displays the parameter estimates of the MNL climate change adaptation model, while Table 4 presents the corresponding marginal effects and their significance levels. The parameter estimates indicate the direction of the independent variables' effect on the dependent variable without providing the exact magnitudes of change. Instead, the marginal effects are reported, representing the expected change in the probability of selecting a specific adaptation strategy. The coefficients are compared to the base category of no adaptation.

To assess the assumption of independence of irrelevant alternatives (IIA) in the MNL model, a nested Logit model, an extension of the MNL, was employed (Hausman & McFadden, 1984). A standard method involving a restricted choice set (shifting planting dates or irrigation alternatives) was used. The model exhibited no significant changes, and the results were further validated through the Hausman test (Long & Freese, 2006), which confirmed that the null hypothesis of IIA could not be rejected. Consequently, using the MNL model to estimate the determinants of climate change adaptation choice is deemed appropriate and justified.

3.2.1. Planting Drought Resistant Crops

The results show a positive and statistically significant relationship ($p<0.1$) between access to extension services (EXTENSION) and the adoption of drought-resistant crops as a climate change adaptation strategy. This result is in line with the *a priori* expectation. The findings indicate that access to extension services increases the likelihood of farmers adopting drought-resistant crops by a factor of 0.046. This underscores the importance of extension officers as a valuable source of agricultural information for smallholder farmers. By accessing extension services, farmers can enhance their understanding of climate change and learn about suitable drought-resistant crop options that are specifically suited to their region. These results are consistent with previous studies that found a positive relationship between access to extension services and adopting drought-resistant crops as a climate change adaptation strategy (Carlisle, 2016; Myeni *et al*., 2019).

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Consistent with the *a priori* expectation, the results revealed a positive and significant relationship ($p<0.01$) between access to credit (CREDIT) and the adoption of drought-resistant crops. The results indicate that having access to credit increases the likelihood of smallholder farmers adopting drought-resistant crops by a factor of 0.128. This implies that farmers who can access informal credit sources such as stokvels and formal credit from financial institutions are more likely to afford and cultivate drought-resistant crops. Given the capital-intensive nature of acquiring drought-resistant crops (i.e., improved crop cultivars), farmers with limited resources may face difficulty purchasing such crops without credit assistance. This finding highlights the critical role of credit in facilitating climate change adaptation. These results align with previous studies (Ojo & Baiyegunhi, 2020; Chipfupa *et al*., 2021).

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TABLE 3: Parameter Estimates of the MNL Climate Change Adaptation Model

Variable code	Planting drought resistant crops		Shifting planting dates		Mixed farming		Irrigation	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
AGE	0.012	0.014	-0.000	0.015	-0.014	0.011	0.023	0.025
GENDER	-0.473	0.372	-1.305***	0.436	-0.440	0.308	-0.401	0.585
EDUCAT	0.080*	0.046	0.050	0.045	0.030	0.035	0.188**	0.094
LAND_SIZE	-0.128	0.183	0.024	0.176	0.181	0.147	0.030	0.259
MARKET_ACCESS	0.522	0.361	1.151***	0.390	1.046***	0.306	0.507	0.581
H_HADULTS	0.024	0.056	0.060	0.055	0.063	0.046	0.031	0.090
TLU	0.036*	0.018	0.035*	0.019	0.047***	0.016	0.021	0.028
CREDIT	1.548***	0.369	1.188***	0.371	0.427	0.292	1.940***	0.683

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TOTAL_INCOME	5.61e-07	2.53e-06	6.24e-07	2.48e-06	1.57e-06	2.28e-06	1.75e-06	2.48e-06
EXTENSION	0.606	0.386	0.638*	0.386	0.243	0.391	0.158	0.677
Base category		No adaptation						
Number of observations		400						
LR Chi-square		124.80***						
Log likelihood		-517.58624						
Pseudo-R^2		0.1076						

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TABLE 4: Marginal Effects from the MNL Climate Change Adaptation Model

Variable code	Planting drought-resistant crops		Shifting planting dates		Mixed farming		Irrigation	
	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE
AGE	0.002	0.001	0.000	0.002	-0.004**	0.002	0.001	0.001
GENDER	0.006	0.041	-0.124**	0.048	0.019	0.052	0.005	0.022
EDUCAT	0.006	0.006	0.001	0.005	-0.004	0.006	0.006	0.004
LAND_SIZE	-0.029	0.019	-0.004	0.016	0.044**	0.020	-0.000	0.009
MARKET_ACCESS	-0.031	0.039	0.064	0.042	0.114**	0.051	-0.009	0.022
H_HADULTS	-0.002	0.005	0.003	0.005	0.008	0.007	-0.000	0.003
TLU	0.001	0.002	0.000	0.002	0.005***	0.002	-0.000	0.001
CREDIT	0.128***	0.041	0.064*	0.039	-0.100**	0.047	0.050*	0.028

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TOTAL_INCOME	-5.24e-08	2.00e-07	-4.63e-08	1.72e-07	2.37e-07	2.38e-07	3.92e-08	5.22e-08
EXTENSION	0.046*	0.026	0.047**	0.024	-0.025	0.054	-0.008	0.025

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

3.2.2. Shifting Planting Dates

Approximately 17.25% of the smallholder farmers in the sample implemented shifting planting dates as a climate change adaptation strategy. The analysis reveals a positive and statistically significant ($p<0.05$) relationship between access to extension services (EXTENSION) and shifting planting dates. This finding aligns with the *a priori* expectation, as extension officers play a crucial role in advising smallholder farmers on the appropriate months for cultivation based on predicted or prevailing climatic conditions in the area. Access to extension services increases the probability of adopting shifting planting dates by a factor of 0.047. This result can be attributed to access to extension services enhancing smallholder farmers' access to climate-related information.

Consequently, farmers become more knowledgeable about the adverse impacts of climate change (Dinku *et al*., 2014) and the potential adaptation strategies that can be employed. Access to information enables farmers to make informed decisions regarding shifting planting dates to mitigate the adverse effects of climate change. These findings are consistent with the study conducted by Kibue *et al*. (2015), which found that farmers' willingness to adapt to climate change increases with improved access to extension services.

The analysis reveals a negative and statistically significant ($p<0.05$) relationship between gender (GENDER) and the adoption of shifting planting dates as a climate change adaptation strategy. This result suggests that female farmers are likelier to shift planting dates than their male counterparts. The probability of adopting shifting planting dates increases by a factor of 0.124 for female farmers. This finding is consistent with previous studies conducted in Kenya (Pello *et al*., 2021) and South Africa (Thinda *et al*., 2020). The higher adaptive capability of female smallholder farmers may be attributed to their heightened vulnerability to climate change, arising from factors such as limited off-farm activities, lower levels of education, and weaker social networks (Djoudi *et al*., 2016). The observed gender disparity in adopting shifting planting dates highlights the need for targeted interventions and support for female farmers to enhance their resilience to climate change.

Access to credit (CREDIT) has a positive and statistically significant ($p<0.1$) relationship with the adoption of shifting planting dates as a climate change adaptation strategy. The probability of shifting planting dates increases by 0.064 when farmers can access credit. Due to unpredictable climatic changes, farmers often plant summer crops later than usual, outside their

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

region's optimum planting time. As a result, farmers might require financial resources to purchase early maturing crops. This finding underscores the importance of financial support mechanisms in promoting climate change adaptation in the agricultural sector.

3.2.3. Mixed Farming

The variable for the age of the household head (AGE) has a negative and statistically significant ($p<0.05$) relationship with the adoption of mixed farming as a climate change adaptation strategy. This suggests that older farmers are less likely to adopt mixed farming as an adaptation strategy. The adoption of mixed farming decreases by 0.004 with increasing age. The negative impact of age on adopting mixed farming may stem from older farmers having limited knowledge about the benefits and practices associated with mixed farming, potentially due to lower levels of education. This finding implies that older farmers may be less aware of the available options and strategies suitable for their farms in the context of climate change. These findings align with the results from Ojo *et al*. (2021), where they identified a negative and significant relationship between age and adopting climate change adaptation strategies in South Africa. Similarly, in Ghana, Zakaria *et al*. (2020) reported a negative and significant relationship between age and adopting climate change adaptation strategies. Overall, the results suggest that age can be an important factor influencing the adoption of specific climate change adaptation strategies, highlighting the need for targeted interventions and education programmes to increase the awareness and knowledge of older farmers regarding suitable adaptation practices.

The variable for land size (LAND_SIZE) has a positive and statistically significant ($p<0.05$) relationship with the adoption of mixed farming as a climate change adaptation strategy. This implies that as the land under cultivation increases by a hectare, the likelihood of adopting mixed farming as an adaptation strategy increases by 0.044. The positive relationship between land size and the adoption of mixed farming can be attributed to the advantages that larger farm sizes offer. Farmers with larger land sizes can explore and integrate various agricultural enterprises, such as livestock, alongside their crop production. This diversification reduces the risks associated with climate change, as different enterprises can provide a buffer against the potential impacts of unpredictable weather patterns. The results suggest that farmers with larger land sizes have the flexibility and resources to implement mixed farming practices, which can enhance their resilience to climate change. These findings align with previous studies that have

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

also demonstrated a positive relationship between land size and adopting climate change adaptation strategies (Ojo & Baiyegunhi, 2020; Bryan *et al*., 2013). Overall, the positive association between land size and the adoption of mixed farming highlights the importance of land resources in facilitating adaptive strategies. It emphasises the potential benefits of promoting larger land holdings or supporting farmers in utilising their available land more effectively to enhance climate resilience in agricultural systems.

The coefficient for market access (MARKET_ACCESS) has a positive and statistically significant ($P<0.05$) relationship with the adoption of mixed farming as a climate change adaptation strategy. The findings indicate that farmers with access to markets are more likely to adopt mixed farming practices to respond to climate change. The probability of adopting mixed farming increases by 0.114 with improved market access. The positive relationship between market access and adopting mixed farming can be attributed to several factors. Firstly, market access allows farmers to procure necessary farm inputs, such as improved seeds or livestock, enabling them to expand and diversify their agricultural activities. Secondly, farmers with market access can easily sell their cash crops or livestock, enhancing their income and financial capacity to invest in mixed farming. This income can contribute to the necessary resources and flexibility for implementing mixed farming practices. These results align with previous studies that have identified a positive association between market access and climate change adaptation (Alemayehu & Bewket, 2017; Adimassu & Kessler, 2016). Improving market connectivity and ensuring farmers access reliable markets can enhance their capacity to diversify their agricultural activities and resilience to climate variability. Access to markets can empower farmers to make informed decisions, access necessary resources, and capitalise on market opportunities, ultimately improving their adaptive capacity in the face of climate change.

The results show that there is a positive and statistically significant ($p<0.01$) relationship between livestock ownership (TLU) and the adoption of mixed farming as a climate change adaptation strategy. An increase in livestock ownership increases the probability of adopting mixed farming by a factor of 0.005. The observed positive relationship can be attributed to the benefits of livestock ownership in diversifying smallholder farmers' agricultural activities. Livestock is an additional enterprise alongside crop farming, enabling farmers to mitigate risks associated with unfavourable climatic conditions and potential crop failures. Farmers can spread their risks by incorporating livestock into their farming systems and enhancing their

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

resilience to climate change impacts. This finding is consistent with other empirical studies highlighting the positive association between livestock ownership and climate change adaptation (Amare & Simane, 2017; Regmi *et al*., 2017). These studies have emphasised the role of livestock in providing alternative sources of income, nutrient-rich manure for soil fertility and potential insurance against crop losses, all of which contribute to farmers' ability to adapt to changing climatic conditions. In addition, the positive relationship between livestock ownership and adopting mixed farming underscores the importance of integrating livestock in climate change adaptation strategies.

Contrary to the *a priori* expectation, access to credit (CREDIT) has a negative and statistically significant ($p<0.05$) relationship with the adoption of mixed farming as a climate change adaptation strategy. This finding suggests that farmers with credit access are less likely to diversify their farming enterprises. With all other variables held constant, access to credit decreases the probability of adopting mixed farming by a factor of 0.1. The unexpected negative effect of credit on mixed farming adoption could be attributed to specific circumstances surrounding credit availability and utilisation in the study area. Focus group discussions revealed that the credit sources for farmers practising mixed farming predominantly stem from informal lending institutions, which tend to impose high interest rates. These exorbitant interest rates may discourage farmers from investing in diverse farming enterprises like mixed farming, as the financial burden becomes a disincentive for pursuing such practices. The findings underscore the significance of considering the presence of credit and its accessibility and affordability. While access to credit is generally perceived as a facilitator of agricultural activities, the specific terms and conditions associated with credit sources can significantly influence farmers' decisions and behaviours. In this context, the high interest rates charged by informal lending institutions appear to hinder farmers' inclination towards adopting mixed farming. Creating favourable credit environments that offer reasonable interest rates and flexible repayment terms could encourage farmers to embrace diverse farming enterprises, contributing to their resilience in climate change.

3.2.4. Irrigation

The results indicate that access to credit (CREDIT) has a positive and statistically significant ($p<0.1$) effect on the adoption of irrigation as a climate change adaptation strategy. Access to credit increases the probability of adopting irrigation by a factor of 0.05. This finding highlights

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

the importance of credit in facilitating the adoption of irrigation, considering its capital-intensive nature. Implementing irrigation systems, which involves acquiring infrastructure such as tanks and pipes, requires substantial financial resources that may not be readily available to smallholder farmers. Farmers gain additional financial resources to purchase the necessary irrigation infrastructure by providing access to credit. This financial support is crucial in overcoming the financial barriers associated with implementing irrigation as a climate change adaptation strategy. Even if farmers possess the necessary information and knowledge about climate change and its impacts, their ability to acquire the required equipment may be constrained if they lack access to credit. These findings align with previous empirical studies (Ojo and Baiyegunhi, 2020), further emphasising the significance of credit in facilitating the adoption of climate change adaptation strategies, specifically in irrigation. Access to credit provides farmers with the means to invest in necessary infrastructure and empowers them to manage water resources better and enhance their agricultural productivity and resilience.

4. CONCLUSION AND RECOMMENDATIONS

The study assessed farmers' choice of climate change adaptation strategies and their determinants in the uMkhanyakude district of KwaZulu-Natal province of South Africa. The study results revealed that smallholder farmers adapted to climate change by employing different adaptation strategies/methods. Indeed, descriptive statistics showed that farmers were employing mixed farming, shifting planting dates, planting drought-resistant crops and irrigation to adapt to climate change. Lack of information, financial resources, and land and labour shortages were the major barriers hindering smallholder farmers from adapting to climate change. Access to credit was not a problem in the study area; smallholder farmers use informal sources of credit to support agricultural activities.

Most of the smallholder farmers in the study area were females and, by implication, were the most affected by the adverse effects of climate change. Access to extension services was low, which has implications for the transfer of agricultural information and innovative practices that mitigate the adverse effects of climate change. Therefore, it is unsurprising that farmers mentioned lack of information as a barrier to adaptation. Farmers in the area owned less than 1.5 ha of agricultural land. With climate change, farmers will need more land to spread climate risk by diversifying farm activities.

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

The results from the MNL marginal analysis indicate that access to credit, access to extension services, gender of the household head (female headship), market access, tropical livestock units, and land size were the factors that influenced farmers' choice of adaptation strategies. Thus, overcoming financial constraints, broadening extension services and supporting mixed farming (livestock systems in addition to cropping systems) methods in rural areas can be underlined as a policy option to reduce the negative impacts of climate change. Access to credit has emerged as a dominant factor affecting the adoption of most adaptation strategies. The study recommends that programmes and initiatives aimed at supporting smallholder farmers should facilitate their access to both formal and informal sources of credit. By addressing this key factor, policymakers can contribute to building the adaptive capacity of farmers and strengthening their ability to cope with climate change challenges.

REFERENCES

ABATE, T., COSMOS, M., AMSAL, T. & PETER, S., 2015. *Maize variety options for Africa*. Zimbabwe: CIMMYT Institutional Multimedia Publications Repository.

ABEGUNDE, V.O., SIBANDA, M. & OBI, A., 2019. The dynamics of climate change adaptation in Sub-Saharan Africa: A review of climate-smart agriculture among small-scale farmers. *Climate.*, 7(7): 132.

ADIMASSU, Z. & KESSLER, A., 2016. Factors affecting farmers' coping and adaptation strategies to perceived trends of declining rainfall and crop productivity in the central Rift Valley of Ethiopia. *Environ. Syst. Res.*, 5: 13.

ALEMAYEHU, A. & BEWKET, W., 2017. Determinants of smallholder farmers' choice of coping and adaptation strategies to climate change and variability in the central highlands of Ethiopia. *Environ. Develop.,* 24: 77-85.

AMARE, A. & SIMANE, B., 2017. Determinants of smallholder farmers' decision to adopt adaptation options to climate change and variability in the Muger Sub-basin of the Upper Blue Nile basin of Ethiopia. *Agric. Food Sec.,* 6: 1-20.

ASFAW, A., SIMANE, B., BANTIDER, A. & HASSEN, A., 2019. Determinants in the adoption of climate change adaptation strategies: evidence from rainfed-dependent

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

smallholder farmers in north-central Ethiopia (Woleka sub-basin). *Environ Dev Sustain.*, 21: 2535–2565.

AWAZI, N.P., TCHAMBA, M.N. & AVANA, T.M., 2019. Climate change resiliency choices of small-scale farmers in Cameroon: determinants and policy implications. *J Environ Manage.*, 250: 109560.

BRYAN, E., RINGLER, C., OKOBA, B., RONCOLI, C., SILVESTRI, S. & HERRERO, M., 2013. Adapting agriculture to climate change in Kenya: household strategies and determinants. *J Environ Manage.*, 114: 26–35.

CARLISLE, L., 2016. Factors influencing farmer adoption of soil health practices in the United States: A narrative review. *Agroecol Sust Food Sys.*, 40(6): 583-613.

DEBELA, B., 2017. Gender and climate change: determinants of female farmer's adaptation strategies to climate change; A survey study in Atsbi Womberta, Ethiopia. *Citizenship and Morality.*, 1(1): 14–40.

DEPARTMENT OF AGRICULTURE, FORESTRY AND FISHERIES (DAFF)., 2012. *A Framework for the development of smallholder farmers through cooperatives development*. Pretoria, South Africa: Department of Agriculture, Forestry and Fisheries. Available from: http://Www.Nda.Agric.Za/Doadev/Sidemenu/Cooperativeandenterprisedevelopment/Docs/Framework-%20of%20small%20farmers%20(2).Pdf

DERESSA, T.T., HASSAN, R.M., RINGLER, C., ALEMU, T. & YESUF, M., 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Glob. Environ. Change.*, 19: 248-255.

DINKU, T., BLOCK, P., SHAROFF, J., HAILEMARIAM, K., OSGOOD, D., DEL CORRAL, J., COUSIN, R. & THOMSON, M.C., 2014. Bridging critical gaps in climate services and applications in Africa. *Earth Perspect.*, 1(15): 1-13.

DJOUDI, H., LOCATELLI, B., VAAST, C., ASHER, K., BROCKHAUS, M. & SIJAPATI, B.B., 2016. Beyond dichotomies: gender and intersecting inequalities in climate change studies. *Ambio.*, 45(3): 248-262.

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

FISHER, M., ABATE, T., LUNDUKA, R.W., ASNAKE, W., ALEMAYEHU, Y. & MADULU, R.B., 2015. Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: determinants of adoption in eastern and southern Africa. *Clim. Change.,* 133: 283–299.

GADÉDJISSO-TOSSOU, A., 2015. Understanding farmers' perceptions of and adaptations to climate change andvariability: The case of the maritime, plateau and Savannah Regions of Togo. *Agric. Sci.,* 6: 1441-1454.

GEBREHIWOT, T. & VAN DER VEEN, A., 2013. Farm level adaptation to climate change: the case of farmer's in the Ethiopian Highlands. *Environ. Manage.,* 52: 29–44.

GREENE, W.H., 2003. *Econometric analysis*. 5th edn. New Jersey: Prentice Hall.

GREENE, W.H., 2000. Econometric analysis. 4th edn. New Jersey: Prentice Hall.

GROTHMANN, T. & PATT, A., 2005. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Glob. Environ. Change.,* 15(3): 199-213.

HAUSMAN, J. & MCFADDEN, D., 1984. Specification tests for the multinomial logit model. *Econometrica.*, 52(5): 1219–1240.

HITAYEZU, P., WALE, E. & ORTMANN, G., 2017. Assessing farmers' perceptions about climate change: A double-hurdle approach. *Clim. Risk Manag.,* 17: 123-138.

ISRAEL, G.D., 1992. *Determining sample size*. Florida: University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, EDIS.

JIRI, O., MAFONGOYA, P., MUBAYA, C. & MAFONGOYA, O., 2015. Seasonal climate prediction and adaptation using indigenous knowledge systems in agriculture systems in Southern Africa: A review. *J. Agric. Sci.,* 8(5): 156-172.

KASSIE, B.T., HENGSDIJK, H., RO¨TTER, R., KAHILUOTO, H., ASSENG, S. & ITTERSUM, M.V., 2013. Adapting to climate variability and change: Experiences from cereal-based farming in the Central Rift and Kobo Valleys, Ethiopia. *Environ. Manage.,* 52(5): 1115-1131.

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

KHAPAYI, M. & CELLIERS, P. 2016. Factors limiting and preventing emerging farmers to progress to commercial agricultural farming in the King William's Town area of the Eastern Cape province, South Africa. *S. Afr. J. Agric. Ext.,* 44(1): 25-41.

KIBUE, G.W., PAN, G., JOSEPH, S., LIU, X., JUFENG, Z., ZHANG, X. & LI, L., 2015. More than two decades of climate change alarm: farmers' knowledge, attitudes and perceptions. *Afr. J. Agric. Res.,* 10(27): 2617-2625.

KOM, Z., NETHENGWE, N.S., MPANDELI, N.S. & CHIKOORE, H., 2022. Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. *GeoJournal.,* 7: 1-12.

KOMBA, C. & MUCHAPONDWA, E., 2018. Adaptation to climate change by smallholder farmers in Tanzania. *Agric. Adapt. Climate Chang. Africa.,* 129(168): 129–168.

LONG, J.S. & FREESE, J., 2006. *Regression Models for Categorical Dependent Variables Using Stata*. Stata Press.

LOTTERING, S.J., MAFONGOYA, P. & LOTTERING, P., 2021. The impacts of drought and the adaptive strategies of small-scale farmers in uMsinga, KwaZulu-Natal, South Africa. *J. Asian Afr. Stud.,* 56(2): 267–289.

LUNDUKA, R.W., MATEVA, K.I., MAGOROKOSHO, C. & MANJERU, P., 2017. Impact of adoption of drought-tolerant maize varieties on total maize production in south Eastern Zimbabwe. *Clim. Dev.,* 11(1): 35-46.

MADALLA, G., 1983. *Limited dependent and qualitative variables in econometrics*. Cambridge: Cambridge University Press.

MARENYA, P.P., KASSIE, M., JALETA, M. & ERENSTEIN, O., 2017. Predicting minimum tillage adoption among smallholder farmers using micro-level and policy variables. *Agric. Food Econ.,* 5: 12.

MARIE, M., YIRGA, F., HAILE, M. & TQUABO, F., 2020. Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from north-western Ethiopia. *Heliyon.,* 6: e03867.

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

MAZIYA, M., MUDHARA, M. & CHITJA, J., 2017. What factors determine household food security among smallholder farmers? Insights from Msinga, KwaZulu-Natal, South Africa. *Agrekon.*, 56(1): 40-52.

MPANDELI, S. & MAPONYA, P., 2014. Constraints and challenges facing the small-scale farmers in Limpopo Province, South Africa. *J. Agric. Sci.*, 6(4): 135-143.

MUGAMBIWA, S.S., 2018. Adaptation measures to sustain indigenous practices and the use of indigenous knowledge systems to adapt to climate change in Mutoko rural district of Zimbabwe. *Jàmbá: J. Disaster Risk Stud.*, 10(1): 388.

MUZANGWA, L., MNKENI, P.N.S. & CHIDUZA, C., 2017. Assessment Of conservation agriculture practices by smallholder farmers in the Eastern Cape province of South Africa. *Agronomy.*, 7(3): 46.

MYENI, L., MOELETSI, M., THAVHANA, M., RANDELA, M. & MOKOENA, L., 2019. Barriers Affecting Sustainable Agricultural Productivity of Smallholder Farmers in the Eastern Free State of South Africa. *Sustainability.*, 11: 3003.

NCUBE, B. & FANADZO, M., 2017. Improving smallholder farmer livelihoods through developing strategies to cope and adapt during drought periods in South Africa. Report on the Literature review on the current knowledge of smallholder farming in South Africa. Water Research Commission Project No. K4/2716/4.

NTSALUBA, G., 2014. *KwaZulu-Natal water crisis: Too little too late*. Corruption Watch. Available from: https://www.corruptionwatch.org.za/kzn-water-crisis-too-little-too-late/

OBAYELU, O.A., ADEPOJU, A.O. & IDOWU, T., 2014. Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria. *J. Agric. Environ. Int. Dev.*, 108(1): 3-16.

OJO, T.O. & BAIYEGUNHI, L.J.S., 2020. Determinants of climate change adaptation strategies and its impact on the net farm income of rice farmers in south-west Nigeria. *Land Use Policy.*, 95: 103946.

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

OJO, T.O., ADETORO, A.A., OGUNDEJI, A.A. & BELLE, J.A., 2021. Quantifying the determinants of climate change adaptation strategies and farmers' access to credit in South Africa. *Sci. Total Environ.,* 792: 148499.

PELLO, K., OKINDA, C., LIU, A. & NJAGI, T., 2021. Factors Affecting Adaptation to Climate Change through Agroforestry in Kenya. *Land.,* 10: 371.

REGMI, N., DHAKAL, D. & GHIMIRE, B., 2017. Determinants of farmers' adaptation to climate change: A case from Syangja district of Nepal. *Agric. Econ. Ext. Rural Dev.,* 5: 658-663.

SAGUYE, T.S., 2016. Determinants of Smallholder Farmers' Adoption of Climate Change and Variability Adaptation Strategies: Evidence from Geze Gofa District, Gamo Gofa Zone, Southern Ethiopia. *J. Environ Earth Sci.,* 6(9): 147-161.

SHISANYA, S.O. & MAFONGOYA, P., 2016. Adaptation to climate change and the impacts on household food security among rural farmers in uMzinyathi District of Kwazulu-Natal, South Africa. *Food Secur.,* 8(3): 597-603.

STATISTICS SOUTH AFRICA (STATS SA)., 2018. *General Household Survey 2015*. Pretoria: Statistics South Africa.

STATISTICS SOUTH AFRICA (STATS SA)., 2020. *Mid-year population estimates*. Pretoria: Statistics South Africa.

TANG, K.C. & DAVIS, A., 1995. Critical factors in the determination of focus group size. *Fam. Pract.,* 12(4): 474-475.

TARUVINGA, A., VISSER, M. & ZHOU, L., 2016. Determinants of rural farmers' adoption of climate change adaptation strategies: Evidence from the Amathole District Municipality, Eastern Cape Province, South Africa. *Int. J. Environ. Sci. Dev., 7*(9): 687-692.

THINDA, K.T., OGUNDEJI, A.A., BELLE, J.A. & OJO, T.O., 2020. Understanding the adoption of climate change adaptation strategies among smallholder farmers: Evidence from land reform beneficiaries in South Africa. *Land Use Policy.,* 99: 104858.

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

TSE, Y.K., 1987. A diagnostic test for the multinomial logit model. *J. Bus. Econ. Stat.,* 5(2): 283-86.

UBISI, N.R., MAFONGOYA, P.L., KOLANISI, U. & JIRI, O., 2017. livelihoods in rural Limpopo province, South Africa change on crop production and household Smallholder farmer's perceived effects of climate. *Change Adapt. Socio-Ecol. Syst.,* 3: 27-38.

UMKHANYAKUDE DISTRICT MUNICIPALITY., 2019. *Integrated development plan review: 4th Generation 2019/2020.*

VILAKAZI, B.S., ZENGENI, R. & MAFONGOYA, P., 2018. Indigenous strategies used by selected farming communities in KwaZulu Natal, South Africa, to manage soil, water, and climate extremes and to make weather predictions. *Land Degrad Dev.,* 30(2): 1-10.

VON LOEPER, W., MUSANGO, J., BRENT, A. & DRIMIE, S., 2016. Analysing challenges facing smallholder farmers and conservation agriculture in South Africa: A system dynamics approach. *S. Afr. J. Econ. Manag. Sci.,* 19: 747-773.

WALE, E., NKOANA, M.A. & MKUNA, E., 2022. Climate change-induced livelihood adaptive strategies and perceptions of forest-dependent communities: The case of Inanda, KwaZulu-Natal, South Africa. *Trees, Forests and People.,* 8: 100250.

ZAKARIA, Z., ALHASSAN, S.I., KUWORNU, J.K.M., AZUMAH, S.B. & DERKYI, M.K.K., 2020. Factors influencing the adoption of climate-smart agricultural technologies among rice farmers in Northern Ghana. *Earth Syst. Environ.,* 4(1): 257-271.

Vol. 52 No. 4, 2024: 97-127
https://doi.org/10.17159/2413-3221/2024/v52n4a18366

Appendix 1

Multicollinearity test between independent variables

Variable code	Variance Inflation Factor (VIF)	Multicollinearity Tolerance
AGE	1.03	0.967
GENDER	1.09	0.916
EDUCAT	1.03	0.973
LAND_SIZE	1.17	0.856
MARKET_ACCESS	1.11	0.900
H_HADULTS	1.15	0.870
TLU	1.23	0.811
CREDIT	1.09	0.915
TOTAL_INCOME	1.10	0.905

https://doi.org/10.17159/2413-3221/2024/v52n4a18366

EXTENSION	1.01	0.990
MEAN VIF	1.10	

S. Afr. J. Agric. Ext. Bontsa, Gwala, Mdiya & Mdoda
Vol. 52 No. 4, 2024: 128-147
https://doi.org/10.17159/2413-3221/2024/v52n4a18367

Determinants of Livestock Smallholder Farmer's Choice of Adaptation Strategies to Climate Change in Raymond Mhlaba Local Municipality, Eastern Cape, South Africa

Bontsa, N.V.[1], Gwala, L.[2], Mdiya, L.[3] and Mdoda, L.[4]

Corresponding Author: N.V. Bontsa. Correspondence Email: nbontsa@ufh.ac.za

ABSTRACT

Globally, climate change is a major challenge facing farmers. This phenomenon threatens the sustainability of smallholder farmers in rural communities who depend solely on agriculture. Farmers are known to take suitable steps to adapt when they observe change and adjust their farming practices to cope with climate change. However, livestock farmers' response to climate change is very low due to insufficient scientific and context-based evidence. Hence, this paper sought to investigate the determinants of livestock small-scale farmers' choices and adaptive strategies in response to the effects of climate change in Raymond Mhlaba Local Municipality. The study used a cross-sectional research design to collect data from 220 livestock farmers using a semi-structured questionnaire. The study used multinomial logistic regression to analyse the data. Empirical results reveal that access to weather forecasts and extension services, farmers' perception of climate change, level of education, age of the household head, distance to input markets, member of farm organisation, income from livestock sales, and livestock holding affect livestock farming decision for climate change adaptation. Therefore, the study recommends that the government improve farmers' access to accurate and timely agro-meteorological forecasts, capacity building, and technical support for income diversification through improved provision of agricultural extension services.

[1] Lecturer, Department of Agricultural Economics and Extension, Faculty of Science and Agriculture University of Fort Hare, Alice, South Africa. Email: nbontsa@ufh.ac.za. ORCID: 0000-0002-6320-4559

[2] Senior Lecturer, Department of Agricultural Economics and Extension, Faculty of Science and Agriculture University of Fort Hare, Alice, South Africa. Email: lgwala @ufh.ac.za. ORCID: 0000-0002-0186-050X

[3] Lecturer, Department of Agricultural Economics and Extension, Faculty of Science and Agriculture University of Fort Hare, Alice, South Africa. Email: MdiyaL@ufs.ac.za. ORCID: 0000-0002-2207-9261

[4] Senior Lecturer, School of Agricultural, Earth and Environmental Sciences, College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Pietermaritzburg, South Africa. Email: MdodaL@ukzn.ac.za. ORCID: 0000-0002-5402-1304

Vol. 52 No. 4, 2024: 128-147
https://doi.org/10.17159/2413-3221/2024/v52n4a18367

Keywords: Adaptation Strategies, Climate Change, Food Security, Livestock

1. INTRODUCTION

Globally, climate change is one of farmers' most significant challenges (Kom et al., 2020). Several climate change models predicted that South Africa would experience temperature increases ranging from 5°C to 8°C (Popoola et al., 2020). Such changes hit smallholder farmers hard since their livelihoods rely on climate-sensitive natural resources (Mdiya et al., 2023). Smallholder livestock farmers in South Africa are adversely affected by current changes in climatic conditions, and it is expected that long-lasting effects will be experienced on livestock production (Mukwena, 2017; Lottering et al., 2021; Maluleke & Bontsa et al., 2023). This can be attributed to communal livestock production being subjected to limited resources and inadequate access to climate change support materials (Ngarava, 2019; Gwala et al., 2021).

Although climate change is problematic to smallholder farmers, using appropriate adaptation strategies is one of the most promising ways to reduce its associated effects (Lemessa *et al*., 2019). Adaptation to climate change can lead to achieving Sustainable Development Goal (SDG) 13, which calls for urgent action to combat climate change and its impact. However, Popoola et al. (2019) reported that smallholder farmers in communal areas of the Eastern Cape province of South Africa have limited ability to cope with climate change. The main reason for this is that most smallholder farmers can only use short-term adaptation strategies to limit the impact of climate change on agricultural production (Mdoda, 2020). This can be attributed to several factors affecting smallholder farmers' adaptation strategies to climate change (Myeni & Moeletsi, 2020; Mtitsilana et al., 2021; Mangwane & Oluwateyo, 2021). Despite several studies documenting factors affecting smallholder farmers' adaptation strategies to climate change in South Africa, there is still limited understanding of the factors affecting livestock smallholder farmers' adaptation choices. Yet, an in-depth understanding of the determinants of smallholder farmers' choice of adaptation strategies to climate change can help to design appropriate adaptation interventions (Ashraf *et al*., 2014). Therefore, it is against this background that this study is carried out to determine the factors affecting livestock smallholder farmers' choices of adaptation strategies to climate change. This study seeks to answer the following question: What factors affect livestock smallholder farmers' choices of climate change adaptation strategies in Raymond Mhlaba Local Municipality?

Vol. 52 No. 4, 2024: 128-147
https://doi.org/10.17159/2413-3221/2024/v52n4a18367

2. MATERIAL AND METHODS

2.1. Description of the Study

The study was conducted in Raymond Local Municipality in the Eastern Cape Province of South Africa focusing on Gaga, Gqumashe, Dyamala, and Ncera villages. The municipality has a total population of 162 000, with about 70% living in villages and farms (Raymond Mhlaba Local Municipality IDP, 2020). Livestock is the primary agricultural activity for commercial and subsistence farming in Raymond Mhlaba's local municipality (Mukuhlani *et al.,* 2019). Nguni cattle are the most-kept livestock breed in the study area due to their tolerance to harsh climate conditions (Adekunle, 2014).

The research area is a semi-arid region, with annual rainfall ranging from 425.5mm to 480mm, with most rainfall occurring in the summer (Ehiobu *et al.,* 2020). The temperature ranges from 4 degrees Celsius in the winter to 38 degrees Celsius in the summer (Maroyi, 2017). Raymond Mhlaba Local Municipality is one of South Africa's most vulnerable municipalities to climate change (Hlaiseka *et al.*, 2016). Variable rainfall, frequent droughts, increased vulnerability to food insecurity, and significant land degradation are all characteristics of the studied area (Raymond Mhlaba Local Municipality IDP, 2020).

2.2. Theoretical Framework

Climate change is negatively affecting smallholder farmers in developing countries. As a result of such devastating effects on their productivity, mitigating and adapting to the impacts of climate change, farmers usually adopt several adaptation strategies, with the decision to use a given strategy being directed by the Utility Maximisation Theory and the protection motivation theory of Rogers (1983), which assumes that farmers' intention to adapt depends on the threat appraisal and coping appraisal.

The study adopted a Utility Maximisation Theoretical approach. The theory hypothesises that economic units (farmers) make decisions directed by the anticipated benefit they expect from such a decision amidst a set of constraints. Sankalpa et al. (2022) argued that this theory is an unobservable indicator that a set of observable factors can, however, project. The theory states that the adaptation strategy would only be used if its use's expected net benefits surpass the net benefits from non-use. Different factors influence the choice of each climate adaptation strategy available to farmers. Thus, smallholder farmer's choice of which adaptation strategy

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

to engage in can be based on utility maximisation. If U_{i0} is the utility derived from the adaptation strategies used by farmers, while U_{i1} is the expected utility from the adaptation strategies, then, although not observed directly, the utility that a farmer i derived from adapting a given measure of the farmers responding to climate change (j) can be expressed as:

$$U_{ij} = X_i\beta_j + \tau_{ij} \quad j = 1,2,3; \quad i = 1,\ldots\ldots\ldots,n$$

Where

X_i is a farm-specific function, the factors that influence livestock farmers' choice of adaptation practices to climate variability, β_j is a parameter to be estimated, τ_{ij} is a disturbance term with mean zero and constant variance. The adaptation strategy variable is a multiple response. n = 1, are the individual livestock farmer and j= 1,…J are the alternative adaptation strategies. In this model, we estimate that livestock farmers are rational decision-makers who maximise the utility of adaptation strategies in their farming activities. We also forecast that farmers who face climatic-related stresses in their farming activities will look for adaptation strategies. If farmer i makes the choice of adaptation, in particular, we assume that Uij has the maximum utility among the J adaptation strategies. Prob ($U_{ij} > U_{ik}$)… for all other k ≠ j, the probability of the livestock farmer choosing a specific alternative j is given by the probability that the utility of that substitute to the farmer is greater than the utility to that farmer of all other alternative J.

The study also used the protection motivation theory. Protection Motivation Theory (PMT) is a commonly used framework for understanding responses to triggers that alert persons to a potential threat. This theory connected farmers' perception variables and their adaptation decision-making. The analysis of this theory is to make sure that the linkage does identify perception variables that drive or hinder adaptation decisions. PMT was initially developed to explain the human response to the fear of health threats (Bagagnan et al., 2019). PMT was first developed by Rogers (1975) to describe the effects of health hazards on individuals' attitudes and behaviours. The PMT states that people (farmers) facing a threat will adopt behaviours that protect themselves if they deem the risk of the threat (climate change) to be high (Rippetoe & Rogers, 1987; Chipfupa et al., 2021). The theory assumes that if the loss due to climate change is deemed lower than the cost of adapting, they are expected to maintain the status quo. Otherwise, they will adapt. For some, climate change risks stimulate fear and anxiety, which under the PMT model would be expected to influence attitude change and decision-making towards adaptive practices.

Vol. 52 No. 4, 2024: 128-147
https://doi.org/10.17159/2413-3221/2024/v52n4a18367

2.3. Study Design and Sampling Procedure

This study aimed to determine the factors affecting livestock smallholder farmers' choices of adaptation strategies to climate change in the study area using quantitative and qualitative methods. The study used a cross-sectional survey of 220 livestock farming households. The study used purposive and random sampling to select Raymond Mhlaba Local municipality. The municipality was chosen purposively because it is one of the most vulnerable municipalities in the Amatole District to the impacts of climate change, which is evidenced by the prolonged drought, fluctuating temperatures, and its fragility and sensitivity to climate variability (Mtyelwa et al., 2022). The study employed random sampling to select four villages in Raymond Mhlaba Local Municipality due to their potential for agricultural production (livestock production). Then, a sample of livestock farmers was selected from each of the four villages using proportionality sampling based on the population size. The desired sample size of 220 livestock farmers was purposively selected.

2.4. Data Collection

The survey was carried out using a semi-questionnaire standard. The questionnaire's first part covers farmers' characteristics and accessibility to supporting institutions. Farmers' perceptions of climate change were then related to past trends from weather-related data. Farmers were asked to describe the changes in climate change parameters. These parameters – expressed as changes in mean temperatures, amount of rainfall, the frequency, duration, and intensity of dry spells and droughts, the timing, duration, and intensity of rain, the start/end of growing seasons, the frequency and intensity of storms and floods were analysed in this study compared to 30 years ago. The questionnaire consists of methods of adaptation to climate change and constraints for smallholder farmers to implement adaptation strategies. The questionnaire was pre-tested with 20 farmers in Keiskammahoek to check its reliability and to train enumerators. The survey was conducted from February to August 2019 and involved 220 livestock farmers as respondents.

2.5. Data Analysis

The collected data was coded in Excel and transported to STATA 13 for analysis. The study used descriptive statistics and multinomial logistic regression for analysis. Descriptive statistics such as percentages, graphs, and frequency were applied to analyse the demographic and socioeconomic characteristics of the sample respondents.

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

2.6. Analytical Framework

The study used multinomial logistic (MNL) regression to estimate factors influencing livestock farmers' choice of adaptation strategies in responding to climate change effects in the study area. The MNL model was specified as follows:

$$p(Y = J/X = \frac{exp\ (X\beta_j)}{(1 + \sum_{j=0}^{j} exp\ (X\beta_j)} \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where

βj is a K x 1 vector and j = 1; 2, 3, 4, 5, 6 …….J.

Equation (1) can only provide the direction of the effect of contextual background on choosing a particular adaptation strategy. The marginal effect is attained by distinguishing equation (1) with respect to independent variables of interest. The marginal probability for a typical independent variable was given as:

$$\frac{\partial P\ (Y = J/X)}{\partial X_k} = P(Y = J/X)\left(\beta_{jk} - \sum_{j=0}^{J=1} P_j \beta_{jk}\right) \ldots\ldots\ldots 2$$

The study considered adaptation strategies such as the use of a mixed crop-livestock farming system (MCL), herd destocking (HD), concentrated supplementary feeding (CSF), dipping of livestock in liquid treatments (DL), vaccination of livestock (VL), construction of shade to reduce heat (CS), and lastly, water harvesting and storage (WHS). The study's application of information on climatic and weather inconsistency was a base outcome. To guarantee that the study's results are robust, the study carried out the following tests to evaluate the occurrence of heteroskedasticity and multicollinearity. Through the Breusch Pagan, White Cameron, and Trivedi Decomposition tests, the study found changeable variances (heteroskedasticity) over various dependent variables.

TABLE 1: Variables Used in the Model

Variable	Description	Measurement	Expected sign
Dependent variable			
Independent variables			
X_1	Gender of the farmer	1= male, 0 = otherwise	-
X_2	Age of the farmer	Actual years	-
X_3	Marital status of the farmer	1= married, 0 = otherwise	+

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

X_4	Family size of the farmer	1 = > 4, 0 = otherwise	+
X_5	Years spent in school by the farmer	1= actual years spent in school, 0 = otherwise	+
X_6	Household source of income by the farmer	1= social grants, 0 = otherwise	-
X_7	Farming years by the farmer	Actual years of farming	+
X_8	Distance to the agricultural marketing center	1= 10 km, 0 = otherwise	-
X_9	Access to extension agents by the farmer	1= access to extension agents, 0 = otherwise	+
X_{10}	Access to a financial institution by the farmer	1= access to finance, 0 = otherwise	-
X_{11}	Member of farm organization	1= member of farm organization, 0 = otherwise	+
X_{12}	Household monthly income	1=> 1500, 0 = otherwise	+
X_{13}	Occupation by the household head	1= full time farmer, 0 = otherwise	+
X_{14}	Knowledge of climate change by the farmer	Dummy, 1 = have knowledge of climate change, 0 = otherwise	+
X_{15}	Access to climate information by the farmer	Dummy, 1 = access to climate information	+
X_{16}	Farmer perceive climate change	Dummy, 1 = increase in rainfall and decrease	+

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

		in temperature, 0 = otherwise	
X_{17}	Farmer adaptation strategies to climate change	Dummy, 1 = adapting to climate change, 0 = otherwise	

3. RESULTS

3.1. Demographic Characteristics of Livestock Farmers

The results in Table 2 show that most livestock producers in the study area were predominantly male (63%). These results were in line with Mdoda and Mdiya (2022) and Dasmani et al. (2020), who indicated that males dominate livestock farming more than their female counterparts. This could be attributed to the fact that males are landowners and heads of the family who make family decisions. The average age of the farmers was 47 years, and they had a family size of 6 persons per household. These results align with Ahmed and Ahmed (2019), who highlighted that livestock farming belongs to the productive workforce with the provision of family labour. About 53% of the respondents in the study area were married and, thus, played a crucial role in farm decisions and providing family labour to assist in many farm activities. The total number of livestock units owned by farmers was 50. Livestock was strictly used for subsistence and sales as they generated livelihoods from practising agricultural activities.

The results further revealed that livestock farmers spent an average of 11 years in school, equivalent to secondary education. This suggests that farmers were literate and could read and interpret climate information for the betterment of the farm. These results agree with Mdoda (2020) that smallholder farmers are well educated, given an average of 10 years or more spent in school, which increases their knowledge and awareness about climate change to adapt to changing weather. Farmers had about 12 years of farming experience. This is important as it helps to transfer knowledge and expertise to young farmers for continuity and sustainable livestock production. Household monthly income from social grants and livestock sales was ZAR 6 345.21, which was crucial in sustaining the farm and household expenses. About 64% of livestock farmers indicated access to extension services, including climate information and new farming techniques. However, 65% of the farmers indicated limited access to credit support depending on social grants to sustain their farming.

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

TABLE 2: Characteristics of Livestock Smallholder Farmers

Variable	**Frequency**	**percentage**
Gender		
Male	139	63
Female	81	37
Marital Status		
Windowed	29	12
Married	116	53
Single	75	34
Access to credit		
Yes	77	35
No	143	65
Access to extension services		
Yes	141	64
No	79	36
Variable	**Mean**	**T-test**
Age	47.08 (8.90)	0.034**
Years spent in school	11.30 (9.10)	0.015**
Total Livestock size (TLU)	50.36(11.45)	0.008***
Family size	5.51 (2.31)	0.008***
Farm experience	12.32 (9.34)	0.087
Distance to markets and institutes	25.10 (6.10)	0.023**
Household monthly income	6 345.21 (4.32)	0.015**

3.2. Livestock Smallholder Farmers' Perception of Climate Change

Climate change is a global phenomenon that affects smallholder farming negatively. Livestock farmers in the study area were not an exception, and they perceived some noticeable changes in weather forecasts over the past 12 years. Figure 3 demonstrates the perception of climate change noticed by farmers. Livestock farmers have noticed a decline in rainfall patterns over

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

the past years, which resulted in prolonged drought, especially in the study area, given that the area is a karoo region. This negatively affected livestock farming and grazing pastures. These results agree with Yetisgin et al. (2022) that rainfall patterns have changed over the years, and there is an increase in dry spells due to prolonged drought. The livestock farmers also perceived an increase in average temperatures. Farmers noticed a change in both minimum and maximum average temperatures. These studies agree with Mdoda (2020), Elum et al. (2017), and Mdoda (2015) that average temperatures have increased rapidly both during the day and night, which affects agricultural productivity. As a result of the decline in rainfall and rise in temperature, the drying season has shortened, which poses a serious threat to livestock farming in the study area. The last perceived climate change by livestock farmers was violent winds, which negatively affected agricultural activities, especially livestock farming.

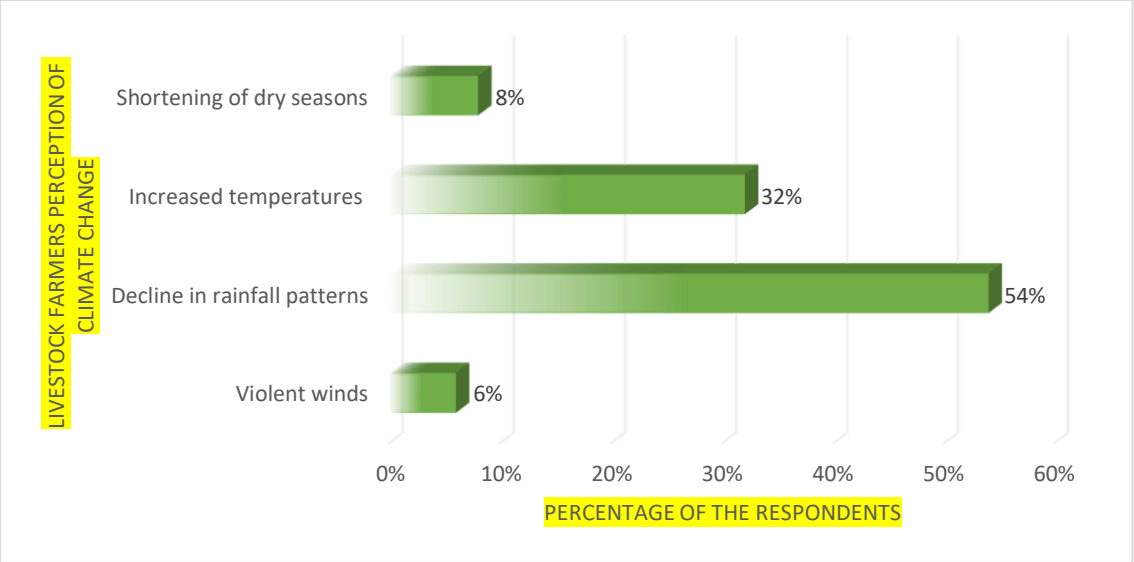

FIGURE 3: Livestock Smallholder Farmers' Perception of Climate Change

3.3. Perceived Effect of Climate Change on Livestock Farming

Livestock farmers do perceive changes in climate change. As a result, most farmers indicated the direct impacts of climate change on livestock production and productivity. Table 3 below shows the perceived impact of climate change on livestock farmers in the study area. A decrease in grazing pastures was the first impact noticed by farmers, as available pastures are not suitable for livestock. The changes in weather conditions have affected grazing's carrying capacity. Climate change has impacted the dry matter content as well as the nutritional value of grazing pastures; as a result, they are reduced to a great extent due to the damaging impacts of climate change, mainly due to the rise in temperature and increased levels of CO2

Vol. 52 No. 4, 2024: 128-147
https://doi.org/10.17159/2413-3221/2024/v52n4a18367

concentration in the atmosphere. These results aligned with Akshit et al. (2020), who stated that an increase in average temperatures negatively reduces fodder production and grazing pastures. The study results revealed an increase in livestock deaths (70%) due to the prolonged drought, which resulted in the dryness of rivers and dams that provide livestock with water and shortages in grazing pastures.

Climate change has resulted in increased livestock pests and diseases (66%) and increased land degradation (68%), which negatively affect the availability of grazing pastures for livestock. These results were in line with Fadina and Barjolle (2017). The results further revealed that climate change has increased by dry spells because of prolonged drought and a decline in rainfall, which has consequently affected livestock production. Lastly, there is an increase in feed shortage due to changes in the distribution, and the amount of rainfall has affected the agricultural system in the area.

TABLE 3: Distribution of Respondents by the Perceived Effect of Climate Change

Perceived effect of climate change	**Percentage**
Increased livestock pests and diseases	66%
Increased land degradation	68%
Decrease in grazing pastures	78%
Increase in dry spells	64%
Increase in livestock deaths	70%
Increase in a feed shortage	60%

3.4. Livestock Smallholder Farmer's Adaptation Strategies Employed

The study results revealed seven adaptation strategies frequently used by livestock farmers in response to the effects of climate change on their farming activities. The strategies adopted by farmers were mainly to reduce the effects of prolonged drought, which dominates the study area and affects farmers. Figure 4 illustrates strategies adopted by livestock farmers in the study area. Forage cropping was livestock farmers' most dominant adaption strategy (78%). Livestock farmers believed that herd destocking (70%) was the second most used adaptation strategy by livestock farmers. Other adapted strategies were vaccination of livestock (68%), dipping of livestock in liquid treatments (66%), constructive shade to reduce heat (64%), concentrated supplementary feeding (64%), and lastly, water harvesting and storage (58%).

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

The use of constructive shade to reduce heat is the most common among smallholder farmers as it is easy to build and less expensive (Mdoda et al., 2020). These adaptation strategies were the multiple strategies livestock farmers adopted to enhance livestock productivity in the study area.

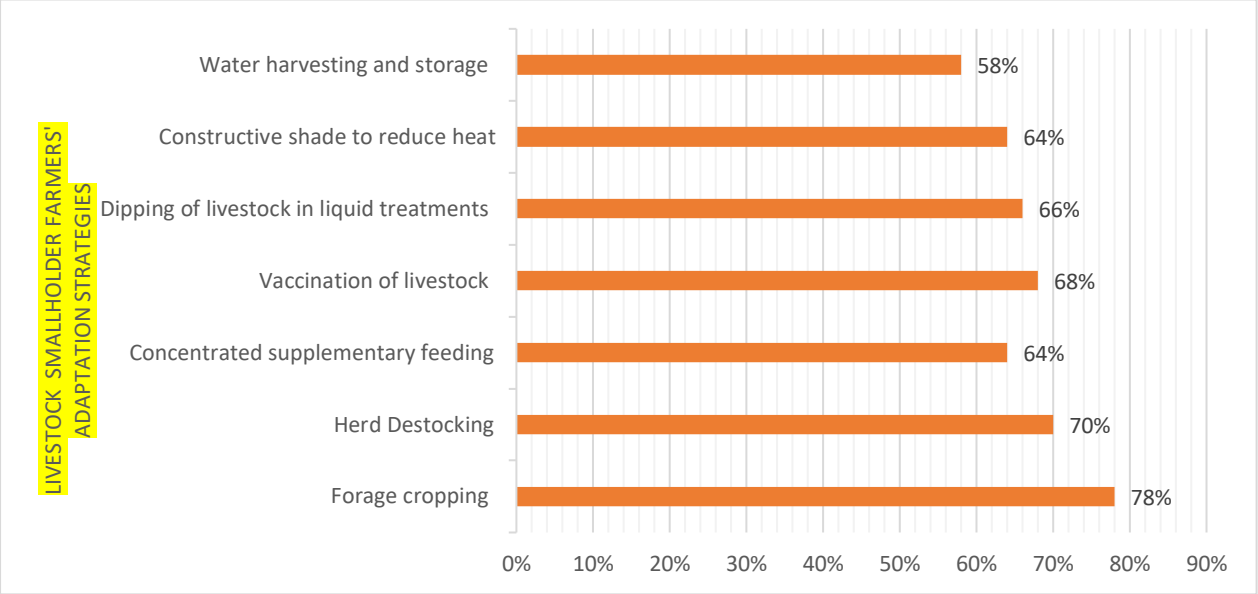

FIGURE 4: Demonstrating Choice of Adaptation Strategies by Livestock Smallholder Farmers

3.5. Challenges Faced by Livestock Smallholder Farmers While Employing Adaptation Strategies

Meanwhile, livestock farmers respond to climate change by adopting various adaptation strategies. They were challenged by different barriers that made adaptation difficult. The result presented in Figure 5 revealed that the most important barriers were poor access to climate information, limited financial capital, and conflict over grazing and resources, which were significant barriers to effective adaptation to climate change. From the study results, it can be revealed that livestock farmers had poor access to climate information, which limited their adaptation capabilities and suddenly forced them to rely on other farmers for information. The second challenge was financial capital, which is a challenge not only in this municipality but also in almost all the smallholder farmers in the Eastern Cape Province, of which this study area forms part. Due to the nature of farming, smallholder farmers find it hard to access financial support. Livestock farmers lack financial capital, which is crucial to purchasing farming inputs, attending training to increase climate change awareness, and investing in innovative technology designed to mitigate climate change. Lastly, livestock farmers were

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

experiencing conflict over grazing land and resources as most farmers did not agree to using allocated grazing pastures for certain periods.

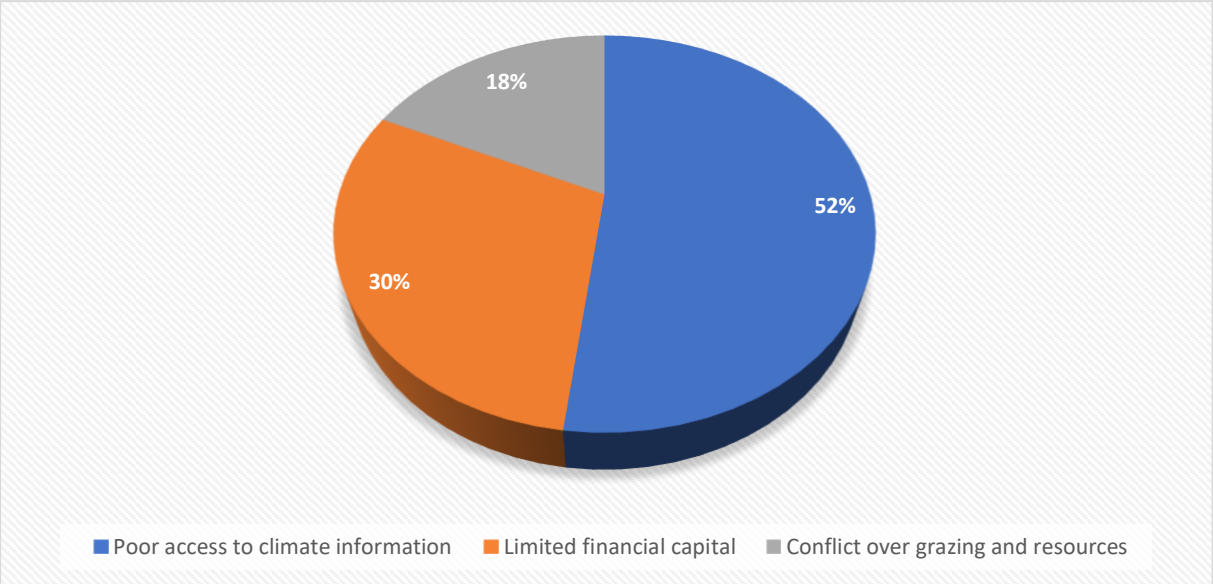

FIGURE 5: **Barriers to Adaptation to Climate Change by Livestock Farmers**

3.6. Factors Influencing the Choice of Adaptation Strategies Employed by Livestock Smallholder Farmers

The multinomial logit model was used to estimate the determinants of livestock farmers' choices of adaptation strategies to climate change effects. Table 4 presents the estimated coefficients of the MNL model, along with the significance levels. The study used water harvesting and storage as a subjective base category for the multinomial logit model fit. The likelihood ratio statistics specified by chi-square statistics were highly significant ($p < 0.000$), signifying the model's strong explanatory power. It was distinguished that the parameter estimates of the MNL model provided only the direction of the effect of the independent variables on the dependent variables and did not represent the actual magnitude of change of its probability. As stated in the hypotheses above, the multinomial logistic regression model results showed coefficient estimates surveyed the expected signs.

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

TABLE 4: Parameter Estimates of Multinomial Logit Model for Climate Change Adaptation Decision

Variables	**Forage cropping**	**Herd destocking**	**Vaccination of livestock**	**Dipping of livestock in liquid treatments**	**Constructive shade to reduce heat**	**Concentrated supplementary feeding**
Years spent in school	0.389 ** (0.456)	1.773*** (0.550)	0.172** (0.033)	0.298** (0.086)	0.252** (0.032)	0.891*** (0.045)
Age	0.618 (0.446)	-0.178 ** (0.031)	0.512 (0.331)	-0.290 ** (0.127)	0.341 (0.212)	1.076 *** (0.024)
Total Livestock Units	0.415 ** (0.207)	0.317 *** (0.046)	0.242** (0.131)	0.279 ** (0.112)	-0.620 ** (0.427)	1.019 *** (0.006)
Access to extension services	1.196*** (0.557)	0.628 ** (0.410)	0.264 ** (0.098)	0.721 ** (0.453)	0.420 (0.275)	1.230 *** (0.489)
Household income	0.754 ** (0.430)	0.293 (0.167)	0.559 (0.368)	0.481 (0.299)	0.365 (0.189)	0.606** (0.294)
Climate change awareness	0.508 ** (0.368)	1.189 *** (0.632)	0.541 ** (0.360)	1.078 *** (0.752)	0.408 (0.273)	0.965 ** (0.628)
Constant	−2.455 (0.043)	−1.717** (0.078)	2.504** (0.042)	−1.884 (0.118)	−1.252*** (0.991)	1.537** (0.017)
Log Likelihood : -175.473	*Number of observations: 220*	*LR chi^2 (70): 128.16*	*Prob > chi^2: 0.0000*	*Pseudo R square 0.590*	*The base category: water harvesting and storage*	

Note: * and ** are Significant at 1% and 5% probability levels, respectively.**

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

Multinomial logistic regression analysis was estimated to determine the factors influencing smallholder farmers' choice of adaptation strategies to cope with the effects of climate change (Table 4). The results indicated that years spent in school by farmers had a positive coefficient and was statistically significant at a 1% level for herd destocking and concentrated supplementary feeding while was significant at 5% for forage feeding, vaccination of livestock, dipping of livestock with treatment effect, and constructive shade to protect heat. This implies that a unit increase in years spent in the school year will increase the probability of farmers adapting to climate change. This is because spending more years in school increases farmers' knowledge about innovations being implemented and increases farmers' awareness about climate change and information about agricultural techniques used. These results agree with Kangogo et al. (2021) and Belay et al. (2017) that education received by farmers through spending more years in school increases the adoption rate of new technologies based on their awareness of the possible benefits of the planned climate change adaptation measures. These results further agree with Mdoda (2020) that educated farmers have a better adaptation rate to climate change effects than less educated and illiterate farmers.

The farmer's age is very important in farming and is also used as a proxy for farm experience. The farmer's age had negative (herd destocking and dipping of livestock with treatment) and positive (concentrated supplementary feeding) coefficients. The age variable was significant at 1% for concentrated supplementary feeding and 5% for herd destocking and livestock dipping with treatment. These results mean that an additional year in farmers' age will result in farmers decreasing their chances of choosing herd destocking and dipping of livestock with treatment as adaptation strategies. On the other hand, an increase in farmers' age will increase the chances of choosing concentrated supplementary feeding as an adaptation strategy. Livestock farmers with many years of experience in livestock rearing were more aware of climate change and its effects and are developing adaptation strategies. The increase in the age of farmers also increases the farming experience of farmers, which plays a key role when it comes to farm operations as well as in observing changes over time so that they compare them to current climatic conditions, allowing them to respond by developing strategies to mitigate effects of climate change. The reason for the reduction in the selection of herds for the destocking and dipping of livestock by farmers is that most livestock farmers do not have herdsmen to assist them with their livestock. So their best way is to decrease that with the experience they have while, on the other hand, they select concentrated supplementary feeding as they can quickly

Vol. 52 No. 4, 2024: 128-147
https://doi.org/10.17159/2413-3221/2024/v52n4a18367

adapt due to the reduced work required. These results agree with Idrissou et al. (2020) and Feleke et al. (2016) that as farmers get older and more experience, they will choose to concentrate on supplementary feeding for their livestock rather than selecting other adaptation strategies as they know what is best for their livestock.

Total livestock unit was another significant variable at 1% and 5%, respectively. The TLU had a negative coefficient for constructive shade to reduce heat while a positive coefficient for concentrated supplementary feeding, forage feeding, livestock vaccination, and livestock dipping with liquid treatment. These results imply that a unit increase in TLU by 1% will induce a decrease in choosing a constructive shade to reduce heat as an adaptation strategy. In comparison, an increase of 1% in TLU will induce an increase in choosing concentrated supplementary feeding, forage feeding, livestock vaccination, and livestock dipping with liquid treatment as adaptation strategies by livestock farmers. These results agree with Menghistu et al. (2021), Gebru et al. (2020) and Idrissou et al. (2020) that changing climatic conditions have forced farmers to think otherwise due to unsatisfactory feed resources and grazing available as well as finance maintaining pastures and dipping tanks being insufficient enough, these strategies of reducing herd, focus on concentrated feed, dipping with treatment, vaccination of livestock and forage cropping is the only adaptation strategies which smallholder livestock farmers can afford.

Household income had a positive coefficient and was significant at a 5% level for forage cropping and concentrated supplementary feed. This suggests a positive relationship exists between household income to forage cropping and concentrated supplementary feed. This implies that a unit increase of additional ZAR 1 in farmers' household income will induce an increase in choosing forage cropping and concentrated supplementary feed as adaptation strategies. This is because livestock farmers can afford to purchase forage cropping and concentrated supplementary feed. Household income increases the financial resources of farmers, and their capacity to take care of their animals also increases. These results agree with Menghistu et al. (2021) that household income plays a crucial role in livestock farmers' adaptation strategies based on their financial resources.

Access to agricultural extension services is very important for farming and is crucial in disseminating information. The study results reveal that access to extension services had a positive coefficient and significance at a 1% and 5% level, respectively, of all adapted

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

strategies by livestock. This implies that farmers with access to extension services will likely adapt to climate change due to available information provided by extension agents. This is because livestock farmers are constantly receiving more frequent agricultural extension services, and they are up to date, which makes it easier for these farmers to adopt forage feeding, vaccination of livestock, dipping of livestock with treatment effect, and constructive shade to protect heat, herd destocking and concentrated supplementary feeding as adaptation strategies. Access to agricultural extension services benefits livestock farmers by providing climate-related information that increases their chances of adapting to climate change (Mdoda, 2020). These results agree with Zeleke et al. (2022) that having access to extension services increases the likelihood of livestock farmers adopting multiple adaptation strategies to enhance livestock production.

Climate change awareness had a positive coefficient and was statistically significant at 1% and 5% levels, respectively, for adaptation strategies by livestock farmers. This implies that a unit increase of 1% in climate change awareness induces an increase in livestock farmers' choice of adaptation strategies. Smallholder livestock farmers who perceive changes in climate change are most expected and observed to use adaptation measures. These results agree with Gebru et al. (2020) that climate change awareness plays a crucial role in making farmers aware of climate change and using adaptation strategies in their farming.

4. SUMMARY AND CONCLUSION

The study revealed that over the past ten years, farmers have observed a decline in rainfall and an increase in temperatures. This led to prolonged drought events, which negatively affected livestock farming by deteriorating conditions of grazing pastures, increased livestock pests and diseases, and a high mortality rate in the stock. Additionally, the results showed that most smallholder livestock farmers used several adaptation strategies to cope with climate change disasters: forage cropping, herd destocking, livestock dipping, and shade construction. The study also revealed that socioeconomic factors such as age, education level, household income, and access to agricultural extension services influenced livestock smallholder farmers' choice of adaptive strategies in response to the effects of climate change. Therefore, a conclusion drawn from the study is that socioeconomic determinants and access to agricultural extension services play a significant role in smallholder farmers' choices of adaptation strategies to climate change. This study recommends the need for policies and programs addressing

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

socioeconomic inequality while improving smallholder farmers' access to agricultural extension services.

5. ACKNOWLEDGMENTS

The authors would like to humbly appreciate the farmers for providing enough information during data collection. Additionally, we are very grateful to the enumerators who assisted during data collection.

6. COMPETING INTEREST STATEMENT

The authors declare no conflict of interest.

REFERENCES

ALEMAYEHU, A. & BEWKET, W., 2017. Determinants of smallholder farmers' choice of coping and adaptation strategies to climate change and variability in the central highlands of Ethiopia. *Environ. Develop.*, *24*: 77-85.

ASRAT, P. & SIMANE, B., 2018. Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. *Ecol. Process.*, 7: 7.

BONTSA, N.V., GWALA, L., NGARAVA, S., MDIYA, L. & ZHOU, L., 2023. Quality of climate change extension services provided to smallholder farmers in Raymond Mhlaba Local Municipality, Eastern Cape Province, South Africa. *S. Afr. J. Agric. Ext.*, *51*(2): 114-127.

CHENG, M., MCCARL, B. & FEI, C., 2022. Climate change and livestock production: A literature review. *Atmosphere.*, *13*(1): 140.

GWALA, L., YUSUF, SFG. & MONDE, N., 2021 Perceptions of communal livestock farmers of institutional support for climate change measures in Amathole District, Eastern Cape, South Africa. *J. Crit. Rev.,* 8(3): 435-447.

KOM, Z., NETHENGWE, N.S., MPANDELI, N.S. & CHIKOORE, H., 2020. Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. *GeoJournal*, pp.1-24.

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

MALULEKE, W. & MOKWENA, R.J., 2017. The effect of climate change on rural livestock farming: Case study of Giyani Policing Area, Republic of South Africa. *S. Afr. J. Agric. Ext.*, *45*(1): 26-40.

MANGWANE, Q. & OLUWATAYO, I.B., 2021. Determinants of climate variability adaptation and mitigation strategies harnessed by smallholder maize farmers in Sebayeng village, Limpopo Province, South Africa. *Food Res.*, 5(2): 410 - 417.

MDODA, L., 2020. Factors influencing farmers' awareness and choice of adaptation strategies to climate change by smallholder crop farmers. *J. Agribus. Rural Dev.*, *58*(4): 401-413.

MDIYA, L., ALIBER, M., NGARAVA, S., BONTSA, N.V. & ZHOU, L., 2023. 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. *S. Afr. J. Agric. Ext.*, 51(2): 150-166.

MKONDA, M.Y., HE, X. & FESTIN, E.S., 2018. Comparing smallholder farmers' perception of climate change with meteorological data: experience from seven agroecological zones of Tanzania. *Weather Clim. Soc.*, 10(3): 435-452.

MTINTSILANA, O., AKINYEMI, B.E. & ZHOU, L., 2021. Determinants of adaptation to climate variability among farming households in Tyhume Valley communities, Eastern Cape province, South Africa. *Int J Clim Chang Str Mange.*, 13(2): 1756-8692.

MTYELWA, C., YUSUF, S.F.G. & POPOOLA, O.O., 2022. Adoption of in-field rainwater harvesting: Insights from smallholder farmers in Raymond Mhlaba Local Municipality, Eastern Cape province, South Africa. *S. Afr. J. Agric. Ext.*, 50(2): 81-100.

MYENI, L. & MOELETSI, M.E., 2020. Factors determining the adoption of strategies used by smallholder farmers to cope with climate variability in the eastern free state, South Africa. *Agric.*, 10(9): 410.

TARUVINGA, A., KAMBANJE, A., MUSHUNJE, A. & MUKARUMBWA, P., 2022. Determinants of livestock species ownership at household level: Evidence from rural OR Tambo District Municipality, South Africa. *Pastoralism.*, 12(1): 1-11.

https://doi.org/10.17159/2413-3221/2024/v52n4a18367

TESSEMA, Y.A., JOERIN, J. & PATT, A., 2018. Factors affecting smallholder farmers' adaptation to climate change through non-technological adjustments. *Environ. Develop.*, 25: 33-42.

S. Afr. J. Agric. Ext. Gcaba, Christian & Usapfa
Vol. 52 No. 4, 2024: 148-165
https://doi.org/10.17159/2413-3221/2024/v52n4a18386

Does the Adoption of Genetically Modified Seeds Improve the Technical Efficiency of Family-Owned Maize Farms? A Case of Alfred Nzo in the Eastern Cape

Gcaba, K.[1], Christian, M.[2] and Usapfa, L.[3]

Corresponding Author: K. Gcaba. Correspondence Email: kgcaba48@gmail.com

ABSTRACT

This study mainly focused on measuring maize farmers' technical efficiency and impact on maize production in Eastern Cape province. This research has employed a formal survey conducted on a sample size of 164 farmers. Data was collected using a semi-structured questionnaire. Mean, standard deviation, frequencies and percentages were used for descriptive statistics to examine the socioeconomic characteristics of family-owned maize farms. The stochastic frontier model was also used to estimate the technical efficiency of family-owned maize farms under present conditions. The results have shown that the socioeconomic characteristics of farmers largely influence accessibility and awareness to these kinds of technologies. The adoption is delayed due to limited farmer support, lack of awareness, scepticism about these technologies within rural households, and poor perceptions and attitudes. Furthermore, the results have revealed that socio-demographic characteristics influence farmers' decisions on whether or not to adopt the technology. Most farmers are old and still believe in what works for them, which limits and elongates the adoption process. The empirical analysis shows that adopting genetically modified seeds enhances the productivity of family-owned farms. Furthermore, this study finds that the technical efficiency of adopters is higher compared to non-adopters. Therefore, this study recommends that strategic alliance is an important and necessary condition for farmers to adopt genetically modified technologies.

[1] Student. Department of Agricultural Economics and Extension, North-West University, Private Bag X2046, Mmabatho 2735, South Africa. Email: kgcaba48@gmail.com. ORCID: 0000-0001-7023-5110

[2] Associate Professor. School of Agricultural Sciences, University of Mpumalanga, Cnr R40 and D725, Mbombela 1200, South Africa. Email: mzuyanda1990@gmail.com. ORCID: 0000-0003-4446-0298

[3] Lecturer. Department of Agricultural Economics and Extension, North-West University, Private Bag X2046, Mmabatho 2735, South Africa. Email: luvhengousapfa@gmail.com. ORCID: 0000-0003-0599-5505

Vol. 52 No. 4, 2024: 148-165
https://doi.org/10.17159/2413-3221/2024/v52n4a18386

Keywords: Adoption, Genetically Modified Seed, Technical Efficiency, Family-Owned Maize Farms.

1. INTRODUCTION

In South Africa, maize is a significant food crop grown primarily for human and animal consumption. It is also the largest locally produced agronomic crop. The agricultural sector significantly depends on agricultural production to sustain their standard of life in South [4]Africa and other African nations (Mabaya *et al.,* 2015). However, Yokamo (2020) and Zanu *et al.* (2012) asserted that smallholder farmers only grow maize to feed themselves and the livestock they are raising, and they solely produce maize primarily to improve their household's standard of living and to maintain their household's livelihood.

The district's primary economic activity is agriculture; however, it has little potential for growth because most farming methods are strictly traditional subsistence farming (Fadeyi *et al.*, 2022). Having that confirmed, some common obstacles smallholder maize farmers face include access to production inputs, advanced technology, limited access to technology and resistant maize seeds, extension and advisory services, and stable markets (Tarus, 2019).

Insufficient agricultural value chain operations are closely related to maize producers in the Eastern Cape (Dos *et al.,* 2003). Small-scale farmers are primarily involved in the primary production of agricultural products and are increasingly distancing themselves from all activities involved in agricultural product value addition. As a result of inadequate farm technology use, it is challenging to satisfy domestic or local market demands. Adoption of genetically modified seeds can benefit family-owned farmers' maize production by increasing their yields and sustaining their maize production, which reduces poverty and fosters economic growth and development in the district and at the provincial level.

2. DEFINITION OF THE PROBLEM

Household food production is argued to remain crucial for sustainable food security and poverty alleviation strategy for many households in many developing countries. Parts of South Africa are evidence of that stabilised food production strategy, but a need to adopt genetically modified seeds by these family-owned maize farmers challenges its success. However, to

Vol. 52 No. 4, 2024: 148-165
https://doi.org/10.17159/2413-3221/2024/v52n4a18386

overcome challenges nullifying the idea of adopting genetically modified seeds by family-owned maize farmers, collective action is necessary as the formation of cooperatives to such an extent that acquiring resources can easily be attained by these farmers. The main goal of encouraging maize farmers to form groups for cooperative farming is to recognise the value of working together to increase farm productivity and profitability.

In addition to being the main economic activity and a sector that feeds the world, agriculture supports many households, which helps ensure household food security. Fresh evolution is kicking in more strongly within the agricultural sector, with maize crops being a widely produced agricultural product in various locations and corners of South Africa. Securing farming supplies, machinery, inputs, and resources is a component. However, some issues prevent farmers from expanding agricultural output because of limited or improper technology adoption and use. Issues like inadequate infrastructure development and a lack of funding destroy the idea of household food sustainability. These elements contribute to low farm profitability, resulting in inadequate income generation and hinder farmer growth. By bringing new farming knowledge that links farmers to innovation and technology, nations worldwide are competing to modernise agriculture (Sahgal, 2021). However, several regions of South Africa continue to produce the least quantity of maize, especially in the province of the Eastern Cape (Statista, 2022).

Hence, conducting this study is of paramount importance, with that being the case this study seeks to improve and encourage family-owned maize farmers to adopt genetically modified seeds in the study area.

3. LITERATURE REVIEW

3.1. Overview of Maize Production in South Africa

The agricultural sector worldwide is the most viable sector with the potential to feed its population. Maize is a staple crop, primarily produced in many parts of the world, that conforms to adaptability to weather conditions. According to Benz (2001), maize or corn is a cereal grain first domesticated by indigenous people in Southern Mexico about 10000 years ago. Maize has become a staple food massively produced worldwide, consumed directly by humans, and used as animal feed. Other countries preferably and broadly use maize products to produce other by-products through undergoing value chain processes such as corn ethanol. Varieties of maize are produced at an international level and undergo different stages of agricultural value chain

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

activities whereby production, processing and other value chain activities occur. In other countries, maize is not only consumed by people and animals; as far as maize is concerned, it also produces environmentally friendly maize products such as ethanol and other biofuels. However, maize production was strictly traditional back then in most African countries and other international countries. Nowadays, industrialisation and evolution are taking place; new information is inventing new ways of production, including advanced technology usage.

Moreover, the cultivation of maize is relatively supported by massive investment in technology, and farmers are called upon to adopt new technologies and innovations. Back then, maize cultivation was achieved through simple and traditional knowledge of indigenous knowledge systems that do not require technology. Hence, the government and other policy structuring bodies ve developed policy intervention strategies that will improve maize production for economic growth in a manner that will improve poor rural farmers by generating income through acting as an employer.

3.1.1. Attributes of Family-Owned Farms in the Eastern Cape

Formation of agricultural cooperatives has been widely promoted as an agricultural development policy initiative to assist farmers in coping with the challenges that arise in the production process, such as access to proper technology, proper storage facilities, availability of resources, limited access to production inputs, output markets, availability of credit facilities, and inadequate extension services. According to Wossen et al. (2017), there is well-documented empirical evidence on the roles of agricultural cooperatives in enhancing the adoption of improved agricultural technologies and involvement in agribusiness practices. Abebaw and Haile (2013) have asserted that if cooperative or group farmers are not supported by the provision of adequate extension services, resource availability, accessibility to reliable markets, investment in technology, and improved infrastructure, the idea of forming a cooperative is most likely to go into the drain with no desired objectives that are met.

3.1.2. Lack of Farming Resources

Acquiring farming resources has become the constraint limiting maize cooperative farmers from outperforming; hence, that is the priority that government institutions and other non-governmental organisations are focusing on, which is trying to put equitable measures in helping farmers acquire the required farming resources on their respective farms. A sudden

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

decline in agricultural production contributes to poverty and food insecurity; hence, the government has introduced an Economic Recovery Plan (ERP) to enhance the agricultural sectors and its players. One of the critical factors in achieving and bridging the gap of poor accessibility to farming resources is to make it environmentally suitable.

3.1.3. Incompetent Family Members

According to the National Development Plan (NDP), agricultural cooperatives can effectively handle rural farmers' challenges by addressing concerns like food insecurity, poverty, and easy access to resources. According to Sabir et al. (2012), cooperatives can address all the concerns at once by obtaining economies of scale, adopting innovations and technology, and involving communities in agricultural development. Incompetent cooperative members sabotage the entire concept of group farming and the easy acquisition of farming resources such as land, equipment, and machinery and access to agricultural consultancy services. Because the costs are regulated and shared among the members, all the above benefits are readily available when farmers pool their resources.

3.1.4. Lack of Agricultural Capital

Inadequate agricultural capital remains one of the challenges tempering the farming progress of many farmers; availability of capital can positively contribute to increased economic growth, rural development, and improved farm income. According to the study conducted by Huger (2016), lack of capital poses a major barrier to technology adoption by cooperative members.

3.1.5. Aging Population

According to Hu and Zlong (2012), the agricultural sector is predominantly controlled by elderly people. Several obstacles, such as hampering farming activities and an ageing workforce, have a detrimental influence on the sector. According to Bates et al. (202)), older workers are less productive on average, and labour force ageing negatively influences output productivity. According to a study conducted by Li and Zhao (2009), the ageing of the agricultural labour force is detrimental to the total development of agricultural productivity. Youth are said to be distancing themselves from farming activities because of this literature; farming is becoming more commercialised due to this new information and dissemination of advanced farming techniques and technologies, and older people are finding it difficult to adapt

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

to this new change. As a result, the need for rural youth to be included in the farming sector is critical and can be helpful to the overall industry.

3.2. Determinants of Technology Adoption by Smallholder Farmers

Smallholder farming is essential for enhancing food security and reducing hunger, although smallholder farmers tend to use technology sparingly. Farm household characteristics and institutional features are two elements that affect how smallholder farmers adopt new technologies. Technology adoption is governed by several factors, with farmer choice being the primary one, according to Mwangi and Kariuki (2015). Introducing a particular technology does not ensure acceptance of the technology (Mwangi & Kariuki, 2015). Farmers can take their time adopting a specific technology, which is hampered by their ability to do so. As a result, affordability or the farmers' economic standing impacts their acceptance, and farmer perception of new technology is a key requirement for adoption.

However, other variables linked to agricultural technology adoption include institutional, technological, and human-specific economic variables (Fadeyi et al., 2022). A large farm size may favour adopting a particular technology, according to Anang (2018), who identified the farm as one of the factors determining technology adoption. Most research has used a farmer's degree of education, age, gender, and household size to evaluate their use of technology (Anang, 2018).

3.3. The Impact of Technology Adoption on Technical Efficiency of Family-Owned Maize Farms

The fundamental goal of technology adoption is to increase farm earnings while also meeting the needs of customers who sustainably consume agricultural products. Farming practices are key in ensuring long-term agricultural output by boosting global crop yields to fulfil increased demand for agricultural food due to rising income and alarming population growth. Modern technology is critical to the development of the farming industry, improving food production, and providing farmers with new tools to raise crop yield. In addition, technology is utilised to preserve crops and identify diseases that threaten crops. According to Singh (2014), the employment of modern technology in agriculture has resulted in significant improvements and has had a favourable impact on how people farm and raise food or agricultural products. As a result, agriculture positively impacts a country's GDP and GNP by creating and conserving

Vol. 52 No. 4, 2024: 148-165
https://doi.org/10.17159/2413-3221/2024/v52n4a18386

foreign exchange, reducing import costs, increasing agricultural productivity, and improving farmers' living conditions (Rambe & Khaola, 2021).

4. MATERIAL AND METHODOLOGY

4.1. The Study Area's Description

This study was undertaken in the Eastern Cape's Alfred Nzo District. Umzimvubu and Ntabankulu local municipalities have been chosen to host the study. Alfred Nzo district is one of the nine districts in the Eastern Cape situated on the north-eastern side of the Province of the Eastern Cape and stretches from the Drakensberg Mountains, borders Lesotho in the North, Sisonke District Municipality in the East and O.R. Tambo District Municipality in the South. Agriculture is the main economic activity in the Alfred Nzo district; it has been elucidated that the district has a limited base for financial expansion and agricultural growth since most of the farming is traditional subsistence farming. Commercial agriculture is confined to the area of Cedarville in the northeast of the district. The district contains favourable and conducive weather conditions for the aggressive development of the agricultural sector, and it is very critical to evaluate the potential of agriculture and devise methods of exploiting the untapped agricultural potential. With that information, the district has also been selected as one of the regions to undertake the implementation of Agri park initiatives, as one of the 27 poorest district municipalities in the country (IDP, 2017-2022). Furthermore, all such initiatives were directly in line with the agricultural policy plan and the district grain production master plan, which aimed to increase production levels within the agricultural sector. Hence, the study has developed an interest within the district to call for an urgent agriculture strategy to unlock the sector's hidden potential, particularly in maize production, to revive agriculture and improve farm profitability through a sustainable agricultural value chain supported by technology use.

4.2. Research Approach, Sampling Techniques and Research Design

The main aim of this study is to measure the adoption of genetically modified seeds on the technical efficiency of family-owned maize farmers in the Alfred Nzo district. This study will adopt a mixed-method research approach using both quantitative and qualitative methods to understand better the research problem than using one method. Using mixed research methods is appropriate to address the purposes of the study (Tashakkori & Teddlie, 2021). According to Creswell (1994), the weakness of one research method is nullified by the strength of another research method. Quantitative data will be obtained by administering semi-structured

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

questionnaires, and qualitative data will be obtained through focus group discussions, the internet, and structured interviews.

4.3. Sample Size

According to Dell (2002), sampling is a technique used to select units in each population of interest, and the results obtained can be used to generalise the sampled population. The population in this study is heterogeneous; hence, the sample size will be determined using a suggested formula by Krejcie and Morgan (1970). For a mixed research method, Bell et al. (2010) suggested a rule of thumb, whereas other scholars opined that a sample size between 30 and 500 is suitable for quantitative and qualitative research. Furthermore, a sample size will be obtained from maize farmers in the Alfred Nzo district. This population sampling method is to categorise the two selected municipalities into strata, in which random sampling is applied to select respondents from each stratum. The following formula is used in sampling the size of the respondents:

Where:

n = sample size

X

2= Chi-square value at 95 percent confidence level with 1 degree of freedom (3.84)

N = Population size

P = Population proportion (0.96 percent)

$$n = \frac{X^2 * N * P\ (1-P)}{ME^2 * (N-1) + (X^2 P * (1-P))}$$

Where:

n = sample size

X^2= Chi-square value at 95 percent confidence level with 1 degree of freedom is 3.84

N = Population size

P = Population proportion (0.96 percent)

ME = desired margin of error express as a proportion (0,05)

Taken from the formular above:

$$n = \frac{3{,}84 * 210 * 0{,}96\ (1-0{,}05)}{0{,}05^2 * (210-1) + (3{,}84 * 0{,}96 * (1-0{,}5))}$$

n = 164

4.4. Research Design

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

This study will use a descriptive research design, which is used for collecting and describing data, examining the relationships between variables, and producing models that are appropriate for the study objectives (Creswell, 1994). This study will use surveys, semi-structured questionnaires, and focus group discussions to gather quantitative and qualitative data on the estimation of technology adoption and technical efficiency on family-owned maize farms in the Eastern Cape.

TABLE 1: Table Depicting the Research Design Strategies Being Used

Research strategy	**The type of research questions**	**Requires behavioural events to be under control**	**Focuses on contemporary events**
Experimental research	Who, What, Where, How many	No	Yes/No
Case study	How, why	No	Yes
Interview and Archival analysis	Are, why	No	No

Source: Adopted from Yin (2014)

4.5. Method of Data Collection

To fulfill this study, a structured questionnaire was designed and administered within the area under study. The study questionnaire mainly contained open-ended and closed-ended questions written in English. This study allowed participants to elaborate and support their answers without fear, as it employed explanatory research. Even though the questions were written in English, interpretation occurred where necessary in IsiXhosa and Isimpondo as the local languages.

This study relied on both primary data and secondary data. This study ensured that the sampling techniques were followed and that the data collection process was successfully and lawfully processed, ensuring that the information of participants complied with the Protection of

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

Personal Information Act. The presidency has asserted the POPI Act. Personal information must be processed and acquired.

- Lawfully, and
- In a reasonable manner that does not infringe on the data subject's privacy.

4.6. Method of Data Analysis

Primary data collected from family-owned maize farmers was coded, edited and verified accordingly. Field data was edited to examine those minor mistakes. Data editing and cleaning were done to ensure data accuracy and consistency with other facts gathered, uniformly entered as completely as possible, and arranged in an orderly manner to facilitate coding and tabulation (Kenny, 1998).

The data collected was analysed using different software suitable for data analysis. Therefore, after collecting and gathering data, it was coded and captured in a spreadsheet in Microsoft Excel and exported to SPSS software using various statistical tests and econometric models.

4.6.1. Socioeconomic Characteristics

This study has employed descriptive statistics as an analytical tool for the socioeconomic characteristics of family-owned maize farmers. Descriptive statistics summarise a given data set, representing a sampled population for this study. Descriptive statistics, such as frequencies and percentages, were used to describe the data from the participants.

4.6.2. Stochastic Frontier Model

Measurement of technical efficiency compares the actual performance to the optimum performance or the true frontier. Empirically, the true frontier is unknown; hence, the best practice farmer is used mostly as a proxy for the true frontier. This study will employ the stochastic frontier approach to estimate the technical efficiency of family-owned maize farms under present conditions. The selection of the stochastic frontier approach is based on its ability to account for stochastic noise and the producer's inefficiency simultaneously.

The stochastic frontier production model that Battese and Coelli (1995) propounded in line with the original model by Aligner, Lovell, and Schmidt (1977) is implicitly defined as:

Y_i = f (X_i, β_i) exp ($V_1 - U_1$), I = 1,2,3,n……..

Where:

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

$Y_i =$ output of the maize farms

X_i = vector of input quantities used by the maize farms

β_i = vector of the unknown parameters to be estimated

f_i = represents an appropriate function

V_i = is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer.

U_i = is a non-negative random variable representing inefficiency in production relative to the stochastic frontier.

Specifically, the production (technical efficiency) of a family-owned maize farms will be estimated using Cobb-Douglas production functional form of the stochastic frontier production function model defined as follows:

$L_nY_i = \beta_0 + \beta_1 L_nX_1 + \beta_2 L_nX_2 + \beta_3 L_nX_3 + \beta_4 L_nX_4 + \beta_5 L_nX_5 + \ldots \ldots \beta_n L_nX_n + (V_i - U_i)$

Where:

Y_i = maize output (kilograms/tons)

X_1 = farm size (hectares)

X_2 = labour input (workdays)

X_3 = Maize seeds (kilograms)

X_4 = Fertiliser used (kilograms)

X_5 =Capital input (Rands), measured in terms of depreciation of farm tools or inputs, equipment, interest on borrowed capital, repairs and rent on land.

$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_n$ are the regression parameters to be estimated, and V_1 and U_1 are defined.

It is also assumed that U_i are to be non-negative random variables, independently distributed and arising from the truncation at zero of the normal distribution with variance σ^2 and mean $Z_i\delta_i$ where Z_i is the vector variables which are assumed to explain technical inefficiency, and δ is a vector of the coefficients to be estimated.

TE = Y^*

Y^* = f (X,B) exp (V_i-U_i)

But f (X,B) exp (V_i) = exp (-U_i)

Where:

Y_i is the observed output

Y^* is the frontier output

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

TE = $\partial_0 + \partial_1 Z_1 + \partial_2 Z_2 + \partial_3 Z_3 + \partial_4 Z_4 + \partial_5 Z_5 + \ldots\ldots\ldots \partial_n Z_n$

Where:

TE = is the technical efficiency of the farmer

Z_1 = Household/family income

Z_2 = Household/family size

Z_3 = Cooperative membership

Z_4 = Extension-contact

Z_5 = Farm experience

Z_6 = Educational level

Z_7 = Credit access

Z_8 = Gender of farmer

Z_9 = Market access

Z_{10} = Use of fertiliser and seeds

Z_{11} = Usage of manure

Z_{12} = Use of pesticides

Z_{13} = Cooperative membership

Z_{14} = access to new maize implements

∂_0 = unit of intercept

$\partial_1 \ldots\ldots\ldots\ldots \partial_{12}$ = Parameters to be estimated

5. RESULTS AND DISCUSSIONS

5.1. Demographics and Socioeconomic Characteristics of the Sampled Maize Farmers

The demographic characteristics of farmers are indispensable when analysing economic data because such factors influence farmers' or homesteads' economic behaviour. Demographic characteristics and socio-cultural contexts are important variables as they illustrate the key factors in the socioeconomic analysis of smallholder systems. Table 2 below illustrates the farmer's profile and characteristics in the study area.

5.1.1. Demographic and Socioeconomic Characteristics of Farmers

TABLE 1: Descriptive Statistics

Variable	Mean	Standard deviation
Age	60.702	12.336

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

Level of education	7.322	4.685
Farming experience	11.049	10.997
Household size	4.602	2.460
Capital investment	602	72.53
Variable	**Frequency**	**Percentage**
Gender:		
Male	105	64
Female	59	36

The results showed that most farming households were headed by men, with a share of 64%, compared to 36% of females. These results are consistent with Kibirige *et al. (2016), who state* that men dominate farming in the province, as women care for the family and household chores. Additionally, the average age of the household head amongst smallholder farmers was 60 years, which implies that elderly persons in the study area dominate farming.

The evidence above shows that the level of education also contributes as a cofactor to farmer's ability and in decision-making in whether to adopt or not adopt genetically modified maize seeds; the results showed that the level of education of these farmers has a mean of 7.322, which is a true reflection that most farmers are not literate and being aware alone does not guarantee adoption of technologies of this nature. The level of education attained by a farmer is crucial in understanding the farming dynamics and changes over time within the farming sector; all these play a crucial role in adopting new technologies. Also, the level of education is expected to enhance efficiency. Education contributes to the knowledge farmers acquire, which they can effectively use in their farming operations. Furthermore, the farmer experience has a mean of 11.049, which indicates that these farmers have more experience in farming and know what works best for them. However, innovation to them threatens what they already know, and no one can convince them better than what they know.

In this study, household size was also considered as the number of persons residing with the participants or respondents; the mean household size between the respondents was 4.602. The household size does not indicate the quantity of labour available for households to rely on because it involves every household member. Capital investment also plays a fundamental role in the adoption of new technologies; the results shown in Table 2 have revealed a mean of 602

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

for capital invested, which indicates little investment by these farmers in farming as their income status is not stable due to most of the farmers who rely on old age grant.

5.2. Technical Efficiencies of Adopters and Non-Adopters

TABLE 2: Stochastic Frontier Model Results

SPF model	Pooled		Adopters		Non-adopters		Test of means
	Mean	SD	Mean	SD	Mean	SD	
Unmatched							
Conventional SPF (pooled)	0.561	0.153	0.572	0.132	0.553	0.152	1.043
Conventional SPF (separate)			0.665	0.122	0.558	0.152	10.780***
Selectivity-corrected SPF			0.738	0.082	0.602	0.116	15.082***
Matched							
Conventional SPF (pooled)	0.577	0.155	0.586	0.137	0.570	0.172	0.874
Conventional SPF (separate)			0.665	0.122	0.547	0.170	8.580***
Selectivity-corrected SPF			0.702	0.112	0.556	0.148	9.823***

The table above compares technical efficiency levels generated through the SPF model. The mean difference of TE levels is not statistically significant in the estimation with pooled samples for both the matched and unmatched. Since it has been observed that the production frontier for each group is different through the likelihood ratio test, the comparison of separate estimations between the two groups is more reliable.

The results of all separate estimations suggest that adopters' average TE is higher than that of non-adopters. In the case where unmatched samples are used, the average TE of adopters is 0.665 in the conventional SPF model, higher by 24% than non-adopters.

Vol. 52 No. 4, 2024: 148-165
https://doi.org/10.17159/2413-3221/2024/v52n4a18386

5.3. Factors Influencing the Adoption

Numerous factors influence rates of technological adoption; these factors are the ones that determine whether a farmer can act decisively upon the innovation or technology being introduced to them. With all that being said, a particular technology's diffusion and adoption processes depend on the effectiveness of extension work and how information spreads and reaches the farmers. Even so, appropriate extension methods are the ones that speed up the process of adoption, as farmers are known to adopt technologies and innovations at different levels.

5.3.1. Socioeconomic Characteristics of Farmers

Any adopter incurs a cost in enquiring about a new technology or innovation, and the socioeconomic status of a farmer determines whether a farmer can afford and attain a particular technology. Financial stability in as much as gives hope that a farmer can acquire technology, but it does not guarantee adoption.

5.3.2. Social System

A social system can assist the diffusion of new technology or innovation, but only if the social system is open and when that particular technology does not conflict with the norms and beliefs of the society. Results have shown that the average age of farmers was 60 years and above, which implies that cultural and traditional beliefs bond these farmers; hence, the adoption rate is more likely to be slowed down and delayed due to the nature of these farmers.

5.3.3. Farmer's View on the Nature of the New Farming Technology

As indicated by the demographical characteristics of these farmers, farmers' views about the nature of the technology or innovation play a role in farmers' decisions to adopt or reject a particular technology. In this case, farmers are old, and most are laggards; they believe in what they believe in, and information dissemination and diffusion to them is regarded as a way of spreading information that the farmer considers unhelpful. Sampled farmers believed in what worked best for them.

6. CONCLUSION AND RECOMMENDATION

Therefore, discovering that accessibility and awareness are primarily influenced by the socioeconomic characteristics of farmers, and the adoption of technologies of this nature is

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

being delayed due to issues of limited farmer support, lack of awareness, scepticism about these technologies within the rural households, perception, and attitudes towards these technologies. Furthermore, the results have revealed that socio-demographic characteristics influence farmers' decisions on whether or not to adopt the technology. Most farmers are old and still believe in what works for them, which limits and elongates the adoption process. However, considering all these factors, appropriate extension services and sustainable and improved maize production practices can significantly increase the adoption rate of genetically modified seeds and other technologies to improve farmer's decisions and change perspectives towards these technologies in improving maize yields.

This study recommends that the adoption of specific technology must be accompanied by support; many factors must be considered when introducing a certain technology to farmers. For instance, the gap between smallholders and commercial farmers will always exist. In cases of peasant farmers or disadvantaged farmers, proper evaluation and assessment are needed in a manner that if there is a need for certain farmers to acquire or adopt an introduced technology, the farmer needs to be evaluated and considered as a special case.

7. ACKNOWLEDGEMENT

The authors are deeply grateful to individual and cooperative maize farmers within the Alfred Nzo region for pertaining to and ensuring the availability of this fruitful research study by cooperating and giving us helpful and necessary information. Gratitude also goes to enumerators and local agricultural advisors who assisted in identifying and visiting maize farmers within the study region.

8. CONFLICT OF INTEREST

The authors have no conflict of interest.

REFERENCE

ANANG, B.T., 2018. Farm technology adoption by smallholder farmers in Ghana. *Rev. Agric. Applied. Econ*., 21(1340-2018-5179): 41-47.

BENZ, B.F., 2001. Archaeological evidence of teosinte domestication from Guilá Naquitz, Oaxaca. *Proc Natl Acad Sci*., 98(4): 2104–2106.

https://doi.org/10.17159/2413-3221/2024/v52n4a18386

CRESWELL, J.W., 1994. *Research design: Qualitative & quantitative approaches*. Sage Publications.

DOSS, C.R., MWANGI, W.M., VERKUIJL, H. & DE GROOTE, H., 2003. *Adoption of maize and wheat technologies in eastern Africa: A synthesis of the findings of 22 case studies*. CIMMYT Economics Working Paper 03-06. Mexico, D.F.: CIMMYT.

FADEYI, O.A., ARIYAWARDANA, A. & AZIZ, A.A., 2022. Factors influencing technology adoption among smallholder farmers: A systematic review in Africa. *J. Agric. Rural Dev. Trop. Subtrop*., 123(1): 13-30.

HU, X., & ZHONG, F., 2012. Rural population aging impact on food production—analysis of rural fixed observation point data. *Chinese Rural Economy*., 2012: 47-55.

KENNY, D., KASHY, D. & BOLGER, N., 1998. Data analysis in social psychology. In D.T. Gilbert, S.T. Fiske, & G. Lindzey (eds.), *The Handbook of Social Psychology* (4th edn), pp. 233–265. New York: McGraw-Hill.

LI, M. & ZHAO, L., 2009. Agricultural labor 'aging' phenomenon and its impact on agricultural production—based on empirical analysis of Liaoning Province. *Issues Agric. Econ*., 10: 12-18.

MABAYA, E., FULTON, J., SIMIYU-WAFUKHO, S. & NANG'AYO, F., 2015. Factors influencing adoption of genetically modified crops in Africa. *Dev. South. Afr.*, 32(5): 577-591.

MWANGI, M. & KARIUKI, S., 2015. Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *J. Econ. Sustain. Dev.*, 6(5).

RAMBE, P. & KHAOLA, P., 2021. The impact of innovation on agribusiness competitiveness: the mediating role of technology transfer and productivity. *Eur. J. Innov. Manag*., 25(3): 741-773.

SABIR, H.M., TAHIR, S.H., ARSHAD, S. AND NASIR, S.B., 2012. Future of cooperative farming in Pakistan. *J. Biol. Agric. Healthcare*., 2(6): 42-48.

SINGH, B., 2014. Technology based entrepreneurship in agriculture-role of agribusiness incubators. *Int. J. Manag. Int. Busi. Stud.*, 4(3): 249-254.

SNYDER, H., 2019. Literature review as a research methodology: An overview and guidelines. *J. Bus. Res*., 104: 333-339.

TARUS, C.B.K., 2019. Maize crisis: A position paper on strategies for addressing challenges facing maize farming in Kenya. *East African Scholars J Edu Humanit Lit.*, *2*(3): 149-158.

TASHAKKORI, A. & TEDDLIE, C., 2021. *Sage handbook of mixed methods in social & behavioural research*. SAGE publications.

WOSSEN, T., ABDOULAYE, T., ALENE, A., HAILE, M.G., FELEKE, S., OLANREWAJU, A. & MANYONG, V., 2017. Impacts of extension access and cooperative membership on technology adoption and household welfare. *J. Rural Stud*., 54: 223-233.

YOKAMO, S., 2020. Adoption of improved agricultural technologies in developing countries: Literature review. *Int. J. Food Sci. Agric.*, 4(2): 183-190.

ZANU, H., ANTWIWAA, A. & AGYEMANG, C., 2012. Factors influencing technology adoption among pig farmers in Ashanti region of Ghana. *J. Agric. Technol.*, 8(1): 81-92.

S. Afr. J. Agric. Ext. Mthombeni, Khwidzhili, Zwane & Mmbengwa
Vol. 52 No. 4, 2024: 166-184
10.17159/2413-3221/2022/v50n1a14407

Assessment of Small-Scale Farmers' Perceptions Towards the Sustainability of Soybean Production in Nkangala District Municipality of the Mpumalanga Province

Mthombeni, V.T.[1], Khwidzhili R.H.[2], Zwane, E.[3] and Mmbengwa, V.M.[4]

Corresponding Author: V.T. Mthombeni. Corresponding Email: trinity.mthombeni64@gmail.com

ABSTRACT

To achieve the FAO's goals of increasing global agricultural productivity and soybean production by 2050, understanding small-scaler farmers' perceptions of the sustainability of soybean production is crucial. This study involved a sample size of 204 participants, randomly selected from a population of 433. Correlation and regression analyses assessed small-scale farmers' perceptions of factors affecting soybean production sustainability in Nkangala District Municipality in Mpumalanga Province. This was achieved by examining the influence of participants' perceived factors and attitudes towards soybean production's sustainability. The inferential findings revealed that farming, economic, extension and education, social, and policymaking factors affected participants' perceived attitudes towards the sustainability of soybean production in the study area. This suggests that any unit increase in these factors is associated with an increased probability of the participants' perceived attitudes towards the sustainability of soybean production. Future studies may focus on socioeconomic factors affecting

[1] Masters student: Faculty of Agriculture and Natural Sciences, University of Mpumalanga, South Africa, Email: 201740060@ump.ac.za or trinity.mthombeni64@gmail.com. This article is part of the author's Master Thesis at the University of Mpumalanga. Orcid: https://orcid.org/0000-0003-0540-9844.

[2] Senior Lecturer: Faculty of Agriculture and Natural Sciences, University of Mpumalanga, South Africa; Email: humphrey.khwidzhili@ump.ac.za. Orcid: https://orcid.org/0000-0002-1964-1102

[3] Head: Centre of Rural Community Empowerment at the School of Agriculture and Environmental Sciences, Faculty of Science and Agriculture, University of Limpopo, South Africa. Email: zwanefrank@gmail.com or elliot.zwane@ul.ac.za, Orcid: https://orcid.org/0000-0002-5933-2910.

[4] Professor: Department of Agricultural Economics and Animal Production. University of Limpopo, South Africa. Email address: victor.mmbengwa@ul.ac.za or vmmmbengwa@gmail.com. Orcid: https://orcid.org/0000-0003-3491-0785.

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

participant's perceived attitudes towards the sustainability of soybean production. The paper concludes by recommending that these factors should be considered by the government and policymakers when implementing programs to improve soybean sustainability through the inclusion of small-scale farmers.

Keywords: Perception, Factors Affecting Sustainability, Soybean Production, Sustainability, Small-Scale Farmers

1. INTRODUCTION

Sustainability is a complex concept that includes environmental, economic, and social aspects. These three pillars are crucial for maintaining a balance between meeting current needs and ensuring that future generations can meet their needs (Mirghaderi & Mohit-Ghiri, 2019). Therefore, gaining insights into the perspectives of small-scale farmers regarding the sustainability of soybean production becomes crucial to achieving the FAO objectives of a 70% increase in global agricultural productivity and a 140% increase in soybean production by 2050 (FAO, 2017). The environmental integrity, economic viability, and social acceptability of soybean production are vital aspects of strategic planning to promote and ensure sustainability. This is particularly critical in developing countries such as South Africa, where strategic planning focuses on developing and promoting sustainable farming methods that comply with agricultural legislation while optimising farm outputs to meet the ever-growing human needs.

The concept of sustainability focuses on promoting holistic approaches to establishing flexible agricultural systems that effectively and efficiently utilise available resources to support sustainable livelihoods. It emerged as a response to the problems caused by the degradation of essential natural resources, which pose a threat to the capacity of existing agricultural systems to meet current food demands and the looming challenges of feeding an expected global population of 9 billion people by 2050 (Fereres & Villalobos, 2016). Huang, Wu and Yan (2015) assessed the notion of "sustainability of farm systems" by examining its environmental, economic, and social dimensions.

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

As opined by Siamabele (2021), small-scale soybean production has the potential to help combat rural food insecurity and malnutrition issues. Soybean seeds are associated with several health advantages, as they contain, on average, 40% protein, 20% oil, and the remaining 40% vitamins, carbohydrates, minerals, and other vital micronutrients necessary to address food insecurity and malnutrition (Ghani *et al*., 2016). Sustainable rural development, which benefits the majority of South Africa's rural population, is primarily driven by the efforts of the country's small-scale farmers (Oluwatayo, 2019). In South Africa, support for sustainability in the small-scale farming sector has been implemented through various programs and projects, such as the Comprehensive Agricultural Support Programme (CASP) administered by the Department of Agriculture, Land Reform, and Rural Development (DALRRD, 2020).

Aliber and Hall (2012) stated that the government has increased the number of small-scale farmers from 250,000 in 2014 to 500,000 in 2020. Budgetary support was also provided for these farmers, such as an allocation of R2.38 billion to the Department of Agriculture for small-scale farmers' support programs in 2014. However, no study has outlined the impact of such initiatives on the perceived attitudes towards the sustainability of soybean production and the factors influencing sustainability. Its essential to consider various factors, including farming practices, economic influences, extension and education efforts, social dynamics, and policymaking decisions to ensure the long-term sustainability of crop production. These factors are interconnected and can positively and negatively affect sustainable agriculture.

To understand how these factors interact and impact farmers' engagement in sustainable practices, stakeholders can effectively develop strategies to promote sustainable agriculture. The sustainability of small-scale farmers is of utmost importance as it enables sustainable food production, utilising available natural resources to alleviate poverty and enhance the economic well-being of individuals residing in resource-constrained areas (Bisht *et al*., 2020). Perception holds significant importance in guiding primary agricultural activities. When considering the sustainability of soybean production in farming, farmers' views can be understood through the theory of planned behaviour (Sok *et al*., 2021). This theory suggests that individual actions are heavily shaped by their intentions, which are influenced by attitudes, subjective norms, and perceived behavioural control. Hence, examining farmers' perspectives is crucial as it can aid

https://doi.org/10.17159/2413-3221/2024/v52n4a18410

governmental efforts in launching rural development initiatives and projects tailored to farmers' perceptions of sustainable farming practices.

Notably, Hosseini *et al*. (2011) discovered that factors such as farming practices, economic considerations, extension and education, social factors and policymaking can influence how farmers engage in sustainable agriculture, thereby impacting the sustainability of their farming systems. Such factors harm the utilisation of scarce natural resources, pose environmental threats that result in land degradation, and cause the loss of livelihoods and food insecurity concerns. The sustainability of agricultural commodities drives small-scale farmers to engage in sustainable agriculture to produce competitive farm products. Additionally, it creates an ideal and inspiring environment that encourages both emerging and existing farmers to participate in agricultural methods that work with nature rather than against it.

However, there is limited literature on small-scale farmers' perceptions regarding the sustainability of soybean production in South Africa. Previous studies conducted outside South Africa have highlighted that farming practices, economic factors, extension and education initiatives, social aspects, and policymaking can influence farmers' adoption of sustainable agriculture, consequently linking with the perceived attitudes towards the small-scale farmer's perceptions towards the sustainability of their farming systems. Understanding these perceptions can aid in developing farming systems that enhance the sustainability of soybean production. Therefore, this study was conducted within this context to assess small-scale farmers' perceptions of the factors influencing the sustainability of soybean production in the Nkangala District Municipality of Mpumalanga Province.

2. MATERIALS AND METHODLOGY

2.1. Study Area

The study was conducted in the Nkangala District Municipalities of Mpumalanga Province, South Africa. It covered the Emakazeni Local Municipality (located at 25°35'01.2" S, 30° 04'56.3" E), Emalahleni Local Municipality (25° 52' 25.2" S, 29° 12'49.5" E), and Steve Tshwete Local Municipality (25°45'49.9" S, 29°27'21.0" E). The region is primarily characterised by small-scale black farmers who own and cultivate small plots of land. However, commercial farmers

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

predominantly carry out soybean production rather than in the small-scale farming sector (Dlamini *et al*., 2014). This discrepancy may be attributed to various factors, highlighting the importance of investigating the perceptions of small-scale farmers regarding the sustainability of soybean production in the study area.

2.2. Study Design and Sampling Procedure

This study aimed to determine small-scale farmer's perceptions towards sustainability and factors affecting their perceived attitudes towards the sustainability of soybean production in the study area. A quantitative research design was deployed to address the aim. The study initially employed purposive sampling to select key soybean-producing areas in the Nkangala District Municipalities based on suitable climatic requirements. Subsequently, random sampling was utilised to choose small-scale farmers from the identified local municipalities, ensuring each respondent had an equal chance of being selected. Simple random sampling yielded a sample size of 204 from a population of 433 small-scale farmers.

2.3. Analytical Framework

The current study employed multiple linear regression analysis. The assumptions integral to multiple linear regression encompass the maintenance of homogeneity of variance, independence of observations, adherence to a normal distribution of data, and linearity. Homogeneity of variance in the linear model is upheld when residuals exhibit consistent variance at all points. The independence of observations underscores the autonomy of datasets for each observation. The assumption regarding the normal distribution of residuals is called the normal distribution assumption. Consequently, linearity in multiple linear regression presupposes a direct linear relationship between each predictor variable and the response variables. The perceived attitudes towards the sustainability of soybean production are presented as follows:

TABLE 1: Variables Utilised in the Multiple Linear Regression

Variable	Explanation	Type of measurement	Expected sign

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

Dependent variable				
Perceived attitudes	Y	Importance of environmentally sustainable economic viability and socially acceptable soybean production	Scale	
Independent variable				
Farming	X_1	Perceived level of importance of farming	Scale	+/-
Economic	X_2	Perceived level of importance of economic factors	Scale	+/-
Extension and Education	X_3	Perceived level of importance of extension and education factors	Scale	+/-
Social	X_4	Perceived level of importance of social factors	Scale	+/-
Policymaking	X_5	Perceived level of importance of policymaking factors	Scale	+/-

2.3.1. Model Specification

The perceived attitudes towards soybean production (Perceived attitudes) are modelled as a function of various perceived levels of importance in relevant domains. The model equation is as follows:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \epsilon$$

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

Where:

Y represents the perceived attitudes towards soybean production.

X_1, X_2, X_3, X_4, and X_5 represent the perceived importance of farming, economic, extension and education, social, and policymaking factors, respectively. β_0 is the intercept term, representing the constant effect on perceived attitudes. β_1, β_2, β_3, β_4, and β_5 are the coefficients of X_1, X_2, X_3, X_4, *and X5,* respectively, indicating the impact of each independent variable on perceived attitudes. ϵ represents the error term.

3. FINDINGS

3.1. Descriptive Findings

This section describes the study's findings. It starts by presenting the outcomes of participants' perceptions concerning farming, economics, extension and education, and social and policymaking with the sustainability of soybean production. Following that, it presents the findings of participants' attitudes towards environmentally sustainable, economically viable, and socially acceptable soybean production. The results are visually represented and elaborated upon in Tables 2 and 3.

TABLE 2: Summary of Descriptive Results of the Perceived Factors in the Sustainability of Soybean Production

Main Items	**Findings**		
	No.	Mean Score	Std. Dev
1. Farming factors	204	4.07	0.762
2. Economic factors	204	4.05	0.763
3. Extension and education factors	204	4.06	0.770
4. Social factors	204	4.05	0.770
5. Policymaking factors	204	4.05	0.763
Average mean score	204	4.06	0.766

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

Table 2 presents an overview of the descriptive findings, categorised by the perceived factors contributing to soybean production's sustainability. These factors include farming, economic, extension and education, social, and policymaking aspects. With a sample size of 204, the average mean score and standard deviation are recorded as 4.06 and 0.776%, respectively. Among these factors, farming received the highest average score of 4.07, while economic, social, and policymaking factors obtained the lowest score of 4.05. Moreover, Table 2 highlights that the extension and education factors obtained a mean score of 4.06. The results from Table 2 strongly indicate that participants regarded these factors as highly significant for the sustainability of soybean production in the study area. Table 3 presents the descriptive findings of participants' perceived attitudes towards the sustainability of soybean production.

TABLE 3: Descriptive Findings of the Perceived Attitudes Towards the Sustainability of Soybean Production

Main Items	**Findings**		
	No.	Mean	Std. dev
1. Environmentally sustainable	204	4.03	0.762
2. Economic viability	204	4.04	0.751
3. Socially acceptance	204	4.04	0.783
Average mean score	204	4.04	0.768

According to Table 3, participants' perceived attitudes toward the sustainability of soybean production have an average mean score of 4.04, with a standard deviation of 0.768, based on a sample size of 204. The economic and social dimensions of soybean production sustainability received the highest mean score of 4.04. At the same time, the environmental sustainability dimension received the lowest mean score of 4.03. These results suggest a consensus among participants, indicating their agreement with the statement regarding the sustainability of soybean production.

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

3.2. Correlation Results

Correlation analysis was conducted to prepare the variables for regression analysis. This analysis aimed to assess the association between the respondents' perceived ideas (mean scores) regarding the farming, economic, extension and education, social, and policymaking factors in soybean production sustainability (independent variables) and their perceived attitudes (average mean score) towards soybean production sustainability (dependent variable). This statistical analysis is crucial as it examines the relationship between variables and allows the researcher to evaluate the strength of the relationship between specific factors and indicators of soybean production sustainability. The correlation coefficients between the independent and the dependent variables and their interpretations are presented in Table 4.

TABLE 4: Correlation Matrix of the Factors

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Farming (1)	-				
Economic (2)	0.559***	-			
Extension and education (3)	0.426***	0.460***	-		
Social (4)	0.389***	0.443***	0.624***	-	
Policy Sustainability (5)	0.508***	0.517***	0.662***	0.736***	-

Table 4 displays a moderately positive relationship between participants' perceived attitudes towards the sustainability of soybean production and farming factors (0.454**) and economic factors (0.439**). The results also indicate that perceived attitudes towards the sustainability of soybean production had a strong positive (0.635**) relationship with extension and education factors (0.635**) and policymaking factors (0.736**). The relationship between perceived attitudes towards the sustainability of soybeans and social factors was found to be very strong (0.905**). The results also indicated that there was neither a mediating nor a moderating influence on how small-scale farmers perceived these factors in the sustainability of soybean production. These findings show that the study's results and interpretation were substantial and valid.

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

In conclusion, Table 4 suggests a significant relationship between the participants' perceptions of farming, economic, extension and education, social, and policymaking factors and their perceived attitudes towards the sustainability of soybean production. The relationships between the independent and dependent variables were subsequently evaluated using regression analysis.

3.3. Inferential Findings

3.3.1. Model Summary

Table 5 presents model fit measures for the sustainability factor. The results R-squared was used to evaluate the model fitness. The model indicates an R-Square value of 0.89, implying that 80% of the variation in the perceived attitudes towards the sustainability of soybean production can be explained by the model containing perceived factors in the sustainability of soybean production at p = < 0.001, adjusted R square = 0.835 and F = 207. This implies that the model's fitness is good.

TABLE 5: Model Fit Measures for the Sustainability Factors

							Overall Model Test		
Model	**R**	**R^2**	**Adjusted R^2**	**AIC**	**BIC**	**RMSE**	**F**	**df1**	**df2**	**p**
1	0.916	0.839	0.835	-93.9	-70.6	0.186	207	5	198	< .001

3.3.2. Test of Multi-Collinearity

Table 6 shows the outcomes of multi-collinearity. These results revealed that the model is free from multi-collinearity as all variables considered have tolerance collinearity statistics greater than 0.1. Additionally, all VIF values are below 10, implying the absence of multi-collinearity problems among the studied variables.

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

TABLE 6: Collinearity Statistics for Multi-Collinearity Tests

Predictors	VIF	Tolerance
Farming factor	1.62	0.618
Economic factor	1.67	0.599
Extension and education factor	1.99	0.503
Social factor	2.34	0.428
Policy factor	2.80	0.357

3.3.3. Model Coefficients Results

Table 7 shows the outcomes of the perceived factors affecting the perceived attitudes towards the sustainability of soybeans. The results indicate that the farming factors had a positive coefficient of 0.0955 and a p-value of 0.008. This implies that there is a statistically significant relationship between farming factors and the sustainability of soybean production as the p-value is less than .005 and that any increase in the perceived ideas on farming factors will induce an increase in the probability of perceived attitudes towards the sustainability of soybean production by 0.0955 times.

The findings from Table 7 indicate that the social factors coefficient value = 0.7513 and p-value = 0.001, implying that any increase in the social factors will increase the probability of soybean production's sustainability by 0.7513 times. The p-value indicates a statistically significant ($p<0.005$) relationship between the social factors and the sustainability of soybean production.

Extension and education factors produced a p-value of 0.124 and a coefficient of 0.0626, as shown in Table 7. As the p-value is less than 0.05, it implies a statistically significant relationship between extension and education factors and the sustainability of soybean production. The findings show that any increase in the participants' perceived ideas on extension and education factors will increase the probability of the perceived attitudes towards the sustainability of soybean production by 0.0626 times.

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

According to Table 7, the coefficient value and p-value of the policymaking factors were 0.0998 and 0.033, respectively. The results infer that any increase in the participants' perceived ideas on policymaking factors will increase the probability of their perceived attitudes towards the sustainability of soybean production by 0.0998 times.

TABLE 7: Model Coefficients - Sustainability

						95% Confidence Interval	
Predictor	**Unstand. Estimate**	**SE**	**t**	**p**	**Stand. Estimate**	**Lower**	**Upper**
Intercept	-0.3174	0.1527	-2.08	0.039			
Farming factor	0.0955	0.0359	2.66	0.008	0.0965	0.02503	0.1680
Economic factor	-0.0368	0.0363	-1.02	0.311	-0.0374	-0.10995	0.0352
Extension and education factor	0.0626	0.0405	1.55	0.124	0.0620	-0.01714	0.1412
Social factor	0.7513	0.0425	17.70	< .001	0.7703	0.68449	0.8562
Policy making factor	0.0998	0.0464	2.15	0.033	0.1025	0.00845	0.1966

4. DISCUSSION

4.1. Discussion on the Perceived Factors in the Sustainability of Soybean Production

The study has actively demonstrated small-scale farmer's perceived ideas towards farming, economic, extension and education, social and policymaking factors and their perceived attitudes on the sustainability of soybean production. The findings also explained how these factors affected

https://doi.org/10.17159/2413-3221/2024/v52n4a18410

the participant's perceived attitudes towards the sustainability of the crop of interest. These findings are imperative for implementing governmental sustainability designed to enhance and improve the participation of small-scale farmers in the sustainability of soybean production.

Farming factors are fundamental for small-scale farmers. The average results on farming factors generated from perceived ideas on labour, machinery, farm inputs, access to improved cultivar and equity in access to land as sub-factors revealed that the participants viewed them as very important factors in the sustainability of soybean production. Idrisa (2012) also highlighted that soybean production is highly labour-intensive and needs advanced technologies such as improved competitive cultivars.

Participants had a strong perception of the role of economic factors in ensuring the long-term viability of soybean production, as indicated by the average mean findings on their views and ideas on these factors. Some factors considered were credit availability for farmers, financial institution assistance, transportation expenses, availability of soybean marketing data, and price stability. These findings align with those of Bicudo Da Silva (2020), who stressed the importance of ready access to farm credit for the successful operation of any farming operation, but especially for the small-scale variety in an era of scarce capital.

Education and extension may influence the perceptions of small-scale farmers regarding soybeans beyond primary production. It significantly contributes to bridging the gap between the negative attitudes toward the sustainability of soybean production and their lack of formal education. The extension and education factors results revealed that the extension training program, e-extension, demonstration, extension visits, and farmer field school were considered essential sub-economic factors for the sustainability of soybean production. Byron *et al.* (2014) endorse the study's findings because they indicate that extension and education effectively assist small-scale farmers in closing knowledge gaps, such as post-harvest data on soybean production.

Social factors incorporate farmers' beliefs, use of indigenous knowledge, formation of grower's cooperatives, and farmers' response towards sustainable practices. The results indicated that the participants strongly perceived these factors as being important to the sustainability of soybean production. According to Rajasekaran (1993), such social factors allow farmers to recruit and

https://doi.org/10.17159/2413-3221/2024/v52n4a18410

attract other farmers to participate in the sustainability of soybean production, provided the sustainable practices meet the societal norms of that area.

The present study also found that the perceived policymaking factors included items such as policy on sustainable agricultural practices, agricultural resources, price and marketing, management of pests, weeds and disease control, and food security are very important factors in the sustainability of soybean production. As opined by Parr *et al.* (2020), policymaking factors could play an important role towards sustainable development. They have shown the ability to enable farmers to utilise average resources to generate adequate farm income and improve food security while building resilience to weather and market shock.

4.2. Discussion on the Perceived Attitudes Towards the Sustainability of Soybean Production

The sustainability of soybean production may depend on farmers' perceptions of environmental, economic, and social dimensions of sustainability (Gennari & Navarro, 2019; Nair & Toth, 2016; Zhen & Routry, 2003). Participants in the study unanimously agreed that soybean production is an agricultural commodity that positively impacts environmental sustainability. This contradicts the findings of Fearnside (2001), who found that industrial soybean production has detrimental effects on environmental sustainability. The environmental threat stems from the impact of expanding soybean production on water quality, forest health, and biodiversity.

The results regarding the economic aspects of sustainability of soybean production indicate that all respondents agreed with the statement on economic sustainability. This suggests that the participants viewed soybean production as a profitable cultivating crop. These findings are consistent with the findings of Schmidt and Herman (2018), who emphasised that soy is a highly profitable and lucrative farm commodity. According to Gbegbelegbe *et al.* (2019), the soybean market and demand will double by 2050. It is especially important for enhancing small-scale farmers' economic and social well-being. The results regarding the social aspects of sustainability are overwhelmingly positive. Participants indicated that the production of soybeans is socially acceptable in their region. These results suggest that it is perceived as a commodity that can assist farms in improving their livelihoods and achieving sustainability while preserving local practices.

Vol. 52 No. 4, 2024: 166-184
https://doi.org/10.17159/2413-3221/2024/v52n4a18410

4.3. Discussion on Factors Affecting Perception Of Small-Scale Farmers About the Sustainability of Soybean Production.

Correlation Coefficients and regression analysis models were used to examine the relationship between participants' perceptions of farming, economic, extension and education, social, and policymaking factors and their perceptions of their attitudes toward the sustainability of soybean production. The correlation analysis revealed a moderate relationship between perceived attitudes regarding the sustainability of soybean production and farming factors. This is supported by the regression analysis results, which revealed that farming factors had a positive coefficient of 0.0955 and a significant level of 0.008. The results indicate a statistically significant relationship between the sustainability of soybean production and farming factors and that any increase in perceived ideas on farming factors will increase the probability of the perceived attitudes towards the sustainability of soybean production by 0.0955 times.

The correlation and regression findings also indicate that the perceived ideas on economic factors had a moderate relationship with their perceived attitudes towards the sustainability of soybean production. According to the regression results, economic factors had a p-value of 0.311 and a coefficient value of -0.0368. As the p-value is less than 0.05, the correlation between economic factors and the sustainability of soybean production is statistically significant. According to the b-value, any increase in economic factors will increase the probability of sustainability of soybean production by -0.0368 times.

According to the findings, there was a significant and positive relationship between the perceived attitudes towards the perceived ideas on extension and education factors and the sustainability of soybean production. In addition, the regression analysis results showed that the factors of extension and education obtained a coefficient value of 0.0626 and a p-value of .001, respectively. The result demonstrates that any increase in extension and education factors will increase the probability of sustainable soybean production by 0.0626 times.

The results of the social factors correlation discovered a very strong relationship between perceived attitudes towards the sustainability of soybean production and perceived ideas on social factors. The regression analysis pointed out that social factors had a coefficient value = 0.7513 and

https://doi.org/10.17159/2413-3221/2024/v52n4a18410

p-value = 0.001, implying that any increase in social factors will increase the probability of the perceived attitude sustainability of soybean production by 0.7513 times.

Further correlation results on policymaking factors demonstrated a strong relationship between perceived attitudes on the sustainability of soybean production and perceived ideas on policymaking factors. At the same time, regression findings indicate that the policymaking factors had a b-value and p-value of 0.0998 and 0.033, respectively. The results infer that any increase in policymaking factors will increase the probability of sustainability of soybean production by 0.0998 times.

5. CONCLUSION

The present study has scientifically demonstrated the small-scale farmers' perceptions of the sustainability of soybean production in Nkangala District Municipality, South Africa. According to inferential findings, small-scale perceived ideas on farming, economic, extension and education, and social and policymaking factors affected the participants' perceived attitudes towards the sustainability of soybean production in the study area. This implies that any increase in these participants' perceived factors is associated with an increase in the probability of their perceived attitudes on the sustainability of soybean production. Therefore, this study recommends that the government consider these variables when implementing initiatives to improve the sustainability of soybean production among small-scale farmers. Future studies may incorporate other factors, such as agronomic and socioeconomic factors, in the sustainability of soybean production.

6. ACKNOWLEDGMENT

The authors acknowledge the participants' small-scale farmers and Agricultural Advisors in the study area. The South African Cultivar Technology Agency has also been recognised for funding this project.

7. CONFLICT OF INTEREST

The authors declare no conflict of interest.

https://doi.org/10.17159/2413-3221/2024/v52n4a18410

REFERENCES

ALIBER, M. & HALL, R., 2012. Support for smallholder farmers in South Africa: Challenges of scale and strategy. *Dev. South. Afr.,* 29: 548–562.

ASODINA, F.A., ADAMS, F., NIMOH, F., ASANTE, B.O. & MENSAH, A., 2021. Performance of smallholder soybean farmers in Ghana; evidence from Upper West Region of Ghana. *J. Agric. Food. Res.*, 4: 100120.

BICUDO DA SILVA, R.F., BATISTELLA, M., MORAN, E., CELIDONIO, O.L.D.M. & MILLINGTON, J.D., 2020. The soybean trap: challenges and risks for Brailian producers. *Front. Sustain. Food Syst.,* 4: 12.

BISHT, I.S., RANA, J.C. & PAL AHLAWAT, S., 2020. The future of smallholder farming in India: Some sustainability considerations. *Sustain.,* 12: 3751.

BRUINSMA, J., 2009. The resource outlook to 2050: by how much do land, water and crop yields need to increase by 2050. In *Proceedings of a technical meeting of experts*, 24-26 June, Rome, Italy: Food and Agriculture Organisation, pp. 1-33.

BYRON, Z., NELSON, M., KEFASI, N. & SHEPHERD, S., 2014. Determinants of soybean market participation by smallholder farmers in Zimbabwe. *J. Dev. Agric. Econ*., 6(2): 49-58.

DALRRD., 2020. *Annual Report 2020/2021*. Pretoria: Departement of Agriculture, Land Reform and Rural Development. Available from: https://www.gov.za/sites/default/files/gcis_document/202204/department-agriculture-land-reform-and-rural-development-annual-report-2020-2021.pdf

DLAMINI, T.S., TSHABALALA, P. & MUTENGWA, T., 2014. *Soybeans production in South Africa.* Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ocl-journal.org/articles/ocl/pdf/2014/02/ocl130028.pdf

https://doi.org/10.17159/2413-3221/2024/v52n4a18410

FEARNSIDE, P.M., 2001. Soybean cultivation as a threat to the environment in Brail. *Environ. Conserv.,* 28(1): 23-38.

FERERES, E. & VILLALOBOS, F.J., 2016. Agronomy and the sustainability of crop production. In E. Fereres & F.J. Villalobos (eds.), *Principles of Agronomy for Sustainable Agriculture*. Cham: Springer, pp. 527–542.

FAO., 2017. *The future of food and agriculture: Trends and challenges*. Rome: FAO.

FOSTER, L., MALHERBE, W., FERREIRA, M. & VAN VUREN, J.H.J., 2015. Macroinvertebrate variation in endorheic depression wetlands in North West and Mpumalanga provinces, South Africa. *Afr. J. Aquat. Sci.,* 40(3): 287-297.

GBEGBELEGBE, S., ALENE, A., KAMARA, A., WIEBE, K., MANYONG, V., ABDOULAYE, T. & MKANDAWIRE, P., 2019. Ex-ante evaluation of promising soybean innovations for sub-Saharan Africa. *Food Energy Secur.,* 8(4): 12.

GHANI, M., KULKARNI, K.P., SONG, J.T., SHANNON, J.G. & LEE, J.D., 2016. Soybean sprouts: A review of nutrient composition, health benefits and genetic variation. *Plant Breed. Biotech., 4*(4): 398-412.

HOSSEINI, S.J.F., MOHAMMADI, F. & MIRDAMADI, S.M., 2011. Factors affecting environmental, economic and social aspects of sustainable agriculture in Iran. *Afr. J. Agric. Res.,* 6(2): 451-457.

HUANG, L., WU, J. & YAN, L., 2015. Defining and measuring urban sustainability: A review of indicators. *Landsc. Ecol.,* 30: 1175–1193.

IDRISA, Y.L., OGUNBAMERU, B.O. & MADUKWE, M.C., 2012. Logit and Tobit analyses of the determinants of likelihood of adoption and extent of improved soybean seed in Borno State, Nigeria. *Greener J. Agric. Sci*., 2(2): 37-45.

MIRGHADERI, S.H. & MOHIT-GHIRI, Z., 2019. Measuring sustainable development: linear regression approach. *Int. J. Sustain. Dev*., 22(1-2): 110-122.

OLUWATAYO, I.B., 2019. Towards assuring food security in South Africa: Smallholder farmers as drivers. *AIMS Agric. Food.,* 4: 485–500.

SCHMIDT, M.A. & HERMAN, E.M., 2018. Characterization and functional biology of the soybean aleuone layer. *BMC Plant Biol.,* 18(1): 1-9.

SIAMABELE, B., 2021. The significance of soybean production in the face of changing climates in Africa. *Cogent Food Agric*., 7(1).

SOK, J., BORGES, J.R., SCHMIDT, P. & AJZEN, I., 2021. Farmer behaviour as reasoned action: a critical review of research with the theory of planned behaviour. *J. Agric. Econ*., 72(2): 388-412.

SOUTHERN AFRICAN GRAIN LABORATORY-NPC., *2021. South African Soybean Crop Quality Report 2020/2021*. Available from: https://sagl.co.za/wp-content/uploads/Soya-Crop-Quality-Report-2020-2021.pdf

STATISTICS SOUTH AFRICA., 2018. *Provincial Profile: Mpumalanga*. Available from: https://statssa.gov.za/publications/Report-03-01-77/Report-03-01-772011.pdf

S. Afr. J. Agric. Ext. Shiba, Mdiya, Aliber & Zantsi
Vol. 52 No. 4, 2024: 185-206
https://doi.org/10.17159/2413-3221/2024/v52n4a18423

Institutional Factors Affecting Smallholder Farmers' Decision to Adopt Climate Change Adaptation Strategies: Evidence from Raymond Mhlaba Local Municipality Eastern Cape, South Africa

Shiba, W.T.[1], Mdiya, L.[2], Aliber, M.[3] and Zantsi, S.[4]

Corresponding Author: W.T. Shiba. Correspondence Email: mtswala.walter@gmail.com/wshiba@ufh.ac.za

ABSTRACT

In recent years, adaptation to climate change has become a global focus; therefore, the present study was conducted in Raymond Mhlaba Local Municipality to understand the adaptation strategies employed by smallholder farmers to the adverse impact of climate change and to examine the extent to which institutional factors play a role in farmers' decisions to adapt to climate change. Using a multistage research design, data were collected from 120 smallholder farmers by administering a pre-tested questionnaire with both open- and closed-ended questions. The collected data were analysed using descriptive statistics and a binary logistic regression model. The results revealed that farmers employed crop diversification, crop rotation, calendar redefinition, resilient crop varieties, and tree planting as adaptation strategies in response to climate change. The binary logistic regression model results indicated that access to extension services, climate change information, and farmers' organisations influenced farmers' decisions to

[1] Lecturer: Department of Agricultural Economics and Extension, Faculty of Science and Agriculture, University of Fort Hare, South Africa, Private Bag X1314, Alice, 5700. Email: wshiba@ufh.ac.za or mtswala.walter@gmail.com. ORCID: 0000-0001-9745-6167

[2] Lecturer: Department of Sustainable Food Systems and Development, University of Free State, South Africa. Email: mdiyal@ufs.ac.za. ORCID: 0000-0002-2207-9261

[3] Professor and Head of Department: Department of Agricultural Economics and Extension, Faculty of Science and Agriculture, University of Fort Hare, South Africa, Private Bag X1314, Alice, 5700. Email: maliber@ufh.ac.za. ORCID: 0000-0001-8739-0379

[4] Agricultural Economist, Economic Analysis Unit, Agricultural Research Council, Hatfield 0081, Pretoria, South Africa. Email: siphezantsi@yahoo.com. ORCID: 0000-0001-9787-3913

Vol. 52 No. 4, 2024: 185-206
https://doi.org/10.17159/2413-3221/2024/v52n4a18423

adopt climate change adaptation strategies. Policymakers should focus on enhancing rural institutional services and increasing climate change education to improve smallholder farmers' capacity in a changing climate.

Keywords: Climate Change, Institutional Factors, Binary Logistics, Smallholder Farmers

1. INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) (2014) has widely recognised climate change as one of the biggest challenges in modern society. Scientific evidence indicates climate change is a global phenomenon characterised by increased temperature because of the increasing greenhouse gas emissions (Landicho *et al*., 2023; Belay *et al*., 2017; Pachauri *et al*., 2014). According to IPCC (2014), the global mean surface temperature changes for the period 2016 to 2035 is similar to the period of 1986 to 2005, will likely be in the range of 0.3 to 0.7 degrees Celsius but is projected to likely exceed 1.5 degrees Celsius by the end of the twenty-first century (IPCC, 2013). A study by Pereira *et al*. (2014) noted that climate change results in low agricultural production and increased food insecurity, while Nwachuku and Shisanya (2017) predicted climate change could significantly decrease agricultural productivity in Africa. Furthermore, the literature points out the vulnerability of the agricultural sector, particularly the smallholder farmers, to climate change impacts (Landicho *et al*., 2016; Evangelista *et al*., 2013; Morton, 2007). These impacts include a decline in crop yield, increased use of farm inputs, a decline in farm income (Landicho *et al*., 2015), and food security after extreme weather events (Harvey *et al*., 2018). Jha and Gupta (2016) noted the importance of adaptation as a critical and practical strategy for climate change impact, and it becomes imperative for all stakeholders involved in food production to understand the various factors that shape farmers' decisions to adapt to climate change. Support provided by national and international institutions to reduce the impacts of climate change has been found to positively influence farmers' adaptation (Comoé & Siegristet, 2015). A study conducted by Bryan *et al*. (2009) on climate change in South Africa and Ethiopia revealed that factors influencing farmers' decision to adapt to climate change were access to climate information, extension services, and credit. Nguyen *et al*. (2016) stated that to achieve climate change

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

adaptation, there is a need to have an in-depth understanding of different factors that shape farmers' agricultural practices and their adaptive responses to stimuli.

Climate change has been proven to negatively impact agricultural productivity, and agricultural production is highly sensitive to climate change due to its high reliance on climate variables such as rainfall, humidity, temperature, and wind speed (Belay *et al*., 2017). Moreover, climate change continues to threaten global economic development and may impact different aspects of domestic life, such as agricultural productivity and food security. Additionally, Sub-Saharan African countries, such as South Africa, have suffered seasonal and yearly unpredictability in rainfall and temperature in recent years, resulting in several adverse effects on the agricultural sector's sustainability (Sousa *et al*., 2018). Sustaining rural households' food security in the face of climate change becomes a critical challenge, as climate change poses a terrible danger to rural areas where agricultural production is primarily practised by smallholder farmers who heavily depend on rainfall for water (Ogundeji 2022; Shisanya & Mafongoya, 2016). Dependence on rainwater is difficult for smallholder farmers because South Africa is viewed as a water-scarce country, reducing agricultural production and contributing to food security (Adetoro *et al*., 2020).

Agriculture is one of the most climate-sensitive sectors directly affected by physical and chemical changes (Mitter *et al*., 2019). In South Africa, agriculture remains an important economic sector, provides employment, especially in rural areas, and is a primary source of foreign exchange. However, climate change and variability have negatively affected agricultural production, especially for smallholder farmers. According to Tomlinson and Rhiney (2018), smallholder farmers face numerous challenges, such as drought, temperature increase, pasture deterioration, increased parasites and diseases, and low production. In the face of climate change, smallholder farmers in developing countries like South Africa are particularly vulnerable due to their reliance on agriculture.

Furthermore, smallholder farmers are particularly vulnerable to climate change due to their reliance on rain-fed agriculture, insufficient access to land, high poverty and poor education levels, limited access to extension training, and lack of financial support to adopt adaptive measures (Harvey *et al*., 2018; Morton, 2007). Climate change poses a significant threat to the sustainability

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

of agriculture production among smallholder farmers in South Africa. To reduce the adverse impact of climate change, smallholder farmers have sought to adopt different adaptation strategies. Fadina and Barjolle (2018) noted that farmers should respond to climate change through various adaptation measures to boost agricultural productivity and improve their livelihoods. Silici *et al.* (2021) highlighted the crucial role of agriculture in the economy and its vulnerability to climate change impacts, with the need to invest in measures that would build and enhance smallholder farmers' adaptive capacity and resilience. To mitigate these challenges, farmers are expected to modify their agricultural practices to align their production methods with the increasing challenges of climate change, which directly affects agricultural activities (FAO, 2010).

Additionally, involvement in non-farm income activities has significantly increased the adoption of climate change adaptation strategies among smallholder farmers (Ojo & Baiyegunhi, 2020). Furthermore, studies have highlighted the importance of smallholder farmers' awareness of climate change impact and their ability to identify relevant coping and adaptation strategies (Yahaya, 2024; Addis & Abirdew, 2021; Kom *et al.*, 2019). Recognising climate change and implementing appropriate adaptation interventions are essential for smallholder farmers to effectively cope with climate change challenges (Mekonnen & Kassa, 2019).

Moreover, the availability of easily accessible and reliable climate change information, often acquired through indigenous and local knowledge, plays a significant role in smallholder farmers' decision-making process for climate adaptation (Zvobgo *et al.*, 2023). Several institutional factors can influence smallholder farmers' decision to adopt climate change adaptation strategies (Amenuvor, 2019). Furthermore, institutional factors influence smallholder farmers' decisions to adopt climate change adaptation strategies. In Sub-Saharan Africa, climate change decreased yield, caused crop failures, diminished quality, and heightened diseases and pests, rendering vegetable production financially unviable (Abewoy, 2018). According to Partey *et al.* (2018), limited attention is given to issues relating to adopting concepts or agricultural practices that tackle climate change, specifically in small-scale agriculture. It is against this background that this study attempts to fill the gap by investigating the institutional factors that influence smallholder farmers' decision to adopt climate change adaptation strategies and what are the climate change adaptation strategies

Vol. 52 No. 4, 2024: 185-206
https://doi.org/10.17159/2413-3221/2024/v52n4a18423

used by smallholder farmers in Raymond Mhlaba Local Municipality (RMLM) in the Eastern Cape Province of South Africa.

2. METHODOLOGY

2.1. Study Area

The study was conducted in Raymond Mhlaba Local Municipality (RMLM) (see Figure 1); the municipality is located in Amathole District Municipality in Eastern Cape Province of South Africa and is the largest local municipality in Amathole District with a total area of 6 357 km2 (Municipalities of South Africa, 2021). The RMLM is a rural municipality whose economy is primarily driven by the agricultural sector (Mtyelwa *et al*., 2022). The study area was chosen because it is predominantly rural, with most households farming. It is one of the areas most affected by climate change due to low rainfall and high temperatures (Household Community Survey, 2016). Moreover, insufficient literature analyses institutional factors influencing smallholder farmers to adapt to climate change strategies.

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

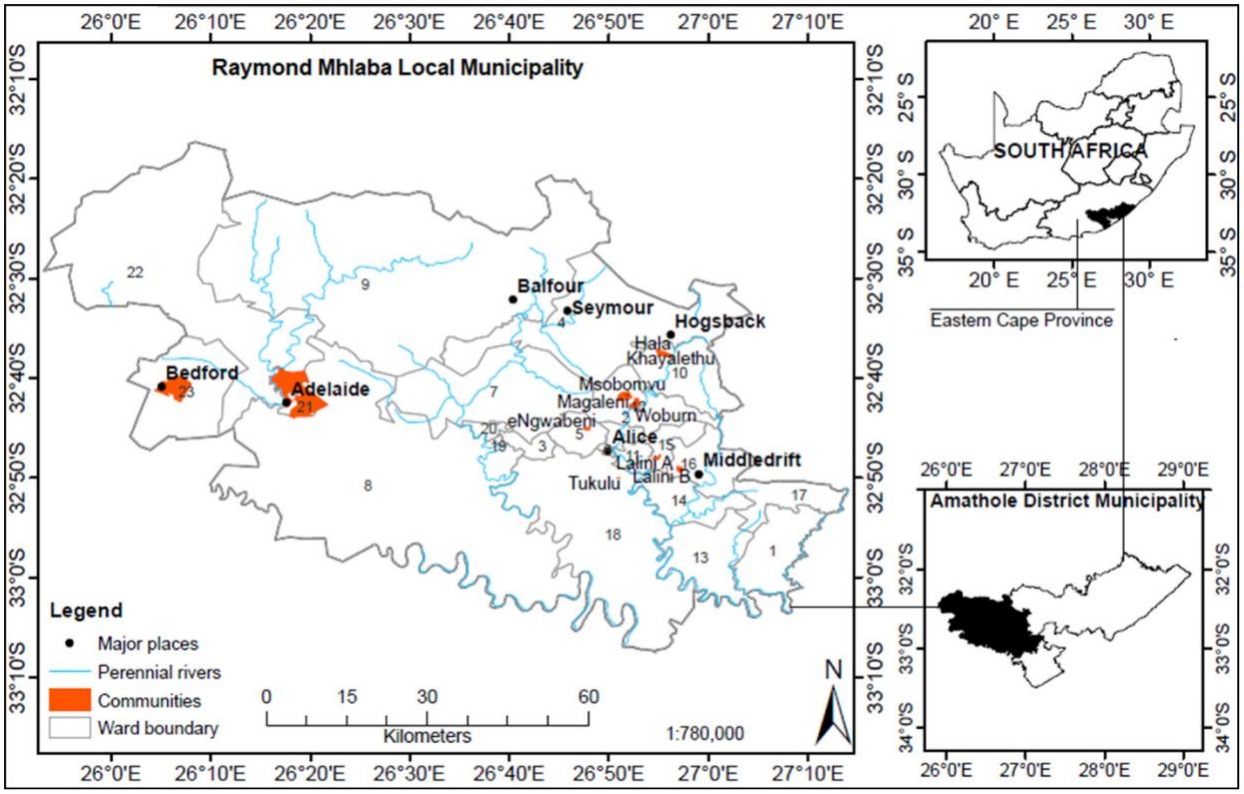

FIGURE 1: Raymond Mhlaba Local Municipality (Source: Mdiya *et al.*, 2023)

2.2. Sampling Procedure and Data Collection

The study used a multistage stratified random sampling procedure, where a combination of purposive and random sampling procedures was used to identify and select smallholder farmers in the study area. A semi-structured pre-coded questionnaire was used to collect data from one hundred and twenty smallholder farmers in Raymond Mhlaba Local Municipality (RMLM). This was done to explore the adaptation strategies used by smallholder farmers for the effects of climate change and the institutional factors that influence the selection of those strategies in the study area. To estimate the appropriate sample size for analysis, the study used the Yamane formula (1967) as shown below:

$$n = \frac{N}{1 + N(e)2}$$

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

where *n*: sample size, *N*: total population (1836 households), *e*: marginal error (10%) was used to determine the study sample size $n = \frac{1836}{1+(1836*0.01)2}$ = 120. Therefore, 120 smallholder farmers were sampled.

The local language, isiXhosa, was used for effective communication for the survey, focus group discussions, and informative interviews. Enumerators fluent in the local language and knowledgeable of the local tradition were recruited and trained before conducting the survey. The study employed qualitative and quantitative data collection methods, as Neuuma (2015) recommended. The data was coded on Microsoft Excel and analysed using descriptive statistics such as frequencies, figures, and tables. The Binary Logistic Regression Model (BLRM) was employed in the STATA 14.2 version. According to Muzamhindo (2015), the binary logit model is appropriate because it considers the nexus between a binary dependent variable and a set of explanatory variables.

2.3. Analytical Framework

To identify the institutional variables that affect farmers' decisions to adapt to climate change strategies, the Binary Logistic Regression Model (BLRM) was used. When predicting the presence or absence of a characteristic or outcome based on the values of a group of predictor variables is necessary, BLRM is thought to be helpful (Norusis, 2004). Like a linear regression model, the BLRM is appropriate for models with dichotomous dependent variables, such as the one used in this study. For each model's independent variable, odd ratios were estimated using BLRM coefficients. According to Norusis (2004), the following link function describes how the dependent variable Z and the likelihood of the relevant event are related in the BLRM:

$$\pi_i = \frac{e^{Zi}}{1+e^{Zi}} = \frac{1}{1+e^{Zi}} = \frac{1}{1+e^{-Zi}} \quad (1)$$

or,

$$\mathcal{Z}_i = log\left(\frac{\pi_i}{1-\pi_i}\right) \quad (2)$$

Where, π_i = probability of the i^{th} case; $\mathcal{Z}_i$ = value of the independent variable for the i^{th} case. The model assumes that Z is linearly related to the predictors. Thus,

$$\mathcal{Z}_i = b_0 + b_1X_{i1} + b_2X_{i2} + \ldots + b_pX_{ip} \quad (3)$$

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

Where, X_{ij} = predictor for the j^{th} case; b_j = j^{th} coefficient and p = number of predictors. Since Z is unobservable, the predictors are related to the probability of interest by substituting Z in Equation 1.

$$\pi_i = \frac{e^{Zi}}{1+e^{Zi}} = \frac{1}{1+e^{Zi}} = \frac{1}{1+e^{-(b_0 + b_1X_{i1} + b_2X_{i2} + \ldots + b_pX_{ip})}} \quad (4)$$

In the regression context, it is assumed that there is a set of predictor variables, $X_1, \ldots X_n$ that are related to Y and, therefore, provide additional information for predicting Y (Greene, 2003).

$$Logit\ (P_i) = ln\ (P_i/1 - P_i) = \alpha + \beta_1X_1 + \ldots + \beta_nX_n + \mu_i \quad (5)$$

Where, $ln\ (P_i/1 - P_i)$ = logit for farmers' decision to adapt to climate change adoption strategies *(Yes or No)*; P_i = *Yes*; $1 - P_i)$ = *No*; β = coefficient; X_1 = covariates; μ_i = error term.

When the variables are fitted into the model in Equation 5, the model is presented as:

$$ln\ (P_i/1 - P_i) = \alpha + \beta_1X_1 + \ldots \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \ldots\ldots \beta_nX_n + \mu_i \quad (6)$$

The estimated model was adapted from Tshikororo *et al*., (2020) and is specified as follows:

$$Y = \alpha + \beta_1ACCI + \beta_2CCC + \beta_3ATMM + \beta_4SS + \beta_5FO + \beta_6AES + \beta_7ATC + \beta_8ATM + \beta_9LTS + \beta_{10}KES + \beta_{11}TSR + \beta_{12}EOV \quad (7)$$

TABLE 1: Description of Dependent and Independent Variables

Variable	Name Description	Type of measure	Expected sign
D	The decision to adopt strategies	Yes = 0, No = 1	
ACCI	Access to climate change information	Dummy; Yes = 0, No =1	+
CCC	Climate change campaign	Dummy; Yes = 0, No = 1	+
ATMM	Access to mass media	Dummy; Yes = 0, No = 1	+
SS	Support source	Dummy; Government = 0, Private institution = 1	-/+

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

FO	Member of farmers' organisation	Dummy; Yes = 0, No = 1	-/+
AES	Access to extension services	Dummy; Yes = 0, No = 1	+
ATC	Access to credit	Dummy; Yes = 0, No = 1	-/+
ATM	Access to market	Dummy; Yes = 0, No = 1	+
LTS	Land tenure security	Dummy; Yes = 0, No = 1	-/+
KES	Kind of extension services	Advice on production = 0, Climate change = 1, Advice on marketing = 2, Other = 3	-/+
TSR	Type of support received	Input provision = 0, Training = 1. Formal credit = 2, Financial assistance = 3	-/+
EOV	Extension officials' visits	Weekly= 0, Monthly =1, Quarterly =2, Yearly = 3	-/+

3. RESULTS AND DISCUSSION

The hypothesised independent variables were evaluated for some statistical issues like multi-collinearity. The Variance Inflation Factor (VIF) test in STATA detected the multi-collinearity issue among the continuous explanatory variables. The VIF was found to be 3.4, less than the conventional threshold of 10 (variables are not significantly correlated).

3.1. Sources of Weather Information on Climate Change

According to Yahaya *et al*. (2024), for effective implementation of informed adaptation strategies, agricultural extension officers need to improve their outreach and training programmes through innovative communication methods that will reach most farmers. Providing useful information, such as weather and flood forecasts and the best agricultural practices, can help reduce climate change's impact on smallholder farmers (Yahaya *et al*., 2024).

The results in Figure 2 show that most respondents (48%) became aware of climate change and its impact through radio station(s). About 20% of the respondents use television as their source of weather information, while 14% use other farmers, 11% use the internet, and 7% use social media, respectively, in the study areas. Smallholder farmers must have accessibility and availability of relevant and reliable information about climate change to make informed decisions on which

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

adaptation strategies to use. These findings are similar to those of Atuber *et al*. (2021), who revealed that receiving weather information is key for farmers to adapt climate change strategies.

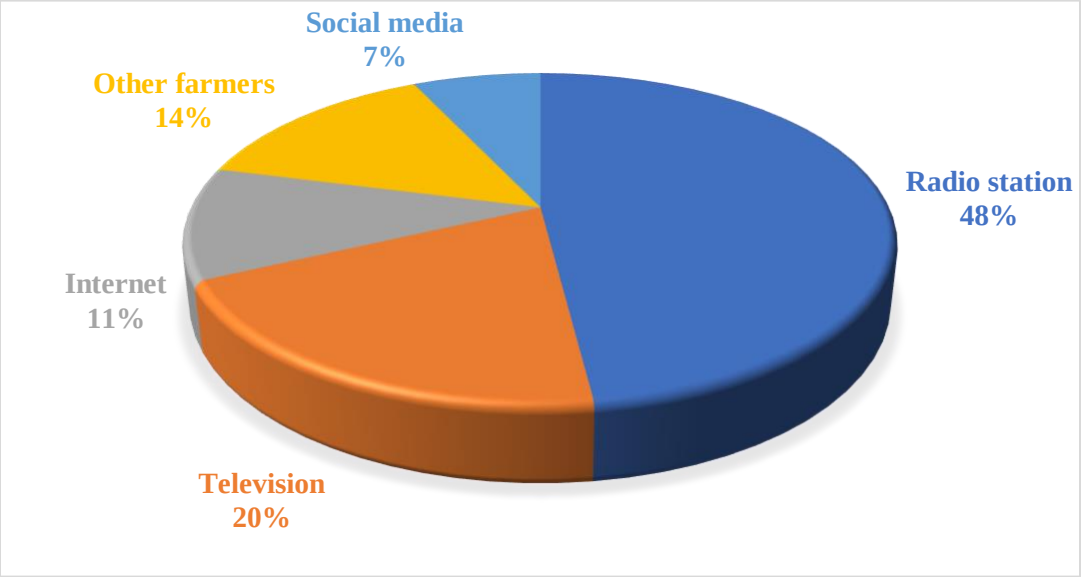

FIGURE 2: Percentage Source of Weather Information

3.2. Impact of Climate Change on Smallholder Farmers

Climate change is having an impact on agriculture and the livelihood of the smallholder farmers in the study area. The results presented in Figure 3 revealed that about 24.17% of the respondents indicated that loss of income was the primary indicator of climate change. The findings also showed that 20.83% of the farmers reported that climate change is responsible for crop yield reduction. The decline in agricultural output (crop yield reduction and crop failure) leads to increased food insecurity and decreased income generation from farming (Makamane *et al*., 2023). About 18.33% reported that climate change led to crop failure. Furthermore, the results indicate that the shift in climate results in about 15.83% water shortage, 10.83% results in the occurrence of pests and disease, and 10% results in seasonal flooding in the study, respectively. Similar results were reported by Atube *et al*. (2021), Marie *et al*. (2020), and Belay *et al*. (2017), who revealed loss of income, crop failure, and yield reduction, shortage of water as indicators of climate change.

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

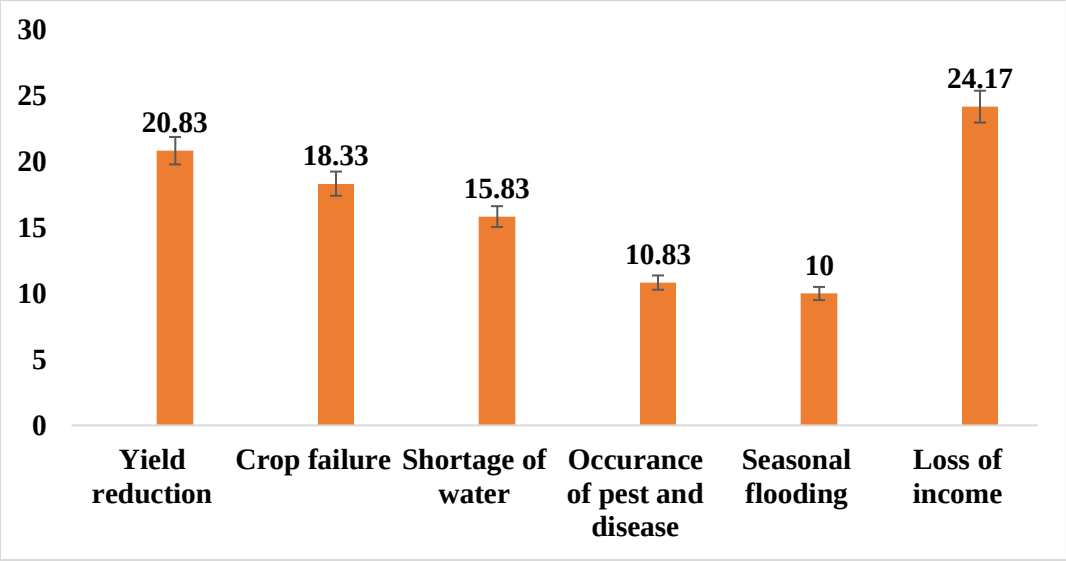

FIGURE 3: Impact of Climate Change on Smallholder Farmers in the Study Area

3.3. Adaptation Strategies to Climate Change Implemented by Smallholder Farmers

The smallholder farmers in the study area have adopted different strategies to adapt to the changing climate, and adaptation is critical to mitigating the impact of climate change on smallholder farming. As illustrated in Figure 4, to alleviate the adverse impact of climate change on agricultural production, some adaptation strategies are implemented by smallholder farmers. The most popular adaptation strategies were crop diversification, crop rotation, calendar redefinition, resilient crop varieties, and tree planting.

Crop diversification is the most common adaptation strategy applied by 32% of the study population. The second most widespread adaptation strategy is crop rotation, which accounts for 29%. About 24% of the farmers use resilient crop varieties as an adaptation strategy to reduce the adverse impact of climate change. These results are consistent with those of Nouri *et al*. (2017), who found that using drought-resistant varieties increased maize productivity under different climate change conditions. Thus, 20% of the farmers use calendar redefinition as an adaptation strategy to cope with the impact of climate change. Also, tree planting (15%) is used as an adaptation strategy to reduce the adverse effects of climate change. This is in line with a previous study by Fagariba (2018), who reported that most smallholder farmers had adopted at least one strategy to cope with the impact of climate change. Crop diversification is perceived as one of the

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

most ecologically feasible, cost-effective, and rational ways of reducing uncertainties in agriculture, especially for smallholder farmers (Makate *et al*., 2016).

Furthermore, crop diversification improves soil fertility, controls pests and diseases, and brings about yield stability, nutrition diversity, and health (Makate *et al*., 2016; Lin, 2011). The findings indicate that many smallholder farmers use this strategy to cope with climate change.

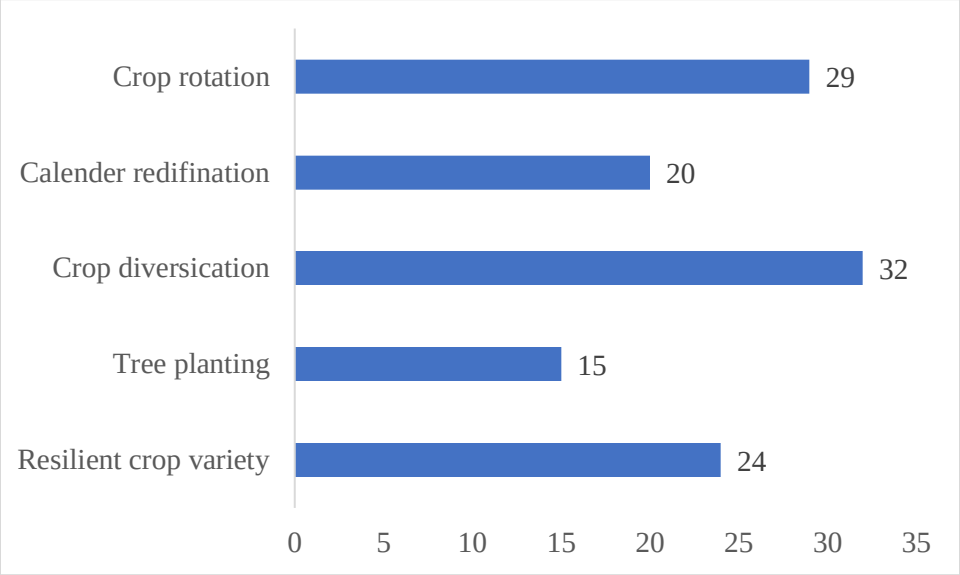

FIGURE 4: Percentage of Adaptation Strategies Used by Smallholder Farmers

3.4. Barriers to Adaptation Strategies

While farmers respond to climate change by adopting various adaptation strategies, they are challenged by different barriers that make adaptation difficult. The result presented in Figure 5 reveals that the most critical obstacles were lack of access to climate change information, shortage of farmland, shortage of farm inputs, lack of access to extension services, lack of credit, and lack of inadequate irrigation. The results in Figure 4 indicate that although diverse climate change adaptation strategies were used in the study area, the farmers did not apply them to their full capabilities due to barriers, as mentioned above. Most respondents (24%) reported that lack of access to climate change information was one of the main barriers hindering farmers' adoption of climate change adaptation measures. This result is supported by Abid *et al*. (2015), who showed

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

that a lack of climate information hinders smallholder farmers' willingness to adopt climate change adaptation strategies.

Moreover, 21% of the farmers mentioned that the shortage of farmland was one of the barriers that hinder farmers' adoption of climate change measures. The results revealed a lack of access to extension services (18%), shortage of farm inputs (13%), lack of access to credit (15%), and lack of adequate irrigation (9%) among barriers that limit farmers' adoption. The results are in agreement with the findings of Anzum *et al*. (2023), Destaw and Fenta (2020), Nega *et al*. (2019) and Belay *et al*. (2017), who indicated a lack of information and inadequate irrigation as significant barriers to adaptation measures.

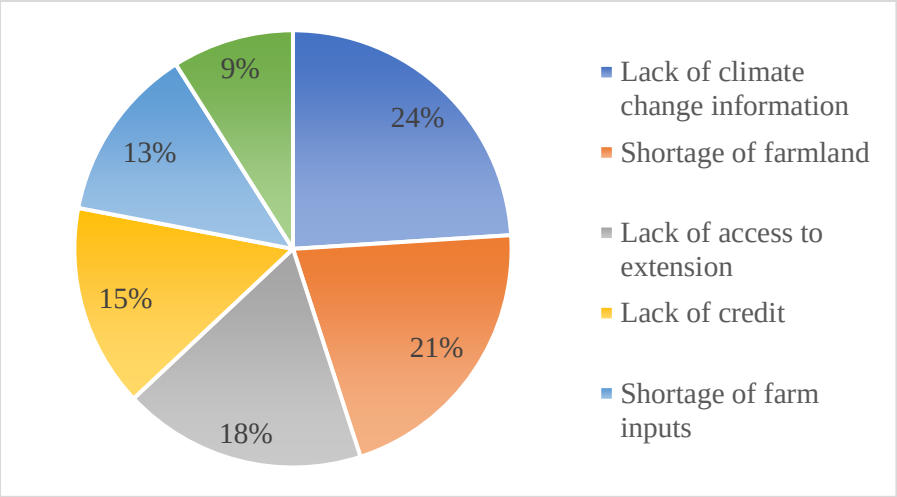

FIGURE 5: Barriers to Climate Change Adaptation in the Study Area

3.5. Institutional Factors Affecting Climate Change Adaptation Strategies

A binary logistic model was used to analyse the institutional factors influencing smallholder farmers' adaptation to climate change strategies. Table 2 indicates that, out of the 12 variables used, five independent variables influencing farmers' decisions to adapt to climate change strategies are statistically significant. These variables were as follows: access to climate change information, access to mass media, access to extension officers, source of support, farmers' organisation, land tenure security, and how to receive extension services. Access to variables such as weather information positively and significantly influences farmers' adaptation to climate change. A unit increase in accessing climate change information would increase the chances of farmers adapting to climate change strategies by 1.10 chances. Similar results were reported by

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

Tshikororo *et al*. (2020), who revealed that farmers who frequently receive information on climate change are more inclined towards adaptation strategies than those who do not. This result aligns with the findings of Mugagga *et al*. (2019), who also noted that access to climate change information through extension agents enhanced farmers' adaptation decisions.

The results further show that access to mass media positively influences farmers' adaptation to climate change strategies by 1.93. These results agree with the findings of Mulwa *et al*. (2017), who observed that access to climate change information is a significant driver of adaptation among farmers. Access to support sources significantly influences smallholder farmers' adaptation to climate change strategies in that a percentage increase in access to support sources increases farmers' adaptation to climate change strategies by 0.95 percent.

This finding is consistent with that of Come *et al*. (2015), who stated that providing farmers' support by national, private, and international organisations to reduce the impacts of climate change positively influences their adaptation strategies. Additionally, access to extension services positively and significantly influences farmers' adaptation to climate change strategies. An increase in the unit of access to extension officers by farmers increases their chances of adapting to climate change strategies by 0.41 chances. Destaw and Fenta (2021) indicated that extension services are critical in enhancing farmers' knowledge and skills to increase the adoption of improved agricultural technology. According to Bryan *et al*. (2013), farmers who do not have access to extension services are more likely to either not perceive climate change or incorrectly perceive it.

This implies that farmers' adaptation to climate change increases when they access different types of extension services. These results agree with the findings of Khanal *et al*. (2018), who revealed that accessibility of extension services is critical to farmers' willingness to adapt to climate change strategies. Similarly, Abid *et al*. (2019) indicated that farmers who receive advisory services from published extension officials adapt to different climate change adaptation strategies. The results showed that farmers' adaptation strategies to climate change are also significantly affected by being a member of the farmers' organisation. Being a member increases the chance of adopting climate change adaptation strategies by 0.95%. The results are supported by Makamane *et al*. (2023) and

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

Issahaku and Abdulai (2021), who revealed a positive and significant association between being a member of a farmer's organisation and adopting climate change adaptation strategies. Farm organisations provide farmers with new agricultural practices and information relevant to increasing agricultural output.

Furthermore, land tenure security positively and significantly influences the probability of adopting options to adapt to climate change. This implies that farmers who own land have 0.623 % more chances to adopt climate change adaptation strategies than their counterparts. This result agrees with the findings of Makamane *et al*. (2023), who revealed that land rights through land ownership are important in improving agricultural productivity, as they motivate farmers to invest more in their land and use improved agricultural practices.

TABLE 2: Parameter Estimates of the Binary Logistic Model of Institutional Factors

Variables	Coefficients	Std. Err.	P>|z|
ACCI	1.108	0.659	0.093*
CCC	0.302	0.313	0.335
ATMM	1.935	0.685	0.005***
SS	-1.008	0.586	0.085*
FO	0.958	0.565	0.090*
AES	-1.283	0.594	0.031**
ATC	0.301	0.623	0.629
ATM	0.842	0.611	0.168
LTS	-0.623	0.250	0.013**
KES	0.415	0.217	0.057*
TSR	0.125	0.321	0.696
EOV	0.147	0.345	0.668
cons	-3.504	1.268	0.006
		Wald chi2(12)	23.07
		Prob > chi2	0.027
		Log pseudolikelihood	-44.112

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

	Pseudo R2	0.207
	Number of observations	120

Note: Dependent variable = Decision to adopt; Yes = 0; No = 1. ***, **, * Significant at 1%, 5%, and 10% probability level, respectively.

4. CONCLUSION AND RECOMMENDATIONS

This study assessed institutional factors influencing smallholder farmers' climate change adaptation strategies. Using primary data from one hundred and twenty smallholder farmers in the study area, as the study sample size, the results indicate that the five most used adaptation strategies to climate change impact were crop diversification, crop rotation, calendar redefinition, resilient crop varieties, and tree planting, respectively.

The results further revealed constraints that limit smallholder farmers from adopting climate change adaptation strategies, such as lack of access to climate change information, shortage of farmland, shortage of farm inputs, lack of access to extension services, lack of credit, and lack of adequate irrigation. Furthermore, the study findings indicated that having access to climate change information, mass media, institutions, extension services, farm member organisations, and land tenure security determined farmers' choice of adaptation strategies to climate change. In addition, access to extension services influenced smallholder farmers towards adaptation strategies. Therefore, this study recommends developing climate change adaptation strategies by providing institutional support to different stakeholders.

This study further suggests that timely weather information should be distributed to farmers to sustain their adaptive levels and assist farmers in making informed decisions. There is also a need to provide access to the market, credit, and training to enhance their adoption of climate change adaptation strategies. In addition, policymakers should focus on strengthening rural institutional services and increasing climate change education to improve smallholder farmers' capacity for the changing climate. In South Africa, the agricultural sector is more vulnerable to climate change, and the variability in temperature and rainfall often results in poor quantity and quality of produce, even at times complete crop failure. Climate change and variability have adverse effects on

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

agricultural productivity, which is vital for the existence of mankind. To overcome the adverse impacts of climate change, climate-resilient agriculture practices should be implemented.

REFERENCES

ABID, M., SCHEFFRAN, J., SCHNEIDER, U.A., & ELAHI, E., 2019. Farmer perceptions of climate change observed trends and adaptation of agriculture in Pakistan. *Environ. Manag.*, *63*: 110-123.

ADETORO, A.A., ABRAHAM, S., PARASKEVOPOULOS, A.L., OWUSU-SEKYERE, E., JORDAAN, H. & ORIMOLOYE, I.R., 2020. Alleviating water shortages by decreasing water footprint in sugarcane production: The impacts of different soil mulching and irrigation systems in South Africa. *Groundw. Sustain. Dev.*, 11: 100464.

ADDIS, Y. & ABIRDEW, S., 2021. Smallholder farmers' perception of climate change and adaptation strategy choices in Central Ethiopia. *Int J Clim Chang Str.*, *13*(4/5): 463-482.

AMENUVO, F.K., 2019. Climate change adaptation strategies adopted by smallholder farmers and its effects on food security at Anloga in the Volta Region of Ghana, West Africa. *Int. J. Humanities Soc. Stud.*, 7(10).

ARUNRAT, N., WANG, C., PUMIJUMNONG, N., SEREENONCHAI, S. & CAI, W., 2017. Farmers' intention and decision to adapt to climate change: A case study in the Yom and Nan basins, Phichit province of Thailand. *J. Clean. Prod.*, 143: 672-685.

ATUBE, F., MALINGA, G.M., NYEKO, M., OKELLO, D.M., ALARAKOL, S.P. & OKELLO-UMAO, I., 2021. Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda. *Agric. Food Secur.*, 10(1): 1-14.

BELAY, A., RECHA, J.W., WOLDEAMANUEL, T. & MORTON, J.F., 2017. Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. *Agric. Food Secur.*, 6: 1-13.

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

BELOW, T.B., SCHMID, J.C. & SIEBER, S., 2015. Farmers' knowledge and perception of climatic risks and options for climate change adaptation: a case study from two Tanzanian villages. *Reg. Environ. Change*., 15(7): 1169-1180.

BRYAN, E., DERESSA, T.T., GBETIBOUO, G.A. & RINGLER, C., 2009. Adaptation to climate change in Ethiopia and South Africa: Options and constraints. *Environ. Sci. Policy*., 12(4): 413-426.

BRYAN, E., RINGLER, C., OKOBA, B., RONCOLI, C., SILVESTRI, S. & HERRERO, M., 2013. Adapting agriculture to climate change in Kenya: Household strategies and determinants. *J Environ Manage.*, 114: 26-35.

CHETE, O. B., 2019. Factors influencing adaptation to climate change among smallholder farming communities in Nigeria. *Afr. Crop Sci. J*., 27(1): 45-57.

COMOE, H. & SIEGRIST, M., 2015. Relevant drivers of farmers' decision behaviour regarding their adaptation to climate change: A case study of two regions in Côte d'Ivoire. *Mitig. Adapt. Strateg. Glob. Chan*g., 20(2): 179-199.

DESTAW, F. & FENTA, M.M., 2021. Climate change adaptation strategies and their predictors amongst rural farmers in Ambassel district, Northern Ethiopia. *Jàmbá: J. Disaster Risk Stud.*, *13*(1): 1-11.

EVANGELISTA, P., YOUNG, N. & BURNETT, J., 2013. How will climate change spatially affect agriculture production in Ethiopia? Case studies of important cereal crops. *Climatic Change.*, 119: 855-873.

FADIMA, A.M.R. & BARJOLLE, D., 2018. Farmers' adaptation strategies to climate change and their implications in the Zou Department of South Benin. *Environments.*, *5*(1): 15.

FAGARIBA, C. J., SONG, S. & SOULE BAORO, S.K.G., 2018. Climate change adaptation strategies and constraints in Northern Ghana: Evidence of farmers in Sissala West District. *Sustain.*, 10(5): 1484.

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

FAO., 2010. *Climate-smart agriculture; policies, practices and financing for food security, adaptation and mitigation*. Rome: Food and Agriculture Organization.

HARVEY, C.A., SABORIO-RODRIGUEZ., M., MARTINEZ-RODRIGUEZ, M.R., VIGUERA, B., CHAIN-GUADARRAMA, A., VIGNOLA, R. & ALPIZAR, F., 2018. Climate change impacts and adaptation among smallholder farmers in Central America. *Agric. Food Secur.*, *7*(1): 1-20.

IPCC., 2018. *Summary for policymakers: Global warming of 1.5°C*. Available from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

IPPC., 2013. *Climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change*. Cambridge, UK and New York, NY, USA: Cambridge University Press.

ISSAHAKU, G., ABDUL-RAHAMAN, A. & AMIKUZUNO, J., 2021. Climate change adaptation strategies, farm performance and poverty reduction among smallholder farming households in Ghana. *Clim. Develop.*, *13*(8): 736-747.

JHA, C.K. & GUPTA, V., 2016. Climate change adaptation in Indian agriculture assessing farmers' perception and adaptive choices. In W. Leal Filho, H. Musa, G. Cavan, P. O'Hare & J. Seixas (eds.), *Climate Change Adaptation, Resilience and Hazards*. Springer International Publishing, pp. 275-288.

KHANAL, U., WILSON, C., HOANG, V.N. & LEE, B., 2018. Farmers' adaptation to climate change, its determinants, and impacts on rice yield in Nepal. *Ecol. Econ*., 144: 139-147.

KOM, Z., NETHENGWE, N.S., MPANDELI, N.S. & CHIKOORE, H., 2022. Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. *GeoJournal*., *87*(2): 677-700.

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

LANDICHO, L.D., LE VAN, N. & XIMENES, A., 2023. Determinants of the decision to adopt climate change adaptation strategies among smallholder upland farmers in Southeast Asia. *For. Soc.*, *7*(2): 200-221.

LIN, B.B., 2011. Resilience in agriculture through crop diversification: Adaptive management for environmental change. *BioScience.*, *61*(3): 183-193.

MAKAMANE, A., VAN NIEKERK, J., LOKI, O. & MDODA, L., 2023. Determinants of Climate-Smart Agriculture (CSA) Technologies Adoption by Smallholder Food Crop Farmers in Mangaung Metropolitan Municipality, Free State. *S. Afr. J. Agric. Ext.*, 51(4): 52-74.

MAKATE, C., WANG, R., MAKATE, M. & MANGO, N., 2016. Crop diversification and livelihoods of smallholder farmers in Zimbabwe: Adaptive management for environmental change. *SpringerPlus.*, *5*: 1-18.

MARIE, M., YIRGA, F., HAILE, M. & TQUABO, F., 2020. Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. *Heliyon.*, *6*(4).

MDIYA, L. & MDODA, L., 2021. Socio-economic factors affecting home gardens as a livelihood strategy in rural areas of the Eastern Cape province, South Africa. *S. Afr. J. Agric. Ext.*, *49*(3): 1-15.

MEKONNEN, Z. & KASSA, H., 2019. Living with climate change: assessment of the adaptive capacities of smallholders in central Rift Valley, Ethiopia. *Am. J. Clim. Change.*, *8*(02): 205.

MITTER, H., LARCHER, M., SCHONHART, M., STOTTINGER, M. & SCHMID, E., 2019. Exploring farmers' climate change perceptions and adaptation intentions: Empirical evidence from Austria. *Environ. Manag.*, *63*: 804-821.

MORTON, J.F., 2007. The impact of climate change on smallholder and subsistence agriculture. *Proc Natl Acad Sci.*, 104(50): 19680-19685.

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

MTYELWA, C., YUSUF, S.F.G. & POPOOLA, O.O., 2022. Adoption of in-field rainwater harvesting: Insights from smallholder farmers in Raymond Mhlaba Local Municipality, Eastern Cape province, South Africa. *S. Afr. J. Agric. Ext.*, 50(2): 81-100.

MUGAGGA, F., ELEPU, J., NIMUSIIMA, A. & BAMUTAZE, Y., 2019. Institutional determinants to climate variability adaptation by smallholder irish potato farmers in Rubanda District, South Western Uganda. *Am. J. Clim. Change.*, 8(01): 77.

MULWA, C., MARENYA, P. & KASSIE, M., 2017. Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics. *Clim. Risk Manag*., 16: 208-221.

MUZAMHINDO, N., MTABHENI, S., JIRI, O., MWAKIWA, E. & HANYANI-MLAMBO, B., 2015. Factors influencing smallholder farmers' adaptation to climate change and variability in Chiredzi district of Zimbabwe. *J. Econ. Sustain. Develop.*, 6(9): 1-9.

NEGA, W., HAILU, B.T. & FETENE, A., 2019. An assessment of the vegetation cover change impact on rainfall and land surface temperature using remote sensing in a subtropical climate, Ethiopia. *Remote Sens Appl: Society & Environ.*, 16: 100266.

NGUYEN, T.P.L., SEDDAIU, G., VIRDIS, S.G.P., TIDORE, C., PASQUI, M. & ROGGERO, P. P., 2016. Perceiving to learn or learning to perceive? Understanding farmers' perceptions and adaptation to climate uncertainties. *Agric. Syst.*, 143: 205-216.

NORUSIS, M.J., 2004. *Straight talk about data analysis and IBM SPSS statistics.*

NWACHUKWU, I. & SHISANYA, C., 2017. Determinants of Agricultural Production in Kenya under Climate Change. *Open Access Library Journal*., 4: 1-10.

OJO, T. O. & BAIYEUNHI, L.J.S., 2020. Determinants of credit constraints and its impact on the adoption of climate change adaptation strategies among rice farmers in South-West Nigeria. *J. Econ. Struct.*, 9: 1-15.

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

ONGUNDEJI, A. A., 2022. Adaptation to climate change and impact on smallholder farmers' food security in South Africa. *Agric.*, 12(5): 589.

PACHAURI, R.K., ALLEN, M.R., BARROS, V.R., BROOME, J., CRAMER, W., CHRIST, R. & VAN YPSERLE, J.P., 2014. *Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.

PARTEY, S.T., ZOUGMORE, R.B., OUEDRAOGO, M. & CAMPBELL, B.M., 2018. Developing climate-smart agriculture to face climate variability in West Africa: Challenges and lessons learnt. *J. Clean. Prod*., 187: 285-295.

PEREIRA, L.M., CUNEO, C.N. & TWINE, W.C., 2014. Food and cash: Understanding the role of the retail sector in rural food security in South Africa. *Food Secur*., 6: 339-357.

RAYMOND MHLABA LOCAL MUNICIPALITY (RMLM)., 2017. *Eastern Cape Province Government Gazette Extraordinary General Notice 3481*.

SILICI, L., ROWE, A., SUPPIRAMANIAM, N. & KNOX, J. W., 2021. Building the adaptive capacity of smallholder agriculture to climate change: evidence synthesis on learning outcomes. *Environ. Res. Commun., 3*(12): 122001.

SHISANYA, S. & MAFONGOYA, P., 2016. Adaptation to climate change and the impacts on household food security among rural farmers in uMzinyathi District of Kwazulu-Natal, South Africa. *Food Secur*., 1-12.

SOUSA, P.M., BLAMEY, R.C., REASON, C.J., RAMOS, A.M. & TRIGO, R.M., 2018. The 'Day Zero'Cape Town drought and the poleward migration of moisture corridors. *Environ. Res. Lett., 13*(12): 124025.

TOMLINSON, J. & RHINEY, K., 2018. Assessing the role of farmer field schools in promoting pro-adaptive behaviour towards climate change among Jamaican farmers. *J. Environ. Sci. Stud., 8*: 86-98.

https://doi.org/10.17159/2413-3221/2024/v52n4a18423

TSHIKORORO, M., CHAUKE, P.K. & ZUWARIMWE, J., 2020. Institutional Factors Affecting Farmers' Decision to Adapt to Climate Change. *J. Agric. Sci.*, 12(10).

YAHAYA, M., MENSAH, C., ADDANEY, M., DAMOAH-AFARI, P. & KUMI, N., 2024. Climate change and adaptation strategies in rural Ghana: a study on smallholder farmers in the Mamprugu-Moaduri district. *Int J Clim Chang Str Manag.*, 16(1): 112-139.

YAMANE, I. & SATO, K., 1967. Effect of temperature on the decomposition of organic substances in flooded soil. *Soil Sci Plant Nutr.*, 13(4): 94-100.

ZVOBGO, L., JOHNSTON, P., OLAGBEGI, O.M., SIMPSON, N.P. & TRISOS, C.H., 2023. Role of Indigenous and local knowledge in seasonal forecasts and climate adaptation: A case study of smallholder farmers in Chiredzi, Zimbabwe. *Environ. Sci. Policy.*, 145: 13-28.