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Understanding beef cattle production practices and associated factors constraining performance: a survey of smallholder farmers in South Africa

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Abstract

Farm practices of beef cattle smallholders in South Africa are characterised by poor management practices with limited advisory services. This study aimed to assess current beef cattle farming practices and limiting factors for improved beef production in South African smallholder farmers. A questionnaire was administered to 460 individual smallholder farmers purposively selected from seven provinces of South Africa (SA). The questionnaire captured information on demographics and farm profiles, constraints on production, marketing, ecological and reproduction management. Frequency procedure and logistic regression were used for data analysis. The majority of farmers were males (77 %), fully committed to cattle farming (92 %) and participated in informal markets (61 %). Farmers constraints included extreme weather events, disease outbreaks, lack of access to information on farm management, supply of cattle nutrition and fair market pricing. The majority (93 %) of farmers had no knowledge on body condition scoring (BCS) prior breeding and recorded inter-calving periods of two years (77 %). Only 17 % of farmers kept calving records and 80 % practices culling of old cows. The regression model revealed that lack of information and understanding of farm business, and information communicated by government were among the dominating factors associated with the constraints. The study confirmed the need to enhance the approach of farm information dissemination and skills transfer to mitigate farming challenges and improve productivity. Policy makers may ensure adoption of farm information chains through more implementations of open platforms such as farmer's schools and farmers days.

Keywords: beef farming, farm constraints, farm management, questionnaire

1 Introduction

Over many centuries, livestock has been central to the economic and social livelihoods of communities in developing countries (Hatab *et al*., 2019). In South Africa (SA) and Africa at large, livestock is kept by 90 % of rural communities (Nyamushamba *et al*., 2017; Njisane *et al*., 2019). South Africa has a diverse climate with up to 80 % of land only suitable for grazing by cattle, sheep and goats (DAFF, 2019). Cattle are the major livestock species farmed compared to small ruminants with 80 % comprising of beef and 20 % for dairy production (Oduniyi *et al*., 2020).

Over many decades the SA agricultural sector has been characterised by its dualistic systems with highly commercialised sector with an annual turnover between R10 – R50 million and a smallholder sector (SHS) that primarily farm for household consumption and profit of excess production (Greyling, 2015; DALRRD, 2020). The commercialised sector accounts for 90 % of the national food supply while in the smallholder sector, production is divided amongst household diet supplementation (77 %), main

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food source (8 %), additional income (6 %) and main income (2 %) (Greyling *et al*., 2015; Queenan *et al*., 2020). In SA context, smallholder farming is divided into three groups: The household farmers (vulnerable and subsistence) that farm in former homelands and they constitute the majority (92 %) in this sector. The subsistence farmers within the household group participate in marketing a portion of their access production and generates less than R 50 000 in sales annually. The second group is referred to as smallholder farmers whose farming is for household production, however have higher annual turnover between R50 001 to R1 million. The last group, which is the minority, are market-oriented farmers whose production is mainly for income through farm produce and household consumption (DALRRD, 2020; Queenan *et al*., 2020).

The SHS is generally characterised by limited farm knowledge, advisory services, recording systems, marketing access and poor breeding management (Baker *et al*., 2015; Dinku, 2019; Myeni *et al*., 2019). Despite these limitations, smallholders are identified to have potential to alleviate poverty in rural communities in line with United Nation Sustainable Development Goals (SDGs) SDG 1 (Terlau *et al*., 2019). As a result, SA government has in the past 18 years implemented programs aimed at providing support on advisory services, marketing, business development and improving herd reproduction performance in the SHS (TIA, 2013; NRMDP, 2017; DALRRD, 2020). These interventions have however yielded a negligible impact (Cheteni & Mokhele, 2019). To date, approximately 37 % of farmers are aware of different marketing avenues, less than 70 % receive extension services and 77 % of beef farmers express constraints in poor breeding management (Molefi *et al*., 2017; Mapiye *et al*., 2018). These figures are not different from the reported 76 % limited market information and 56 % local extension officers visits from the past decade (Musemwa *et al*., 2008; Baloyi, 2010;).

This study assumes that for improved understanding of beef cattle production in smallholder herds, integrated factors on farm demographics and constraints related to production, marketing, ecological and reproduction management should be evaluated. Insights on these constraints may assist in designing support targeted to the diversity and complexity of different farmers groups recognizing gender, age, employment and access to agricultural land. These factors may expand the narrative of cattle feed availability, nutrition and health in smallholder systems. Proper nutrition and health can increase reproduction efficiency by up to 25 % (McGowan *et al*., 2014), ultimately, improved reproduction management means improving farm outputs and attraction of marketing channels that lead to maximization of farm profits. The current study was based on a quantitative survey to assess beef cattle farming practices and identify the primary constraints influencing smallholder beef cattle farmers in SA.

2 Materials and methods

2.1 Data origin

Ethical clearance for the use of external data to conduct the study was granted by the Animal Ethics Committee (AEC) of the University of Pretoria (NAS339/2020). Data for the study was obtained from the behaviour change survey within the High Beef Value Chain (HBVC) project funded by the Australian Centre for International Agricultural Research (ACIAR).

A structured questionnaire with 114 questions was developed to investigate cattle production profiles and constraints. The study followed a cross-sectional research design approach. The questionnaire provided close-ended questions and a five-point likert scale ranging from very low to very high was used to capture the responses level of each constrain (Mapiye *et al*., 2018). The questionnaire was structured in English and administered in respective languages of the farmers. The targeted farmers for the current research were smallholder farmers.

Data collected consisted primarily of (i) demographic profiles (gender, age, education level, off farm income), (ii) farm profile (reason for farming and farming engagement, herd size composition, and farmers objectives on their cattle farming operations), (iii) reproduction management which captured information on breeding systems, bull management (source of breeding bulls, bull to cow ratio), cow management (body condition score awareness, calving interval, calving records, handling of non-productive and old cows) and heifer management (age of breeding heifers, selecting criteria of heifers for breeding). Lastly (iv) constraints limiting farmers performances. Data on farming constraints included farmer's responses on provided ecological, production and marketing constraints (Table 1).

2.2 Sampling strategy

The current study analysed a subset sample of 460 cattle farmers purposively selected based on cattle farming and ownership from 789 respondents of the behaviour change survey that included poultry farmers. Seven provinces (Limpopo, Mpumalanga, Free State, Gauteng, Eastern Cape, North West and Northern Cape) were randomly selected to participate in the main survey based on the HBVC project

Table 1: *Summary of categories of constraints faced by farmers considered in the study.*

Category	*Parameters*
Production constraints	Disease outbreak
	Cattle nutrition
	Stock theft
	Annual cattle income
	Access and interpretation of farm information
Marketing constraints	Complying with market regulations
	Access to reliable markets
	Fair cattle pricing
Ecological constraints	Extreme weather events
	Weed encroachment
	Competing agricultural land use

provinces. The number of participants extracted for the current study differed per province as provided in Fig. 1. Purposive sampling was used to administer the reproduction management questionnaire. This was based on available herds where monitoring and collection of herd reproduction performance such as pregnancy diagnosis on breeding cows was achievable. As a result, five provinces Limpopo, Mpumalanga, Free State, North West and Eastern Cape participated in the reproduction management questionnaire. A total of 21 reproduction management questions were administered to 30 exclusively available farmers across the five provinces. The questionnaire followed the same methodology as in 3.1.

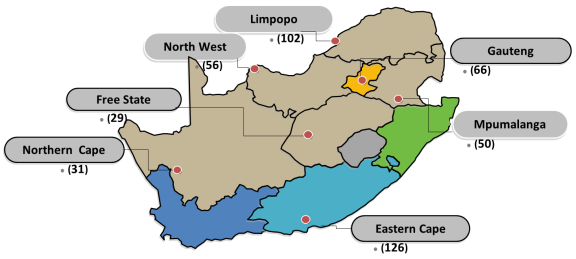

Fig. 1: *Map of South Africa indicating the seven study provinces and the number of cattle farmers studied in each province.*

Description of explanatory variables used in the study and hypothesized effect are highlighted in Table 2. All the variables have been selected at the alpha level of ≤ 0.05, however selection differed amongst each predictor variable.

2.3 Statistical analysis

The majority of the questions were categorical and were analysed by frequency tables and graphs, as well as ordinal logistic regression using Statistical Analysis System (SAS, 2012). Descriptive statistics included frequencies and percentages on household demographics, farm profiles and reproduction management data. Stepwise ordinal logistic regression procedure with a cumulative logit was used in the model building processes to determine factors associated with production, marketing and ecological constraints in smallholder herds. Literature has established that farmers in the smallholder sector face multiple challenges on production, marketing and ecology. However, the logistics model applied in the study primarly captured disease and nutrition factors on production constraints and compliance of market regulations factors on marketing constraints. The ecological constraints predominately captured factors on competing of agricultural land use and weed encroachment on grazing lands.

The cumulative logit procedure simultaneously estimates multiple equations for the comparison of the cumulative odds of high versus low response level. For this study, each farmers concern on a given constrain had 5 outcomes as follows:

$$J_5 \begin{cases} very\ low \\ low \\ moderate \\ high \\ very\ high\ concern \end{cases}$$

where level of concern is very low = 1, low = 2, moderate = 3, high concern = 4 and very high = 5. Therefore the logits regression model used for analysis was defined as:

$$[Logit\,(y \leq j)] = log\left[\frac{P\,(Y \geq j)}{1 - P\,(Y < j)}\right] = \alpha_{j+\beta_{x,}} \quad (j = 1, 2, 3, \ldots j-1)$$

Where $P\,(Y \geq j)$ is the odds of the event of the farmers response to the category j of a given predictor variable (constraint); α_j is the intercept parameter and β is the vector of regression coefficients corresponding to X covariates. The model specifies that the intercept parameter differs across all j categories however, the x covariates remain constant. The logits for the model intercepts for j categories are defined in Table 3:

The odds of the highest level is used to compare famers response with the lower level. The explanatory variables that specify the effect of the dependent variable for the response of farmers to a specific constraint where as follows:

$$\text{Disease outbreak} = \alpha_i + \beta_1 X_2 + \beta_2 X_8 + \beta_3 X_9 + \beta_4 X_{14} + \beta_5 X_6$$

$$\text{Cattle nutrition} = \alpha_i + \beta_1 X_1 + \beta_2 X_3 + \beta_3 X_4 + \beta_4 X_5 + \beta_5 X_{16} + \beta_6 X_6$$

Table 2: *A description of variables included in the study.*

			Dependent variable: Constrain		
	Variables	*Description*	*Production*	*Marketing*	*Ecology*
X1	Availability of skilled farm labourers	1 = yes, 2 = no	±	-	±
X2	Lack of access information on managing farm business	Farmer's concern on information on managing (1 = very low ; 5 very high)	±	+	+
X3	Difficulty accessing services	Farmer's concern on access to services (1 = very low; 5 very high)	±	+	-
X4	Years farming with cattle	Period farming in years	±	-	-
X5	Disease outbreak concern	Farmer's concern about disease outbreaks in the area (1 = very low; 5 very high)	+	+	±
X6	Herd size (number)	1 = small (1-50), 2 = medium (50-100), 3 = large (100-200) 4 = extra - large (over 200)	+	-	±
X7	Education level	1 = primary, 2 = high school, 3 = Tertiary 4 = no school	-	-	±
X8	Cattle nutrition	Farmer's concern on cattle nutrition (access to grazing and supplementary feeding) (1 = no concern; 5 very)	+	+	±
X9	Lack of understanding information communicated by gov	Farmer's concern on understanding farm information by government agencies (1 = very low; 5 very high)	±	-	+
X10	Cattle sold in 12 months	numbers cattle sold	-	+	-
X11	Lack of trust of value chain trust	Farmer's concern on value chain trust (1 = very low; 5 very high)	-	+	-
X12	Lack of fair pricing for cattle	Farmer's concern on cattle pricing (1 = very low; 5 very high)	-	+	-
X13	Cattle theft	Farmer's concern on cattle theft in the area (1 = very low; 5 very high)	-	+	-
X14	Climate change concerns	Farmer's concern on access to reliable markets (1 = very low; 5 very high)	+	-	±
X15	Credit loan repaying	1 = yes; 2 = no	-	-	±
X16	Province	Limpopo, Mpumalanga, North West, Free state, Northern Cape, Eastern Cape	+	-	±

Note: All variables were selected at a significant level of P ≤ 0.05 into the model.

Complying with market regulations = $\alpha_i + \beta_1 X_2 + \beta_2 X_{10} + \beta_3 X_{11} + \beta_4 X_8 + \beta_5 X_3 + \beta_6 X_5 + \beta_7 X_{13} + \beta_8 X_{12}$

Computing of agricultural land use = $\alpha_i + \beta_1 X_2 + \beta_2 X_{16} + \beta_3 X_{15} + \beta_4 X_9 + \beta_5 X_7$

Encroachment of weeds on grazing land = $\alpha_i + \beta_1 X_8 + \beta_2 X_2 + \beta_3 X_1 + \beta_4 X_{14} + \beta_5 X_6 + \beta_7 X_9 + \beta_8 X_{16}$

The chi-square test was used to assess collinearity between the covariates with the Cramer V statistics at 0.07. All variables that reflected collinearity were eliminated from the model. Results are presented in the form of odds ratio (OR) and corresponding 95 % confidence interval (CI).

Table 3: *Logit models for intercept parameters*

Farmer response level	*Intercept models*
Very low	$\left[Logit\,(P \leq 1) = log\left(\frac{\pi_1}{\pi_2+\pi 3+\pi 4+\pi 5}\right)\right] = (P = 1)$
Very low versus low	$\left[Logit\,(P \leq 2) = log\left(\frac{\pi_1+\pi_2}{\pi 3+\pi 4+\pi 5}\right)\right] = (P \leq 1) + (P \leq 2)$
Very low, low, moderate versus high	$\left[Logit\,(y \leq 3) = log\left(\frac{\pi_1+\pi_2+\pi_3}{\pi 4+\pi 5}\right)\right] = (P \leq 2) + (P \leq 3)$
Very low, low, moderate versus high versus very high	$\left[Logit\,(y \leq 4) = log\left(\frac{\pi_1+\pi_2+\pi_3+\pi_4}{\pi 5}\right)\right] = (P \leq 3) + (P \leq 4) = Very\,high$

Note: The model described cumulative odds with four response level for each dependent variable.

3 Results

3.1 Demographic characteristics of cattle farmers

Table 4 shows the demographic profiles of the interviewed farmers. The majority of farmers were males (77 %) above the age of 60 (42 %). Most of the farmers had high school education (53 %) and generates their off farm income through pension funds and business operations (29 %). It was also found that majority in the households practice livestock farming (76 %) compared to mixed farming (24 %).

Table 4: *Demographic characteristics of interviewed farmers.*

Variables	*Modalities*	*Percentage*
Age	< 35	12
	46-55	20
	35-45	14
	55-60	12
	> 60	42
Education	No formal education	6
	Primary	20
	high school	53
	Tertiary	21
Gender	Female	23
	Male	77
Type of farming	Livestock	76
	Mixed	24
Type of grazing livestock	Cattle	67
	Cattle, sheep and goats	31
	Cattle, sheep, goats, donkeys and horses	2
Off farm income	Employment	16
	Pension	29
	Social grant	26
	Business operations	29

Frequency percentage (%) of the surveyed farmers.

3.2 Production management of farm profiles

3.2.1 Main reasons for cattle farming and farm engagement

The primary reason for cattle farming to majority of the farmers was for sales purposes (78 %) and farming engagement was regarded as a full-time practice to majority (92 %) of the respondents (Fig. 2).

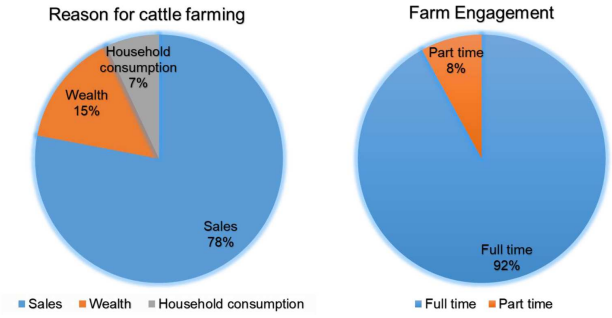

Fig. 2: *Percentage responses of the main reasons for cattle farming and farming engagement of surveyed farmers.*

3.2.2 Farmers intentions and future prospects to cattle farming.

There were variations in farmers perceptions and future prospects of farm operations. Within the group, majority of the farmers anticipated that their farming business will benefit the local economy (37 %), become reliable source of income (36 %), benefit the community (36 %) and provide food for the family (36 %). Meanwhile, 38 % and 31 % of the farmers intentions were for cultural needs and gaining respect from the community (Fig. 3).

3.2.3 Farmers herd size, market outlets and proportion of sales of cattle farming.

The majority of farmers sell cattle at informal markets (61 %) compared to auctions (34 %) feedlots (4 %) and abattoirs (1 %). The results further showed that most farm-

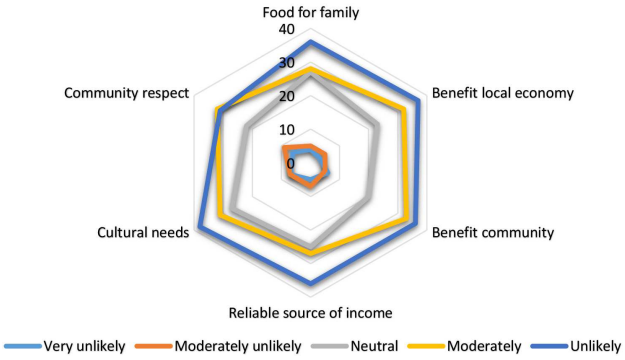

Fig. 3: *Percentage responses of surveyed farmers objectives to beef cattle production.*

ers own small herds (49 %) with annual cattle sales (60 %) within the R 1-50 000 scale (Table 5).

Table 5: *Herd size, market outlets and proportion of sales in cattle farming.*

Parameter	*Frequency*	*Percentage (%)*
Herd size		
Small herds	223	49
Medium herds	124	27
Large herds	60	13
Extra large	53	11
Market outlet		
Informal market	279	61
Auction	157	34
Feedlot	17	4
Abattoir	7	1
Cattle annual income		
Zero	96	20
R1-50000	277	60
R 51 000-R100 000	61	13
Over R100 000	21	7

Frequency percentage (%) of the surveyed farmers.

3.3 Reproduction management

On reproduction management, the present study observed that 63 % of the farmers do not practice breeding seasons and up to 53 % obtain breeding bulls from commercial stock auctions. Majority of the farmers (87 %) do not perform heifer selection either by age or parent breeding history and 60 % reported their replacement heifers not to be pregnant at first service after breeding season. The results also indicated that majority of the farmers (53 and 80 %) do not cull non-productive and old cows, respectively. Furthermore, 83 % of the farmers do not keep calving records and 93 % have no knowledge on evaluations of body condition score prior breeding. Most farmers (77 %) reported intercalving of two years, and 27 % of the farmers experience abortions in their herds (Fig. 4).

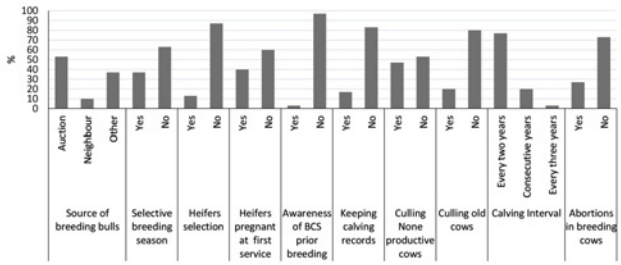

Fig. 4: *Percentage responses of breeding management practices of surveyed farmers.*

3.4 Constraints faced by farmers

3.4.1 Production constraints

Fig. 5 represents production constraints faced by farmers. Farmers were very highly affected by variety of constraints including cattle nutrition (35 %), difficulty in assessing services (36 %), lack of access of information on farm management (34 %), disease outbreaks (31 %) and lack of understanding of information communicated by government (40 %).

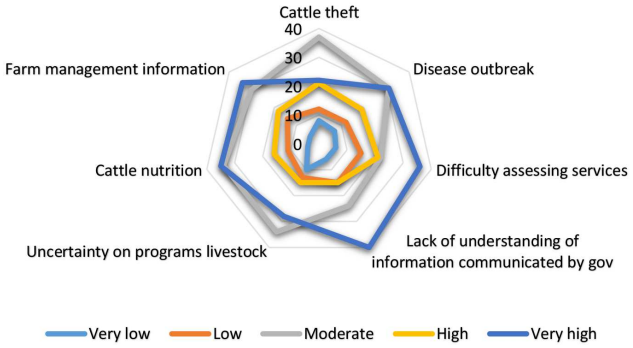

Fig. 5: *Percentage responses of major cattle production constraints faced by surveyed farmers.*

Table 6 presents the logistic regression model analysis for concerns of disease outbreaks. The model predicted variables: lack of access of information on managing farm business, cattle nutrition and province to be highly significant factors associated with disease outbreak concerns $p < 0.0001$. There was an increase in the odds [OR = 1.588] of disease outbreaks concern for farmers on every increase in lack of access of information on managing the farm. The model predicted greater increase in the odds [OR = 1.749, 1.172, 1.070 and 1.312] of disease outbreak concern for farmers in Gauteng, Limpopo, Mpumalanga and North West compared to Eastern Cape and Free State province respectively [OR = 0.274 and 0.349]. Extra-large herd size, cli-

Table 6: *Summary of association between risk factors and the odds of production constraints (disease outbreak) in smallholder beef cattle herds.*

			95 % CI of OR		
Variable	*SE*	*OR*	*Lower*	*Upper*	*P value*
Lack of access of information on managing farm business	0.1043	1.588	1.295	1.949	< .0001
Cattle nutrition	0.1004	1.596	1.310	1.943	**< .0001**
Province					**< .0001**
Eastern Cape *vs* Northern Cape	0.2041	0.274	0.127	0.588	< .0001
Free state *vs* Northern Cape	0.3697	0.349	0.122	0.995	0.0189
Gauteng *vs* Northern Cape	0.2415	1.749	0.762	4.014	0.0021
Limpopo *vs* Northern Cape	0.1958	1.172	0.551	2.494	0.0794
Mpumalanga *vs* Northern Cape	0.2630	1.070	0.456	2.513	0.3381
North West *vs* Northern Cape	0.2741	1.312	0.537	3.210	0.0960
Lack of understanding information communicated by gov	0.0872	1.209	1.019	1.434	**0.0002**
Climate change concerns	0.0842	1.281	1.086	1.511	**0.0023**
Herd size					**0.0456**
Extra-large herds *vs* small herds	0.2263	1.745	0.947	3.215	0.0263
Large herds *vs* small herds	0.2157	0.626	0.348	1.127	0.0154
Medium herds *vs* small herds	0.1649	1.135	0.731	1.765	0.6571

Note: Bold values are generalised Wald-test P values. Statistical significant at level ($p < 0.01$; $p < 0.05$). SE = Standard Error, OR = odds ratio, CI = confidence interval.

Table 7: *Summary of association between risk factors and the odds of production constraints (cattle nutrition) in smallholder herds.*

			95 % CI of OR		
Variable	*SE*	*OR*	*Lower*	*Upper*	*P value*
Availability of skilled farm labourers	0.1144	2.810	2.246	3.516	**< .0001**
Lack of information on managing farm business	0.1104	1.707	1.375	2.119	**< .0001**
Difficulty accessing services	0.0828	1.282	1.090	1.508	**0.0003**
Years farming with cattle	0.0851	0.725	0.613	0.856	**0.0028**
Disease outbreak concern	0.0808	1.283	1.095	1.503	**0.0465**
Province					**0.0363**
Eastern Cape *vs* Northern Cape	0.2113	3.789	1.693	8.479	< .0001
Free state *vs* Northern Cape	0.3740	0.857	0.297	2.472	0.1310
Gauteng *vs* Northern Cape	0.2518	1.352	0.568	3.217	0.6673
Limpopo *vs* Northern Cape	0.2095	2.081	0.945	4.583	0.1234
Mpumalanga *vs* Northern Cape	0.2743	1.651	0.679	4.012	0.7394
North West *vs* Northern Cape	0.2989	1.170	0.453	3.022	0.3972
Herd size					**0.0106**
Extra-large herds *vs* small herds	0.2507	1.371	0.672	2.796	0.4980
Large herds *vs* small herds	0.2264	2.918	1.533	5.553	0.0097
Medium herds *vs* small herds	0.1743	1.742	1.103	2.752	0.6891

Note: Bold values are generalised Wald-test P values. Statistical significant at level ($p < 0.01$; $p < 0.05$). SE = Standard Error, OR = odds ratio, CI = confidence interval.

mate change concerns and lack of understanding information communicated by government agencies were also variables predicted to have greater odds [OR = 1.745, 1.281 and 1.209] of concerns on disease outbreaks.

The results of the analysis of cattle nutrition concerns demonstrated that farmers with concerns on the availability of skilled farm labourers, lack of information on managing farm business and difficulty accessing services

[OR = 2.810, 1.707 and 1.282] had increase odds of concerns on cattle nutrition. There was an increase in the odds of concerns of cattle nutrition for every increase in disease outbreaks and farmers with larger herds [OR = 1.283 and 2.918]. The model further predicted farmers in the Eastern Cape and Limpopo province [OR = 3.789 and 2.081] to have an increase in cattle nutrition concerns compared to other provinces (Table 7).

3.5 Marketing constraints faced by smallholder farmers

Fig. 6 shows results of marketing constraints faced by farmers in the study. Majority of the respondents were moderately concerned about reliable markets (34 %), value chain trust (40 %). High concern on fair cattle pricing (31 %) and complying with market requirements (41 %) on the majority of the farmers were also observed.

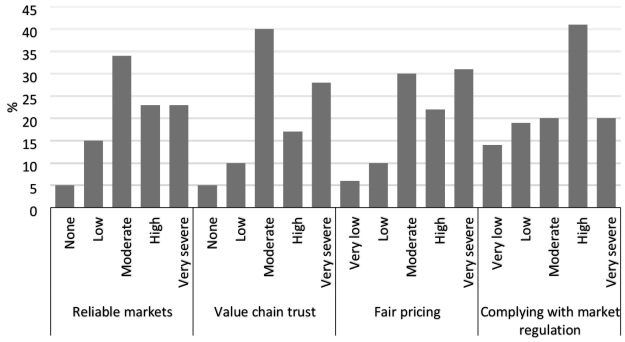

Fig. 6: *Percentage responses of marketing constraints faced by surveyed farmers.*

Table 8 presents factors associated with concerns on compliance of market regulations by farmers. The model revealed that farmers with lack of information on managing farm business, difficulty accessing government services, cattle theft and value chain trust are predicted to have an increase in odds [OR = 1.462, 1.207, 1.341 and 2.967] of concerns on complying with market regulations. Moreover, farmers who had concern on cattle nutrition and disease outbreaks are expected to have an increase [OR = 1.156 and 1.150] odds for concern of complying with market regulations. The model further predicted cattle sold in 12 months (P <. 0001) as a factor associated with concerns on compliance of markets regulations.

3.6 Ecological constraints

Fig. 7 highlights the ecological constraints smallholder farmers encountered in the present study. The results shows that majority of the farmers had (38 %) severe concerns on extreme weather events. Respondents were further affected

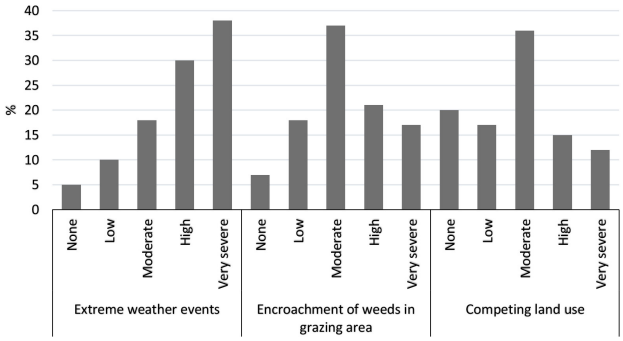

Fig. 7: *Percentage responses of ecological constraints faced by surveyed farmers.*

by the encroachment of weeds in grazing areas (37 %) and competing of agricultural land use (36 %).

The regression model showed an increase in the odds [OR = 2.070, 1.933, 1.550, 1.698 and 1.126] of concern of competing of land use in the Gauteng, Limpopo, Free State, Mpumalanga and North West, respectively. Farmers who had concerns on accessing of information on managing farm business, lack of understanding of information communicated by government agencies and disease outbreaks were predicted to have greater increase [OR = 3.169, 1.191 and 1.464] in concerns of competing agricultural land use. The model further predicted education level to have an increase in odds [OR = 1.168] of concern of competing of land use (Table 9).

Table 10 presents factors associated with concerns of weed encroachment in grazing lands. The model predicted cattle nutrition (P <. 0001), lack of access of information on managing farm business (P <. 0001), availability of skilled farm labourers (P = 0.0002) and province (P = 0.0007) as factors associated with weed encroachment. Extra-large herds and climate change concerns had increase odds [OR = 1.758 and 1.166] in concern of weed encroachment in grazing land compared to small herds. Farmers with increased concerns of lack of understanding of information communicated by government agencies had greater odds [OR = 2.222] in the increase of weed encroachment on grazing land.

4 Discussion

This paper described smallholder beef cattle farming practices and challenges in seven provinces of SA. The reported higher percentage of male compared to female farmers correspond with multiple studies conducted on smallholders in SA and neighbouring countries (Otieno, 2013; Chingala *et al*., 2017; Cheteni & Mokhele, 2019). Gender inequality in

Table 8: *Summary of association between risk factors and the odds of marketing limitations (complying with market regulations) in smallholder beef cattle herds.*

			95 % CI of OR		
Variable	*SE*	*OR*	*Lower*	*Upper*	*P value*
Lack of information on managing farm business	0.0850	1.462	1.237	1.726	**<. 0001**
Cattle sold in 12 months	0.0954	1.520	1.261	1.833	**<. 0001**
*Value chain trus*t					**0.0002**
None *vs* severe concerns	0.3113	2.756	1.126	6.749	0.0966
Low *vs* severe concerns	0.2553	0.740	0.342	1.602	0.0018
Moderate *vs* severe concerns	0.1672	1.978	1.120	3.494	0.2670
High *vs* severe concerns	0.2117	2.967	1.594	5.520	0.0052
Cattle nutrition	0.1001	1.156	0.950	1.406	**0.0011**
Difficulty accessing services	0.0804	1.207	1.031	1.413	**0.0055**
Disease outbreak concerns	0.0738	1.150	0.995	1.328	**0.0292**
Cattle theft	0.1678	1.341	0.965	1.863	**0.0529**
Lack of fair pricing	0.2244	1.030	0.499	2.128	**0.0375**

Note: Bold values are generalised Wald-test P values. Statistical significant at level ($p < 0.01$; $p < 0.05$). SE = Standard Error, OR = odds ratio, CI = confidence interval.

Table 9: *Summary of association between risk factors and the odds of ecological constraints (competing of agricultural land use) in smallholder herds.*

			95 % CI of OR		
Variable	*SE*	*OR*	*Lower*	*Upper*	*P value*
Lack of information on managing farm business		3.169	2.543	3.951	**<. 0001**
Province					**<. 0001**
Eastern Cape *vs* Northern Cape	0.2139	0.520	0.224	1.210	<. 0001
Free state *vs* Northern Cape	0.3755	1.550	0.533	4.513	0.6345
Limpopo *vs* Northern Cape	0.2555	1.933	0.772	4.839	0.1181
Gauteng *vs* Northern Cape	0.2046	2.070	0.914	4.689	0.0223
Mpumalanga *vs* Northern Cape	0.2770	1.698	0.670	4.307	0.3304
North West *vs* Northern Cape	0.3030	1.126	0.414	3.059	0.6403
Disease outbreak	0.0808	1.464	1.250	1.715	**<. 0001**
Credit loan re-paying	0.3169	0.237	0.127	0.441	**0.0005**
Lack of understanding information communicated by gov	0.0889	1.191	1.001	1.418	**0.0049**
Education level	0.0861	1.168	0.986	1.382	**0.0108**

Note: Bold values are generalised Wald-test P values. Statistical significant at level ($p < 0.01$; $p < 0.05$). SE = Standard Error, O R= odds ratio, CI = confidence interval.

the agricultural sector has been a prominent subject in rural farming in which customs and traditions such as *''restrictions of women to enter cattle kraal"* are used as a tool to discriminate against women (Gumede *et al*., 2018). The report by Wisborg (2014) highlighted that women face discrimination regardless of gender equality being enforced. Despite the dominance of males in agriculture, tools such as the Women's Empowerment in Livestock Index (WELI) developed for communities in East Africa are available to monitor the enforcement of equal opportunities to women and girls in the livestock sector according to the SDG five (Alkire *et al*., 2013; Galiè *et al*., 2019). This tool may be an effective way of addressing gender inequality in SA agriculture.

In livestock production, old age has been associated with smallholder farming (Mapiye *et al*., 2018; Myeni *et al*., 2019) and similarities have been reported on the current study with majority of farmers above the age of 60. Studies by Otieno (2013) and Bahta & Baker (2015) argue that older farmers have been found to be enthusiastic towards farming, this may be the reason for their dominance in beef cattle

Table 10: *Summary of association between risk factors and the odds of ecological constraints (encroachment of weeds on grazing lands) in smallholder herds.*

			95 % CI of OR		
Variable	*SE*	*OR*	*Lower*	*Upper*	*P value*
Cattle nutrition	0.7985	2.222	1.810	2.729	**<. 0001**
Lack of access of information on managing farm business	0.5242	1.689	1.369	2.084	**<. 0001**
Availability of skilled farm labourers	0.4368	1.548	1.251	1.916	**0.0002**
Climate change	0.1538	1.166	0.993	1.369	**0.0388**
Herd size					**0.0072**
Extra large herds *vs* small herds	0.5275	1.758	0.939	3.291	0.0218
Large herds *vs* small herds	-0.4817	0.641	0.358	1.147	0.0235
Medium herds *vs* small herds	-0.00893	1.028	0.664	1.592	0.9564
Lack of understanding information communicated by gov	0.1069	2.222	1.810	2.729	**0.0278**
Province	0.8066	2.534	1.100	5.837	**0.0007**

Note: Bold values are generalised Wald-test P values. Statistical significant at level ($p < 0.01$; $p < 0.05$). SE = Standard Error, OR = odds ratio, CI = confidence interval.

smallholder farming. However, more emphasis on developmental projects to encourage participation of youth and middle age group to farming are needed as this may be vital to the direction of the future of SHS. The reported high percentage of farmers solely committed to farming may imply that smallholder farmers are dependant on agriculture to sustain household needs (Jari & Fraser, 2009). The above further emphasize that agriculture is the centre of poverty alleviation in smallholder sector as it has been recognised by major government entities (DAFF, 2019; DALRRD, 2020). Farmers demographics further indicated that majority practices livestock compared to mixed farming. This may suggest the need for sufficient knowledge on crop production and its benefit on feed provision for cattle especially in smallholders where livestock feeding is a scarce resource.

Low literacy has been considered to be dominating in smallholder farmers and the present study was no different (Marandure *et al*., 2017). The report by Myeni *et al*. (2019) stated that education is known as a barrier between farmers adoption to new technology and transformation for improved farm outputs. Moreover, Ferreira (2018) found that education is associated with a 1.0 % and 3.0 % increase in agricultural productivity in Malawi. The above, therefore, may anticipate a potential link between the level of education attained and the minimal (7 %) annual return of over R100 000 reported by the respondents.

Within the group, majority of the farmers anticipated that their farming business will benefit the local economy. These findings highlight clear intentions of smallholder farmers to the livestock industry. However, as much as majority of farmers highlighted sales as main reason for keeping cattle, it is concerning to note that 38 % of farmers were still in cattle farming for cultural reasons. Culture has over time become a persistent factor as a barrier between subsistence and commercial value chain (Sikhweni & Hassan, 2013; Mapiye *et al*., 2020). Kahan (2012) suggested that the enforcement of entrepreneur behaviour to farmers may be one of the initiatives to break through the barrier between culture and profitization. In essence, farmers are thus far running a business with all the cattle maintenance such as purchasing of feed, medication and hiring of a herdman. Therefore, more entrepreneurship support from provincial departments is needed to guide farmers to profit without defining cultural views, however, reconciling farmers values.

Farm engagement, objectives and choice of market are linked to farm revenue and define farmer's produce (Zantsi & Bester, 2019). Majority of the farmers sell cattle at informal markets and fall within the R1-50 000 annual scale of earnings. These results are similar to Khapayi & Celliers (2016) who reported that 84 % of farmers make use of informal markets as the main market for livestock. The sentiment, however, differs with small stock and cattle smallholders from other neighbouring countries. Cheteni & Mokhele (2019) highlighted 65 % of sheep farmers to have adopted formal markets compared to farm gates markets. Moreover, empirical studies in countries such as Swaziland and Kenya demonstrated that majority of smallholder cattle farmers have now adopted formal markets outlets such as auctions, abattoir and butcheries (Otieno, 2013; Dlamini & Huang 2020). Access to formal markets in these countries might have been as a results of availability of information regarding farm business. For example, in the study reported by

Dinku (2019) in Ethiopia, majority of farmers have access to extension services and are visited by local extension officers and advisors at least twice a week. However, majority of SA farmers relies on inexperienced personnel such as family members or neighbours for market information and thus most farmers are therefore unable to participate in markets due to failure to meet market regulations (Ndoro *et al*., 2015; Khapayi & Celliers, 2016). It was also noted that 20 % of the farmers fell within a category that generated zero income per annum. This indicates a matter of concern that requires an in-depth investigation to current systems in the smallholder. In Vietnam, participation of cattle smallholder in the value chain includes fattening of cattle in pens using farm-grown fodders (Stür *et al*., 2013). Consequently, more adoption of initiations such as stall-fed systems by SA cattle smallholders may increase participation of beef supply in the domestic market.

There were numerous production constraints identified from the surveyed households. Respondents were constraint by the accessibility of farm information, lack of access of information on farm management, disease outbreaks and cattle nutrition. Support services remains a barrier for smallholder livestock farmers and may impact poverty alleviation in rural area. However, accessibility of farm information that is clear and understandable to farmers may serve as a stepping stone for the improvement of rural development and farm growth (Baker *et al*., 2015).

The present study highlighted that farmers with lack of access to information on managing the farm and lack of understanding of information communicated are less likely to respond to disease outbreaks. These findings are in line with Khapayi & Celleirs (2016), who reported that majority of smallholders have limited knowledge on the identification of livestock diseases with 94 % of farmers illiterate on animal hygiene and clear protocols on how to respond to outbreaks and vaccination programs. Unlike SA, farmers in Swaziland are practicing health screening of purchased cattle and selecting replacements from their herds (Dlamini & Huang, 2020). Such practices may be of importance to the improvement of cattle production in SA as disease in livestock remains an obstacle for smallholder farmers to trade their produce (Namayasha *et al*., 2017).

The report by Fidzani (1993) and Cheteni & Mokhele (2019) indicated that large herds provide higher marketable surplus compared to smaller herds, however in concurrence with sound knowledge of good management of the farm. This might be the reason reported disease outbreak concerns for farmers in larger herds in this study as a result of limited and accessible knowledge of farm operations including identification of sick animals. Despite the limitation of farm health information in smallholder, the Ciskei and Transkei formally known as the Eastern Cape was the first province to have benefited from SA state veterinary services in the 1970s followed by post apartheid smallholder farmers in 1994 in the Eastern Cape (Jenjezwa & Seethal, 2014). Therefore, this may be the reason the model predicted Gauteng, Limpopo, and North West to have greater odds of disease outbreaks concerns as compared to Eastern Cape Province.

Similar to disease outbreaks, the model predicted lack of information on managing farm business and difficulty accessing government services as major factors associated with cattle nutrition concerns and weed encroachment in grazing land. Therefore, knowledge of programs on rotational grazing, veld rest and stocking rate needs to be implemented in smallholder herds. Moreover, the adoption of crop residues as supplementation needs to be promoted and this emphasis on the argument made earlier that cattle smallholder farmers should implement mixed farming.

The model in this study predicted cattle theft to have an impact on markets participation. Stock theft has been an ongoing issue for decades in SA, the cost has amounted to close to R118 million (Ndoro *et al*., 2015). Smallholder farmers can however, do better by adopting animal identification for livestock since Coetzee *et al*. (2005) highlighted that animal identification remains a rare practice in smallholder herds since farmers view it as an expensive task.

Majority of smallholder farmers cattle fails at market point often due to farm nutrition as most animals appear lean and unhealthy (Ndoro *et al*., 2015), hence the model predicted adequate supply of nutrition to have increased odds of concern in complying with market regulations. However, extension officers have skills and appraisal to identify market issues and transparency to benefit farmers (Devendra *et al*., 2000). Therefore, there is a need to strengthen the relationship between these two parties to permeate information gap on value chain trust and market pricing.

Ecological constrain of extreme weather events has drastically affected both commercial and smallholder sector (Mare *et al*., 2018). Agricultural production declined by 8.4 % due to the 2015 drought (Agri SA, 2016). The impact have been advanced on smallholders as a result of vulnerability in the sector, hence majority of the farmers responded very severe consent on extreme weather events in the study. Similar to extreme weather events competing of agricultural land has been a trend in the agricultural sector worldwide (Kanianska, 2016). The model predicted an association on lack of information on managing farm business and understanding information communicated with concern of competing of agricultural land use. This calls for infor-

mation transparency of land policies from entities protecting agricultural land to landholders (Ladu *et al*., 2019).

Urbanization has grown in the past year due to increasing population and many cities are being built on fertile agricultural land. In Europe, approximately 64 % of agricultural land has been taken over by urbanization (Primdahl *et al*., 2013). A simulation study in Belgium has shown 50 % in reduction of farmers as a result of urbanization (Beckers *et al*. 2020). Migration in SA has been the main reason for urbanization. Urbanization occurs in most SA provinces, however is more prevalent in Gauteng province (Annobea, 2018). Henceforth, the model predicted Gauteng to have higher odds of concern for competing of agricultural land as compared to other provinces.

There is an improvement in the source of breeding bulls reported in this study as majority of the farmers reported buying from auctioneers as source of breeding bulls compared to neighbours bulls (Molefi *et al*., 2017). However, cow management remains a challenge as majority of farmers do not practice culling of non-productive cows and old cows. This provides zero contribution to the production growth and may have a greater deal to the farmers pocket. Bahta & Baker (2015) once said *"In agribusiness, a competitive farm is one that has the ability to produce and sell quality products in a given market at a profit over the life of the farm"*. The reported statement needs to be one of the imperative knowledge to be transferred to SA smallholder farmers. Tait *et al*. (2017) emphasize that BCS in cows during and post-breeding season influence pregnancy rates and calving interval as it may encourage the incidence of anestrus and anovulatory cycles. This is an unpleasant reality in smallholder herds as majority of the herds are not aware of BCS and it may have had an influence on the extended inter-calving periods reported in the study. Moreover, the non-adoption of a planned breeding season by majority of the farmers is a contributing factor to the slow economic growth within smallholders as breeding season should be aligned with available grazing for the achievement of more healthier and heavier calves (McGowan *et al*., 2014). Furthermore, an investment on selection of herd replacement should be top priority as it affects the long-term sustainability and productivity of the cowherd, therefore the decision of majority of the farmers not selecting replacements may affect farm growth. The above mentioned imply that lack of reproduction knowledge remains a need for improved farm management practices.

Improvement in beef cattle smallholders may depend on developmental strategic plans to be implemented for programs targeted to disseminate farm knowledge and management skills. Promotion of open platforms for more deliberations of scientific outputs such as national farmer's days are needed as they strengthen information chain from scientist to extension officers and farmers. Farm business schools is another platform to provide a positive way to access farm information with extension officers as facilitators to exchange efficient advisory services. The school may open up ventures for a do one teach one for farmers to share farm experiences. Furthermore, a key step to improved production may involve interventions such as contract farming as a way of enhancing the economic growth in smallholder farmers according to National developmental plan vision 2030 and SDG 8.

5 Conclusions

The study assessed smallholder beef cattle farming practices and the primary constraints limiting the system. The results outlined that there is a need to amplify the mode of communication to farmers given majority of the farmers are constrained by lack of access and understanding of farming knowledge that is necessary to combat challenges on nutrition, disease outbreaks, marketing and reproduction management.

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Conflict of interest

The author declares that they have no conflict of interest.

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