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EVALUATING THE IMPACT OF FODDER PURCHASE AS A DROUGHT MITIGATION STRATEGY FOR SMALLHOLDER CATTLE HOLDINGS IN SOUTH AFRICA

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Abstract The study set out to investigate how fodder-purchase as a drought response strategy impacts smallholder cattle farmers' (SCF) cattle inventory during drought years. Information on self-financed fodder purchasing as a drought mitigation strategy is thin in the literature. We used pooled survey data from the National Income Dynamics Study (NIDS) collated in the years 2015 and 2017 in South Africa. The nationally representative data was comprised of smallholder cattle households that experienced 2015 to 2017 sustained drought events in South Africa. Propensity score matching method (PSM) was used for the analysis. Factors that influence SCF's decision to adopt fodder purchasing as a drought mitigation strategy include age, income, market participation, crop farm ownership, recipients of secondary off-farm income, social support beneficiaries and land ownership. The PSM result shows that fodder-purchase significantly and positively impacts smallholder cattle production during drought.

Keywords: *Cattle, Drought, Fodder, Propensity Score Matching (PSM), Smallholder*

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INTRODUCTION

Erratic rainfall patterns and climatic variations are common in South Africa as recordings of mild and extremely low precipitations have been registered in South African climate history (Vogel & Olivier, 2019). Among these drought occasions include those of 1983, 1992, 2003, 2007 and 2015–2017 (Chikoore & Jury, 2021; Meza et al., 2021; Vetter et al., 2020). Recent drought events of 2015/2017 and that of 2003 have been reported in the literature (Meza et al. 2021; Vetter et al., 2020, and Elum et al., 2017). Drought occurrence is mostly decadal in South Africa, with significant variation in spatial expansion and intensity over the years (Chikoore & Jury, 2021). This characteristic feature of drought in South Africa presents an unsettled demarcation of drought-prone precipitation districts. In the study of drought events between 1986 and 2015, Meza et al. (2021) affirm that drought occurs in all municipalities of South Africa. Drought affects plants, animals and humans as below-average precipitation levels result in water shortages within specific periods (Dzavo et al., 2019). In areas of rainfed agriculture, the effect is more pronounced as the livelihood of farmers is exposed to a high risk of losses. The socio-economic stresses of drought have been advocated for, in the view that individuals go through hardship when drought occurs, hence the need for more human-centred approaches to drought policies and measures (Vogel & Olivier, 2019).

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Smallholder farmers' planning processes often guard against perceived events and incidences that reduce their income or increase their production costs (Nketiah et al., 2019). Like other non-market risks, guarding against drought is difficult for smallholder cattle farmers (SCF) as it may involve storing large quantities of silage and hay as well as acquiring water storage systems to help minimize the effect of drought. The widespread nature of disasters and the complexity of social differences, experiences and degree of exposure are issues that encompass the difficulty in adopting specific strategies to curb the effects of disasters Osbahr et al. (2010). Nonetheless, other responses to disasters are almost certain and sometimes localized in specific geographical areas, such that investigating their effectiveness in lowering the effect of disasters is a necessity.

Mitigation strategies and preparedness help in planning and management decisions towards reducing the impact of hazardous events such as drought (Pili & Ncube, 2022; Elum et al., 2017). Smallholder farmers may seek to intensify farm activities or may diversify to other non-farm ventures, all in the quest to avert the adverse effect of farm risks on their livelihood (Nketiah et al., 2019). A shift towards intensification decisions for smallholder cattle farmers may include the acquisition of fodder from the market as a short-term mitigation strategy for drought. Livestock farmers engage in the purchase of grains or fodder to meet the dietary needs of their herd in occasions when naturally existing pasture depletes (Salmoral et al., 2020). South African livestock farmers are no exception to this strategy, as Pili & Ncube (2022) highlighted their engagement in the purchase of fodder and the transport of water to farms during the recent drought period. Some farmers may also engage in grazing adjustment and feed rationing or sell off some livestock as short-term mitigation strategies towards navigating feeding stress in occasions of drought (Salmoral et al., 2020).

Knowledge of the efficacy of drought mitigation strategies is required not only to deepen the understanding of drought management measures but also to inform the choices of farmers and agricultural stakeholders in planning against drought. Inquest into the impact of additional fodder-purchase as a livestock management strategy for drought features in the literature. For example, Bekele & Abera (2008) set out a controlled experiment in southern Ethiopia and found that cattle fed with purchased fodder from the market maintained lower cattle mortality during drought relative to unfed groups. Similarly, the impact of purchased fodder for livestock in Kenya was observed to be effective for herd size maintenance during the drought of 1999-2001 (Aklilu & Wekese, 2002). Both studies report on the evaluation of sponsored interventions by developmental agencies. In the absence of donor-sponsored drought response, smallholder farmers employ varying strategies by which they navigate the menace based on their specific capacities and resource endowments. Studies that investigate self-financed supplementary cattle feeding for drought mitigation are rare. This study assesses how smallholder cattle farmers' socioeconomic characteristics influence supplementary fodder-purchase decisions and their impact on cattle inventory during drought.

The importance of cattle enterprise to global food security is enormous. Demand for beef and its variant products has seen an increase in recent times worldwide as population increase affects demand for food (FAO, 2019). This shift in demand has met modern trends of taste and preferences that emphasize product differentiation as the new path for meeting demands of developed markets towards traceability, and certified breeds, among others (MLA, 2021). Such emerging issues prompt a sense that efforts are needed to ensure that demand for beef is met with increases in production within a fixed land size constraint. In finding effective ways to resolve such a demand gap, stakeholders cannot overlook the efforts of SCF and their potential in worldwide beef frontiers. An effort in this direction will lead to accomplishing not only the Sustainable Development Goals (SDGs) 1 and 2, which aim at ending poverty and hunger but also goals 13 and 15 on climate change awareness and the protection of life on earth.

Conceptualization of Study

Conceptually, this study postulates that weather variability plays a key role in influencing the dynamics of household livelihoods and assets. This claim stems from the risk aversion behaviour of rational farmers and their desire to leave a bequest (Keske et al., 2021; Worthy et al., 2020). Such that, in the unlikely event of a shock, cattle farmers will commit resources to protect their investments even when keeping cattle becomes unrewarding due to decreasing returns of the production mix. The drought effect on smallholder cattle farming is such that it hampers the expected growth of cattle herds and sometimes results in deaths. This also has a direct effect on the expected incomes of the farmer. Some farm households may have the capacity to acquire fodder in other to protect their investment.

On the other hand, the sale of a herd is a plausible means by which farmers neutralize their perceived risk to reinvest later. Losing herds to extreme weather events such as drought will lead to undesirable outcomes such as reduced resistance to shocks, asset base decline, reduced household incomes and welfare loss, as presented in the pathway shown in Figure 1.

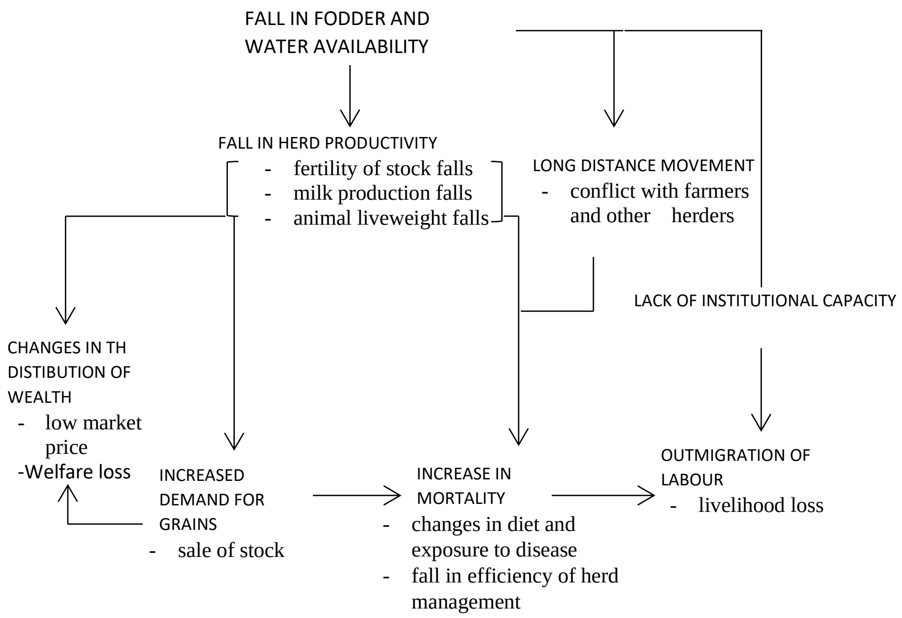

Figure 1. Drought and cattle loss pathway (Source: Adapted from Toulmin (1985)).

In the event of drought, farm households fall on their internal emergency response measures. One such strategy includes supplementary fodder purchase among cattle households as a mitigation measure against drought.

METHOD AND MATERIALS

Study Area

South Africa has a total land surface area of about 122.3 million hectares, of which 80% is suitable for grazing (DAFF, 2018). The country's ecology is largely semi-arid and arid, with major parts experiencing summer rains and relatively dry winter periods. Agricultural Sector Education and Training Authority (AgriSETA, 2020) highlights South Africa’s contribution of about 24% of total beef on the African continent, representing one percentage of global beef production. Moreover, the beef industry contributes 34.1% of total agricultural output domestically. The significant contribution of the beef sector of South Africa to the world economy makes the sector viable and one that is essential for smallholder livelihood enhancement and sustainability.

Data

The study used data drawn from the National Income Dynamics Study (NIDS) collated from 2008, 2010, 2012, 2015 and 2017, with each survey referred to as a wave. The national representative data sampled all 52 administrative districts of South Africa and arrived at about 52000 random households using a stratified two-stage cluster sample design. Households were interviewed on key socioeconomic indicators across waves. A total of 1009 smallholder cattle households were captured in the survey. The context of smallholder cattle farmers in this study refers to communal and emerging farmers having a cattle herd size less than or equal to 100, according to the 2016 household survey by Statistics South Africa (StatsSA, 2016).

Our study focused on smallholder cattle farmers in the drought years of 2015 and 2017 which comprised of 588 households, with 102 (17%) households appearing in both years. In all, 690 responses were realized for this study, within which 561 (95%) of the responses (fodder purchase) were unidirectional for both years. An F-test was conducted on the unbalanced panel data to check if fixed effects were equal to zero, and we failed to reject the null. The pooled data with year dummies is the most suitable approach for this data in the quest to estimate the effect of fodder-purchase decisions since drought effects and impacts persist over time. Pooling the data will help exude the contemporaneous effect of the decision to purchase fodder.

Table 1. Definition of variables.

Variable	**Definition**	**Measurement**	**Apriori**
Herd	Total number of herds	Count	NA
Income	Total household monthly income	Amount (Rand)	+
Education	Household head's formal education	1 = Yes, 0 = No	+
Gender	Sex of household head	1=Male, 0=Female	-/+
Age	Age of farmer	Count	+
Crop household	Households having crop farm	1 = Yes, 0 = No	-/+
Market participation	Households that sold cattle	1 = Yes, 0 = No	+
Social support	Households receiving social support	1 = Yes, 0 = No	-/+
Cattle loss	Households experience cattle death	1 = Yes, 0 = No	+
Secondary income	Household head receiving secondary off-farm income	1 = Yes, 0 = No	-/+
Year	Drought years	1 = 2015, 0 = 2017	-/+
Land ownership	Total farmland owned by households	0 = No land, 1 = <5000m^2 2 = >5000m^2	-/+

The exogenous variables hypothesised in this study to influence the decision to purchase fodder as a drought mitigation strategy have been defined in Table 1. The choice of variables was informed by the work of Mohamed Sala et al. (2020), which identified off-farm income, age, gender, and proximity to towns, among other variables, as having a significant effect on fodder purchase decisions. This study extends the model to include beneficiaries of social support, off-farm income, and loss of herd as important factors in livestock management practice during periods of shock. Household ownership of crop farms was also postulated to have an effect on fodder purchasing decisions. Moreover, the effect of smallholder farmers' assets on drought mitigation was captured as land ownership, a more common asset to farmers. An endogeneity test was conducted to check for the effect of income as a determinant of fodder purchase and we failed to reject the null of income being endogenous (Appendix III).

Propensity score matching

The study employed a Propensity Score Matching (PSM) analysis as the suitable econometric tool for observational data in estimating the impact of smallholder cattle farmers' fodder-purchase decisions as a drought mitigation strategy. PSM can distinguish between treated and untreated groups in the aftermath determination of impact on an outcome (Heckman et al., 1998; Smith & Todd, 2005). The method operates on a first-stage probit modelling given a binary response where the treatment variable (feed purchase) takes a binary response, $Y_i = 1$ if household purchased feed and $Y_i = 0$ if household purchased no feed. The theoretical pivot of choice modelling is the Random Utility Framework (RUF), where the utility of a farm household is unobserved but can be approximated using observable characteristics of the household. The assumption here is that households are rational in their choices and will always choose bundles that optimize their utility among a given bundle set. Smallholder cattle farmers' investment in feed is presumed to be based on the expected utility derived from fodder purchase during drought. Propensity scores are then derived from the probit estimation for matching.

The latent variable (Y_i^*) is specified as

$$Y_i^* = Z_i'\gamma + e_i \quad \text{……….(1)}$$

Where Y_i^* = unobserved dependent variable, Z_i = observable characteristics of students, γ = unknown parameters relating to each explanatory variable. The observed part of the probit model can be expressed as;

$$Y_i = \sum_{j=1}^{jth} \beta_j X_{i,j} + e_i \text{ ……….(2)}$$

For i =1, …. N; denotes individual households and 'e' is the error term. Y_i represent binary response fodder purchase. β represents parameters to be estimated, and X denotes observed characteristics of smallholder cattle households. In the specified empirical model, all continuous variables were log-transformed. The outcome variable in the second stage estimation is the cattle herd size of the farm household as total inventory at the time of data collection.

Propensity scores derived from the binary model help deal with selection bias that arises from self and sample selection among treated and untreated respondents. Using the propensity scores, the two sets of respondents are then statistically compared based on similar observable traits.

ATE = E[Y(1) – Y(0)] = E[Y(1)] - E[Y(0)]...(2.1)

ATT = E[Y(1) – Y(0) | D =1] = E[Y(1) | D =1] - E[Y(0) | D =1]...(2.2)

PSM produces an average treatment effect (ATE) from the comparison between similar cohorts of feed-purchasing and nonfeed-purchasing smallholder cattle households. The equation depicts a mean difference between the comparing sets based on the observable characteristics of respondents, as shown in equation 1.1. A distinct measure of the exact effect of feed purchase on cattle holdings is shown in equation 2.2 as the average treatment effect on the treated (ATT). The indicator variable is represented by 'D' (D = 1 for fodder-purchasing households, 0 for non-fodder-purchasing households). In equation 2.3, the relation for estimating the exact effect of purchased fodder use among non-fodder purchasing households had it been that they bought fodder is given. The variables used in the model are shown in Table 1.

ATU = E[Y(1) – Y(0) | D = 0] = E[Y(1) | D = 0] - E[Y(0) | D = 0]…(2.3)

RESULTS AND DISCUSSION

Out of the total sample of 690 respondents, majority (83%) did not purchase supplementary fodder compared to 17% of respondents that purchased fodder during drought. A comparison of means among the two groups shows that income, age, herd size and crop producing households were significantly higher for fodder purchasing households than their non-purchasing counterparts, as shown in Table 2. On the contrary, access to land and social support recorded significantly higher means for non-fodder purchasing households.

Table 2. Descriptive statistics of variables.

	Non-fodder buyers		Fodder buyers		T-test	
Variable	Mean	SD	Mean	SD	Difference	SE
Gender	0.38	0.49	0.39	0.49	0.01	0.05
Education	0.67	0.47	0.66	0.47	-0.01	0.05
Market participation	0.17	0.38	0.13	0.34	-0.04	0.04
Secondary income	0.13	0.34	0.09	0.28	-0.05	0.03
Crop household	0.63	0.48	0.73	0.44	0.10**	0.05
Social support	0.82	0.39	0.75	0.43	-0.07*	0.04
Cattle loss	0.19	0.39	0.25	0.44	0.06	0.04
Land access	0.97	0.60	0.85	0.64	-0.12**	-1.93
Education	5.81	4.23	5.84	4.40	0.04	0.43
Herd size	7.55	6.93	9.41	7.82	1.85***	0.72
Age	60.63	15.20	63.92	13.53	3.29***	1.52
Income	6082.87	4945.69	7033.80	6121.27	950.93*	525.47

Source: Authors (2023) *ρ<0.1, **ρ<0.05; ***ρ<0.01

Factors Influencing the Decision to Purchase Fodder During Drought.

To ascertain the factors that affect smallholder cattle households' decision to adopt fodder purchasing as a drought response strategy in South Africa, a binary probit model was employed, and the result is shown in Table 3. The output from the partial effect of the average (PEA) estimates indicated that variables such as household monthly income, record of cattle sale, age of farmer, farming of crops, recipients of secondary off-farm income and social support and farmers' land ownership significantly determine the fodder purchasing decision of smallholder cattle households.

The result showed a positive and significant (10%) relationship between income and the decision to purchase fodder. A smallholder household's decision to purchase fodder is more likely when income increases. This shows that financial endowment is key in the affordability and purchase of supplementary fodder for drought emergency response. This is plausible because high-income households are most likely to purchase fodder to offset the drought menace, as highlighted by Salmoral et al. (2020) and Mohamed Sala et al. (2020).

The study found that the age of the household head has a 1% significant influence on smallholder cattle households' decision to purchase fodder. A year's increase in age raises the likelihood for a household to engage in the purchase of fodder during drought seasons. This result shows that older household heads may have accumulated experiences from previous drought events. It positions them to adopt a better drought response strategy, such as purchasing fodder during drought shock.

Table 3. Results of the probit model.

	Coefficient		Marginal effects	
Variable	Estimate	SE	Estimate	SE
Gender	-0.039	0.124	-0.009	0.029
Log age	0.697	0.262	0.164***	0.061
Log education	0.090	0.139	0.021	0.032
Log income	0.142	0.082	0.034*	0.019
Secondary income	-0.296	0.197	-0.062*	0.036
Crop household	0.341	0.141	0.076***	0.029
Market participation	-0.450	0.173	-0.090***	0.029
Social support	-0.355	0.150	-0.093**	0.043
Herd loss	0.242	0.143	0.061	0.039
Land<5000 m^2	-0.406	0.144	-0.101***	0.037
Land>5000 m^2	-0.540	0.204	-0.104***	0.031
Year	-0.036	0.119	-0.008	0.028
_cons	-4.625	1.116		

N= 688; likelihood ratio χ^2 = 33.84; Prob(χ^2) = 0.000; Pseudo R^2 = 0.058; log likelihood = -292.52.
*ρ<0.1, **ρ<0.05; ***ρ<0.01

The 1% significant negative relationship between SCF market participation and the decision to purchase fodder shows that smallholder cattle households that sold cattle within drought years have a lower likelihood of purchasing fodder during drought. Fanadzo et al. (2021) and Bahta (2020) highlight the decision to purchase fodder and the decision to sell cattle as drought-mitigating measures. Smallholder cattle households may decide to weigh their options in choosing between purchasing fodder and selling off some herd towards effective farm management, given the prevailing stress from sustained drought and resource endowment of the farmer. The result implies an inverse relationship between the two drought-mitigating strategies.

The result further shows that households that own a crop farm increase the likelihood of purchasing fodder as a drought mitigation strategy. This relationship is at a 1% significance level. Fodder availability and access become a challenge for smallholder cattle households, but crop residue serves a good purpose for the households that cultivate crops, such that the residue can support cattle feeding. Also, income gained from crop farming may be used to purchase fodder for cattle maintenance.

On the other hand, SCFs' receiving secondary off-farm income is negative and significant at 10%, showing less likelihood for a cattle household to engage in fodder purchasing during drought. This is consistent with the study of Mohamed Sala et al. (2020) and implies that SCFs with secondary off-farm income do not have the desired attention and care for the cattle-raising enterprise, which may compete directly with their interest in other off-farm engagements, hence the low likelihood to adopt fodder purchasing strategy during drought.

Farmers that benefit from social support grants are less likely to adopt fodder-purchasing as a strategy for drought mitigation. This outcome could mean that beneficiaries of social support may lack the capacity to support fodder purchasing for cattle in drought. The PEA estimates further indicate that the size of land owned by individual farmers has a 10% negative significance to the decision to purchase fodder. The result further indicates that SCFs' ownership of farm sizes less or greater than $5000m^2$ renders them less likely to purchase fodder relative to farmer households that do not own land. This suggests a rational advantage to farmers with larger land sizes to better engage in grazing adjustment or cultivate fodder to avoid purchasing fodder during drought events.

Effect of Fodder Purchase on Smallholder Cattle Holdings

Using multivariate matching methods, nearest neighbour matching (NNM) was conducted based on the one-to-one matching pair, regression adjustment (RA) and propensity score matching (PSM) techniques, as shown in Table 4. RA produces results based on the treatment and untreated subjects' possible outcome means whilst accounting for their systematic differences. It also checks for the specification adequacy of the outcome model (Iddrisu 2017). Figure 2 shows the distribution balance of the density function conditional on propensity scores. The baseline covariates are expected to be balanced between treated and untreated groups. From the graph, it can be observed that matching is balanced between the treatment and control groups matching.

Table 4. Results of matching analysis.

	NNM		RA		PSM	
Outcome	Coefficient	SE	Coefficient	SE	Coefficient	SE
ATE	0.292 ***	0.095	0.263 ***	0.082	0.223 **	0.099
ATT	0.292 **	0.120	0.250 ***	0.083	0.212 *	0.119
ATU	0.291 ***	0.100	-	-	0.225 **	0.113

Notes: Number of observations 695. Number of matches 1. Minimum1. Maximum 2. ***ρ<0.01

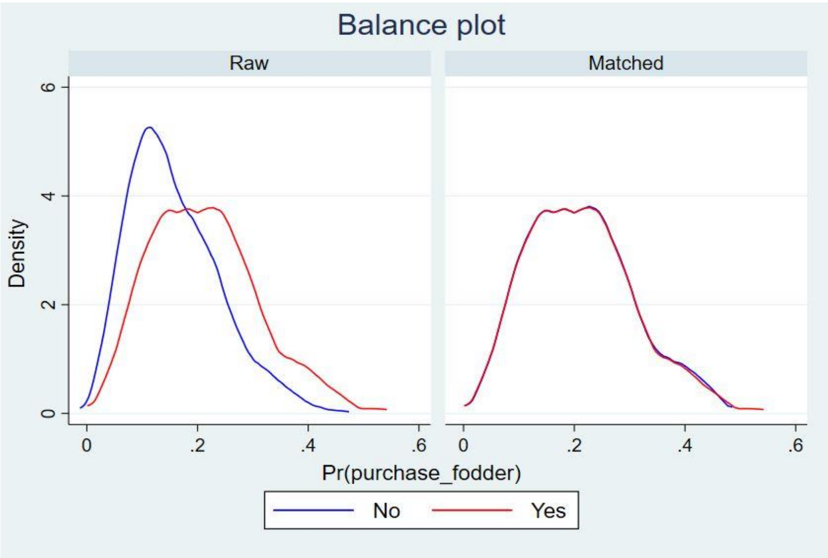

Figure 2. Density plot of fodder purchase decision before and after matching.

Generally, the ATE estimated effect shows that the decision to purchase supplementary fodder significantly and positively affects cattle holdings. The ATT outcome indicates that fodder purchase contributes 29, 25 and 21 percent increment in cattle herd sizes among the treated sample, respectively, in the NNM, RA and PSM. This indicates that smallholder cattle households that purchased fodder in drought seasons were, on average, better off as they maintained larger herd sizes ahead of their counterparts who did not purchase fodder.

On the other hand, ATU results from the NNM and PSM showed that households that did not buy fodder would have recorded 29 and 22 percent respectively, than the adopters if they did. This shows that if these households had adopted fodder purchase as a drought response strategy, they would have experienced increased cattle holdings.

CONCLUSION

Immediate response strategies of smallholder farm households towards shocks are a critical component of farm management practices. Such responses are expected to shield farm investments and reduce the negative impact that may arise from uncertainties of drought events. The study sought to investigate the determinants of fodder purchase as a response strategy and how it affects smallholder cattle holdings during sustained drought such as the 2015 to 2017 event in South Africa.

The study found that farmers' choice of fodder purchase and sale of cattle as mitigation strategies are inversely related in occasions of sustained drought. Also, the PSM revealed that adopting fodder-purchase as a drought response strategy contributes positively to cattle herd size maintenance. Relative to herd sizes of households that did not engage in the purchase of fodder, adopters of the strategy are able to maintain larger cattle herds during drought.

The result from the probit model indicates a systematic inequality in the capacity of Smallholder cattle farmers, such that, low resource endowed farmers are more likely to be exposed to intense drought effects on their livelihood. This implies that external interventions are required to help smallholder cattle farmers in drought prone countries like South Africa to mitigate the effect of drought on their livelihood. We, therefore, recommend that disaster support programs for smallholder cattle farmers in the country should be modified and prioritize access to functioning fodder markets. The expansion of fodder subsidy through vouchers or input loans especially, can help support and encourage smallholder cattle farmers to build resilience against drought.

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COMPETING INTERESTS

The authors declare no known personal or financial relations that could have appeared to influence the content of this work inappropriately.

DATA AVAILABILITY

Data used for this article is not available for sharing as no new data were created or analysed in this study.

ETHICAL CONSIDERATIONS

This article followed all ethical standards for research without any direct contact with human or animal subjects.

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Prince Nketiah is a PhD student in the Department of Agricultural Economics at the University of Pretoria. Before this, he had acquired an MPhil in Agricultural Economics at the University for Development Studies in Ghana. Having a research interest in farmers' risk and uncertainty studies, he enquired into the drought events of 2015 to 2018 in South Africa.

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REFERENCES

AgriSETA. (2020). Red meat sub-sector skills plan 2020/2021. Accessed 12 December. www.agriseta.co.za/wpcontent/uploads/2021/02/Agriseta_Red_Meat_SSSP_DIGITAL.pdf.

Aklilu, Y., & Wekesa, M. (2002). Drought, livestock and livelihoods: lessons from the 1999-2001 emergency response in the pastoral sector in Kenya: Overseas Development Institute London.

Bahta, Y. T. (2020). Smallholder livestock farmers coping and adaptation strategies to agricultural drought. *AIMS Agriculture and Food, 5(4),* 964-982. doi: 10.3934/agrfood.2020.4.964.

Bekele, G., & Abera, T. (2008). *Livelihoods-based Drought Response in Ethiopia: Impact Assessment of Livestock Feed Supplementation*. Feinstein International Center, Tufts University and Save the Children US, Addis Ababa.

Chikoore, H., & Jury, M. R. (2021). South African drought, deconstructed. Weather and Climate *Extremes, 33,* 100334. Doi: 10.1016/j.wace.2021.100334

DAFF. (2018). South Africa yearbook 2018/2019. edited by Forestry and Fisheries Department of Agriculture: www.gcis.gov.za/sites/default/files/docs/resourcecentre/yearbook/yb1919-3-Agriculture.

Dzavo, T., Zindove, T. J., Dhliwayo M., & Chimonyo, M. (2019). Effects of drought on cattle production in sub-tropical environments. *Tropical Animal Health and Production*, *51*(3), 669-675. Doi: 10.1007/s11250-018-1741-1

Elum, Z. A., Modise, D. M., & Marr, A. (2017). Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. *Climate Risk Management*, *16*, 246–257. Doi: 10.1016/j.crm.2016.11.001

Fanadzo, M., Ncube, B., French, A., & Belete, A. (2021). Smallholder farmer coping and adaptation strategies during the 2015-18 drought in the Western Cape, South Africa. *Physics and Chemistry of the Earth*, *Parts A/B/C, 124,* 102986. Doi: 10.1016/j.pce.2021.102986

FAO. (2019). Developing sustainable value chains for small-scale livestock producers. Edited by G. Leroy & M. Fernando. In FAO Animal Production and Health Guidelines, edited by G. Leroy & M. Fernando. Rome: Food and Agriculture Organisation.

Heckman, J., Ichimura, H., Smith, J., & Todd, P. (1998). *Characterizing selection bias using experimental data* (w6699; p. w6699). National Bureau of Economic Research. Doi: 10.3386/w6699

Keske, C. M. H., Arnold, P., Cross, J. E., & Bastian, C. T. (2021). Does conservation ethic include intergenerational bequest? A random utility model analysis of conservation easements and agricultural landowners. *Rural Sociology*, *86*(4), 703–727. Doi: 10.1111/ruso.12370

Meza, I., Eyshi Rezaei, E., Siebert, S., Ghazaryan, G., Nouri, H., Dubovyk, O., Gerdener, H., Herbert, C., Kusche, J., Popat, E., Rhyner, J., Jordaan, A., Walz, Y., & Hagenlocher, M. (2021). Drought risk for agricultural systems in South Africa: Drivers, spatial patterns, and implications for drought risk management. *Science of The Total Environment*, *799*, 149505. Doi: 10.1016/j.scitotenv.2021.149505

MLA. (2021). Global Beef Industry and Trade Report. Australia. Meat and Livestock Australia.

Mohamed Sala, S., Otieno, D. J., Nzuma, J., & Mureithi, S. M. (2020). Determinants of pastoralists' participation in commercial fodder markets for livelihood resilience in drylands of northern Kenya: Case of Isiolo. *Pastoralism*, *10*(1), 18. Doi: 10.1186/s13570-020-00166-1

Nketiah, P., Ayamga, M., & Mabe, F. N. (2019). Land Deals and Small-Scale Intensive Farming Decisions. *Review of Agricultural and Applied Economics*, *22*(2), 18–25. Doi: 10.15414/raae.2019.22.02.18-25

Osbahr, H., Twyman, C., Adger, W. N., & Thomas, D. S. G. (2010). Evaluating successful livelihood adaptation to climate variability and change in southern africa. *Ecology and*

Society, *15*(2), art27. Doi: 10.5751/ES-03388-150227

Pili, O., & Ncube, B. (2022). Smallholder farmer coping and adaptation strategies for agricultural water use during drought periods in the Overberg and West Coast Districts, Western Cape, South Africa. *Water SA, 48*(1 January). Doi: 10.17159/wsa/2022.v48.i1.3846

Salmoral, G., Ababio, B., & Holman, I. (2020). Drought impacts, coping responses and adaptation in the uk outdoor livestock sector: Insights to increase drought resilience. *Land*, *9*(6), 202. Doi: 10.3390/land9060202

Smith, J. A., & Todd, P. E. (2005). Does matching overcome LaLonde's critique of nonexperimental estimators? *Journal of Econometrics*, *125*(1–2), 305–353. Doi: 10.1016/j.jeconom.2004.04.011

StatsSA. (2016). *Community Survey 2016 Agricultural households*. South Africa: Statistics South Africa.

Toulmin, C. (1985). *Livestock losses and post-drought rehabilitation in sub-Saharan Africa.* ILCA LPU Working Paper.

Vetter, S., Goodall, V., & Alcock, R. (2020). Effect of drought on communal livestock farmers in KwaZulu-Natal, South Africa. *African Journal of Range & Forage Science*, *37*(1), 93–106. Doi: 10.2989/10220119.2020.1738552

Vogel, C., & Olivier, D. (2019). Re-imagining the potential of effective drought responses in South Africa. *Regional Environmental Change*, *19*(6), 1561–1570. Doi: 10.1007/s10113-018-1389-4

Worthy, S. L., Mountain, T., Chatterjee, S., Johnson, C., Kiss, E., O'Neill, B., Saboe-Wounded Head, L., & Gutter, M. S. (2020). Differences in the determinants of retirement preparation between farm and nonfarm households. *Journal of Applied Farm Economics*, *3*(2). Doi: 10.7771/2331-9151.1048

APPENDIX

Table I.Shows result from endogenous switching regression model.

	Selection		Fodder buyers		Non fodder buyers	
	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
Log income	0.07	0.09	0.17	0.27	0.09**	0.05
Veterinary access	0.59	0.36	-0.22	2.98	0.22	0.15
Gender	-0.05	0.24	0.13	0.56	0.14**	0.07
Crop household	0.35	0.16	-0.45	1.44	0.15**	0.08
Education	0.02	0.02	0.02	0.11	0	0.01
Cattle sale	-0.49	0.19	1.12	2.02	0.55***	0.11
Remit	0.05	0.27	-0.07	0.32	0.03	0.07
Landsize<5000 m^2	-0.42	0.26	0.5	1.76	0.17*	0.1
Landsize>5000 m^2	-0.55	0.22	0.92	1.76	0.22*	0.13
Year	-0.07	0.15	0.11	0.46	0.03	0.07
Water proximity	-0.56	0.28	0.44	2.34	0.29**	0.14
Log age	0.86	0.58	-0.06	4.01	-0.05	0.17
Social support	-0.26	0.92				
Loss herd	0.23	0.4				
_cons	-4.83	1.69	1.45	25.77	0.58	0.7
/lns1			0.012	3.057		
/lns2					-0.205***	0.065
/r1			-1.135	7.001		
/r2					-0.327	0.478
Log likelihood			-1094.17			

N= 687; Prob(χ^2) = 0.001 Wald test of indep. Prob(χ^2) = 0.4925

Table II. Shows result from fixed effect regression.

Fodder purchase	Coefficient	Std. err.
Gender	0	(omitted)
education	0.004	0.300
Log age	-1.529	4.812
Log income	0.060	0.081
Secondary job	0.074	0.167
Crop household	-0.005	0.089
Cattle sale	-0.015	0.116
Social support	-0.227*	0.137
Loss herd	0.074	0.104
Landsize<5000 m^2	-0.273***	0.100
Landsize>5000 m^2	-0.370***	0.144
Year	-0.066	0.176
_cons	6.323	19.759

N= 687; corr(u_i, Xb) = -0.8265 Prob(χ^2) = 0.38; u_i=0: F(584,91) Prob>F = 0.44

Table III. Shows result from endogeneity test.

Residuals	Coefficient	Std. err.	P>t
Gender	1.85E-11	0.0015	1.00
ln_edu	-1.59E-12	0.0009	1.00
l_age	-1.08E-10	0.0032	1.00
l_inc	-7.41E-12	0.0010	1.00
multijob	6.08E-11	0.0024	1.00
crop_hshd	-3.09E-11	0.0016	1.00
Mkt_prt	1.06E-11	0.0021	1.00
Social	1.85E-11	0.0020	1.00
Loss_stock	-7.90E-11	0.0019	1.00
_land2	-1.55E-11	0.0019	1.00
_land3	6.81E-12	0.0025	1.00
Y	-1.80E-11	0.0015	1.00
_cons	5.23E-10	0.0143	1.00

N= 687