

Limitations and prospects of improving beef cattle production in the smallholder sector: A case of Limpopo Province, South Africa

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Abstract

The opportunity for the smallholder beef farming system to support the growth of South Africa's livestock industry is untapped. Slow growth of the sector is attributed to many limitations that affect the smallholder beef farming sector. The objectives of the current study were to identify and characterize the systemic challenges and constraints that confront market-oriented smallholder beef farmers in the Limpopo Province, South Africa. Data collection involved interviewing all the 62 farmers under the Limpopo Industrial Development Corporation (IDC)-Nguni project using structured questionnaires. The sample was predominantly males (87%) and adults aged over 45 years (88%). Close to half (47%) of the respondents had tertiary education. Major ecological and production challenges reported as percentages of respondents were drought (96%), rangeland degradation (94%), diseases (89%), feed shortage (86%) and inadequate water (82%). Nearly 50% of the respondents ranked the extent of these challenges as high to very high. Results indicated that poor access to finance, lack of infrastructure and poor access to markets were some of the key limitations reported by more than 80% of the respondents with above 50% ranking them as high to very high. Logistic regression models showed that respondents' perceptions to the majority of the challenges were largely influenced ($p < 0.05$) by education, access to formal training, farm size and age. Given all the limitations found, current findings point to the prospects of designing strategies that support knowledge flows and capacitating the farmers with skills to combat the challenges.

Key words Challenges · Constraints · Nguni · Smallholder farmer · South Africa

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Introduction

The livestock sector is an integral component of South Africa's agricultural industry contributing more than 48% of total agricultural output, with cattle farming being the largest sub-sector with a share of 26.2% (DAFF 2017). According to the Industrial Development Corporation (IDC 2016), the contribution can be improved if livestock, particularly cattle from the smallholder sector, are brought into the formal economy. The smallholder sector comprised of subsistence and market-oriented (previously known as emerging) farmers (Chingala et al. 2017) collectively own close to 40% of the available 13.4 million cattle in South Africa (DAFF 2017). The market-oriented smallholder farmers are transitioning from subsistence to commercial farming hence are in between the two groups (South African Institute of Race Relations, 2016). Under apartheid policies, the indigenous people of South Africa were dispossessed of their productive land which was allocated to the minority white population. Therefore, in a bid to redress the imbalance, the new government in 1994 embarked on land redistribution and other pro-poor development initiatives (Kloppers and Piennar, 2014). Programmes such as the Land Redistribution for Agricultural Development (LRAD) which mainly superseded the Settlement Land Acquisition Grant (SLAG) scheme (MacLeod et al. 2008; DAFF News 2013) gave birth to the market-oriented smallholder farmers previously referred to as emerging farmers. The LRAD programme was designed to focus more on assisting previously disadvantaged individuals to acquire existing farms as a step for their transition to become commercial producers (MacLeod et al. 2008). The Limpopo IDC-Nguni Cattle Development Trust founded in 2006 in another programme supporting the development of market-oriented smallholder farmers. The Trust is a development orientated partnership formed by the IDC, Limpopo Department of Agriculture (LDA) and the University of Limpopo (UL). Its objective is to improve cattle production in the rural areas of

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Limpopo through the introduction of indigenous Nguni cattle bloodlines and the creation of commercial benefits for the market-oriented smallholder farmers (DAFFnews 2013). Beneficiaries of this programme constitute part of the rapidly growing population of market-oriented smallholder cattle farmers (MacLeod et al. 2008; DAFF 2012b) hence are a strategic component to the future of the cattle production industry in South Africa. They are a unique group distinct from commercial and communal farmers and are likely to be confronted with challenges and constraints that are exclusive to them.

Generally, South Africa and the Sub-Saharan region's cattle production at the subsistence and market-oriented smallholder level is constrained by a variety of factors including poor access to land and water, lack of access to markets and extension services, high transaction costs, small herd sizes, and risks associated with animal diseases, drought and theft (Mapiye et al. 2009; Khaphayi and Celliers, 2016). These challenges hamper productivity and market access hence the effective graduation of smallholder farmers into commercial producers. A number of research studies have been conducted with the goal of broadening the understanding of these factors (Khaphayi and Celliers, 2016). Invariably, these challenges have been identified as affecting smallholder farmers in general by most studies. Hence, there is remarkable scarcity of information unpacking the systemic picture of the challenges constraining the development of market-oriented smallholder farmers.

Since the advent of the LRAD programme, the South African government increased its budget for supporting the development of market-oriented smallholder farmers (Aliber and Hall, 2012). Despite such efforts, Aliber and Hall (2012) argued that there is not enough evidence that these efforts have been effective. This is supported by the growing evidence that smallholder cattle farming sectors continue to be weighed down by production and market access issues

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(DAFF 2012a; DAFF 2017) hence have remained partially sustainable (Marandure et al. 2016). Given, the failure by several attempts from the government to integrate market-oriented smallholder farmers into the commercial agricultural economy, studies that exclusively generate well-grounded information on the limitations arresting the development of these farmers could be essential. In that regard, the objective of the current study was to identify limitations impeding the improvement of beef production by market-oriented smallholder cattle farmers in Limpopo Province, South Africa.

Materials and Methods

Study site

The study was carried out in Limpopo Province of South Africa. The province is administratively divided into 5 municipal districts, which are further subdivided into 25 local municipalities. The study focused on 14 local municipalities where the Limpopo IDC-Nguni cattle farmers are located. Limpopo Province has three distinct climatic regions: arid (Lowveld), semi-arid (Middle, Highveld) and the sub-humid (the escarpment) (LDA 2016a). Generally, the province receives summer dominant rainfall with an average annual range of between 300 and 600mm (LDA 2016b). The province experiences long sunny days and dry weather conditions on most days with average temperatures rising up to 27°C and 20°C in summer and in winter, respectively. Figure 1 show the map of South Africa with Limpopo and the province's local municipalities. Cattle production is a major livestock activity and is predominantly carried out in the arid and semi-arid western and northern parts of the Province. However, water has remained the most limiting resource in the Province (LDA 2016a).

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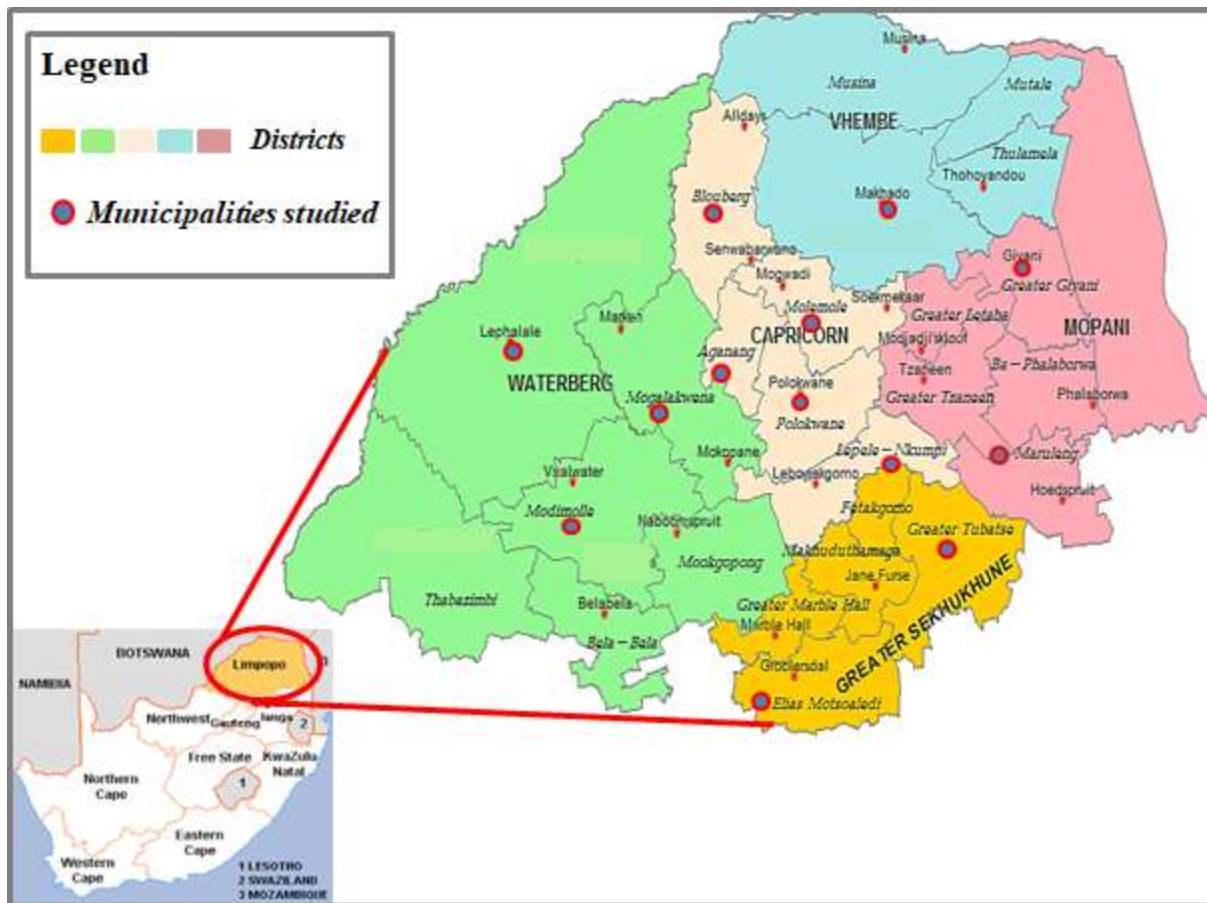


Fig. 1 Map showing the location of Limpopo Province and the local municipalities

Farmer selection

The population of the study comprised ‘market-oriented smallholder beef cattle farmers’ who are the beneficiaries of the Limpopo IDC-Nguni Cattle project. A census approach was employed where all the 62 farmers recorded since the inception of the project were involved in the study.

Table 1 shows the distribution of the farmers in the province.

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Table 1 The distribution of Limpopo IDC-Nguni cattle farmers across the province

District Municipalities	Local Municipalities	Number of farmers
Capricorn	Aganang	3
	Blouberg	3
	Lepelle-Nkumpi	1
	Molemule	9
	Polokwane	10
Greater Sekhukhune	Elias Motsoaledi	3
	Ephraim Mogale	1
	Fetak Gomo/Greater Tubatse	2
	Lephalale	3
Waterberg	Mogalakwena	13
	Mookgophong/Modemolle	10
Mopani	Maruleng	1
Vhembe	Makhado local	3
TOTAL		62

Data collection

Between August and September of 2016, data were collected through observation and by interviewing the household heads using a pre-tested structured questionnaire (Human ethical clearance: SU-HSD-000505). Four trained enumerators assisted in administering the questionnaire. The questionnaire was designed in English but administered in the local languages (Sipedi and Tshivenda) for the farmers to understand and respond comfortably. Data on the respondents' demographic profiles and farm characteristics were collected. Data collected

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included farmers' responses on whether they were constrained by the provided ecological, production, institutional, infrastructural and marketing limitations or not. If the response was 'yes' they were further asked to provide the extent or level of the challenge/constraint. A four-point Likert scale ranging from very low to very high was used to capture the responses.

The study captured ecological challenges relating to the interaction of livestock (cattle) and respective farming practices with the environment which was affecting the development of market-oriented smallholder farmers. These include constrains such as drought conditions, soil erosion, heat waves, biodiversity loss and pollution. Production challenges recorded include the limiting factors that directly reduce the nature and quantity of outputs for the farmers. These were challenges related to input access (feed, water and drugs), pest and diseases prevalence, poor breeding as well as stock theft and predation. Infrastructural challenges consisted of the fundamental facilities required by farmers and farming communities in the production, transportation, processing and marketing of outputs such as unavailability and poor access to community production and marketing infrastructure by the respondents. Lack of institutional support such as extension services, finance and training could be some of the challenges constraining the development of the farmers. Specific marketing constraints including poor access to markets and marketing information, marketing transactions costs, and market unreliability were recorded in the survey.

Statistical analysis

Demographic information and farm characteristics were subjected to descriptive statistics using the PROC FREQ of SAS 9.4 (SAS Institute 2012). A binary logistic regression model was computed at 5% confidence interval to determine factors (farm and farmer characteristics) that

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significantly influenced the farmers' responses to each of the limitation reported. Positive signs on the variable coefficients indicate that as the value of the coefficient increases, the probability that the farmer responded positively to the limitation also increases and the vice versa is true for the negative signs. Table 2 shows the specified explanatory variables used for each model.

Table 2 Description of variables used in the logistic regression models

Y_i	<i>Lim</i>	Emerging beef farmers 'response to the challenge/constraint faced which takes the value of 1 if the farmer faces the challenges/constraint, 0 otherwise
X_1	<i>Age</i>	Farmer's age; 1 if farmer is adult (>40 years), 0 if otherwise
X_2	<i>Gend</i>	Gender; 1 if male, 0 if otherwise
X_3	<i>MStat</i>	Marital status; 1 if married, 0 if otherwise
X_4	<i>FormTrain</i>	Access to formal training by the farmer; 1 access to training, 0 if otherwise
X_5	<i>HHSIZE</i>	Household size; 1 if large (>5 members), 0 if otherwise
X_6	<i>Edu</i>	Education level; 1 if high, 0 if otherwise
X_7	<i>TTDeed</i>	Availability of tittle deeds; 1 if available, 0 if otherwise
X_8	<i>FamSize</i>	Size of the farm; 1 if large (> 1000ha), 0 if otherwise

The logistic model was specified as follows:

$$\pi_i = \Pr(Y_i = 1 | X_i = x_1) = \frac{\exp(\beta_0 + \beta_1 x_i)}{1 + \exp(\beta_0 + \beta_1 x_i)} \quad (1) \quad (\text{Greene, 2003})$$

Equation 1 was linearised into equation 2 as follows:

$$\text{logit}(\pi_i) = \log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_1 x_i = \beta_0 + \beta_1 x_{i1} + \dots + \beta_k x_{ik} \quad (2)$$

Where:

Y_i is a binary dependent variable, $Y_i = 1$ if the response was Yes, the farmer was confronted by the limitation i , and 0 otherwise.

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$X = (X_1, X_2, \dots)$ is a set of explanatory variables which are dichotomous. The explanatory variables are listed in Table 2. All explanatory variables take the value 1 if the response was yes and 0 if otherwise. The following characteristics were identified: gender (x_1), age (x_2), education level (x_3), household size (x_4), marital status (x_5), farm size (x_6), access to formal training (x_7) and title deeds (x_8).

Example of the actual model used for drought challenge was specified as:

$$\text{Drought} = \beta_0 + \beta_1 \text{Age}_i + \beta_2 \text{Education}_i + \beta_3 \text{Formal Training}_i \quad (3)$$

Results and Discussion

Characteristics of the farmers

Table 3 shows characteristics of the interviewed beef cattle farmers. The majority of cattle owners were males (87%). This is consistent with the common trend in Africa where, although most agricultural activities are carried out by women (FAO 2011; WFO 2016), large-stock, especially cattle are largely owned by males (Mapiye et al. 2009). Given the significant role of women in smallholder livestock production (WFO 2016), poor access to large stock, such as, cattle by them may negatively impact the overall production and contribution of the sector towards food and income security. Over half (54%) of the respondents had household sizes ranging between 3 and 6 members and the overall mean household size for the sample was 6. In the smallholder or rural farming communities, most farmers depend on family labor. Therefore household size is used as a proxy for labor availability (Kabunga 2014). The majority of farmers (64%) were between the ages of 46 and 65 years while nearly one-fifth were above 65 years.

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Table 3 Characteristics of the emerging beef cattle farmers in Limpopo province, South Africa

Variable	Options provided	Response %
Gender	Male	87
	Female	13
Household size ¹	Below 3	6
	3-6	54
	7-10	36
	Above 10	4
Age of the household head ¹	Below 35	4
	36-45	9
	46-55	23
	56-65	42
	Above 65	23
Education level of household head ¹	No formal education	2
	Primary education	21
	Secondary education	30
	Tertiary education	47
Land ownership ²	Private/Own	16
	Communal	23
	Leased	61
Farm sizes (ha) ²	Less than 700	21
	701-1400	33
	1401-2100	27
	2101-2800	7
	Above 2801	12

Characteristic¹- Sample size include all 62 farmers

Characteristic² - Sample size includes 53 farmers because 9 respondents belong to CPA (group of farmers) hence characteristics of a single household head could not be identified for the groups.

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Similarly, Mapiye et al. (2009) reported that older people (>50 years) were more involved in smallholder cattle farming than youths. However, such distributions could inhibit the widespread adoption and application of new agricultural technology. In that regard, suggestions by FAO (2014) to support the inclusion of youths in cattle farming businesses through improved financial support and increased access to information should be upheld.

Almost half (47%) of the farmers had tertiary qualifications, 30% had secondary level while, 21% had primary level with 18 being the overall mean number of years spent in school. On the contrary, Khapayi and Celliers (2016) found that above 60% of the interviewed market-oriented smallholder farmers had less than secondary education. The implication of the current finding could be that the farmers are better able to understand the challenges constraining them and have a better chance of adopting and using new strategies and innovations to create appropriate solutions for the limitations. Over 60% of farmers were farming on leased land, while 23% and 16% were respectively farming on communal and privately owned farms. Majority of these farmers are leasing land under the government's land restitution programme. The system of land restitution was introduced by the current government to restore land to South Africans who had been dispossessed of land under racial discriminatory legislation and practices of Apartheid (Kloppers and Piennar, 2014). Also, it involves resolving the restitution claims within the set period, by negotiating settlements that restore land rights as well as awarding other forms of equitable redress to the claimants. The new farmers were therefore issued with 30 year leases which can be renewed for another 20 years with the initial 5 years being treated as a probation period.

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Challenges and constraints for market-oriented smallholder cattle farmers in Limpopo Province

Challenges and constraints were classified into ecological, production, institutional, infrastructural and marketing. Overall, these challenges are similar to those documented as affecting the growth and sustainability of subsistence (communal) cattle farming in South Africa (MacLeod et al. 2008; Munyai, 2012; DAFF 2012a). This shows that even if the market-oriented smallholder farmers were trying to commercialize, they still have some characteristics similar to communal farmers.

Ecological challenges

Specific ecological challenges and respective perceptions about the extent of the ecological challenges are presented in Table 4. The parameter estimates of the binary logistic regression models used to identify the factors influencing farmers' responses to the ecological challenges are presented in Table 5. Almost all the respondents reported that they were confronted by drought and 69% of them ranked the extent of the challenge as high to very high (Table 4). According to the logistic regression model, education level of the farmers positively ($p=0.023$) moderated their responses to the challenge of drought (Table 5). According to Limpopo Economic Development, Environment and Tourism (LEDET 2015), at least 60 % of Sub-Saharan Africa (SSA) is susceptible to drought with nearly 30 % being highly vulnerable. The province of Limpopo is one of the highly vulnerable areas of the region where drought was declared a natural disaster in November of 2015 (LDA 2016b). Similar findings where drought is reported as a huge constraint to cattle farming were reported in studies by Udmale et al. (2014) in Maharashtra state, India and also Mpandeli et al. (2015) in Limpopo Province. Severe drought

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incidences can cause feed shortages and heat stress which leads to reduced livestock production Udmale et al. (2014), Agri-SA (2016) and high mortality incidences (LDA 2016b). Apart from government's drought management programmes such as the provision of supplementary feeds and water supplies to the affected regions (LDA 2016b) this, improving access to tailored weather forecasts and provision of sustainable drought-proofing skills to local cattle producers is highly encouraged.

Table 4 Ecological challenges and constraints faced by emerging cattle farmers in Limpopo province, South Africa

Challenge/ Constraint	% of farmers faced with challenge or constraint	Extent of challenge or constraint			
		Very High (%)	High (%)	Low (%)	Very low (%)
Drought	96	26	43	29	2
Soil erosion	94	30	65	5	0
Heat waves	90	10	37	48	5
Biodiversity loss	86	4	29	60	1
Pollution	71	4	25	53	18
Floods	69	2	19	53	26
Frost/Cold spells	64	5	11	66	18
Wind	58	8	74	18	0

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Table 5 Regression outputs of factors influencing farmers' responses of whether they were faced by ecological challenges or not

Challenge	Variables	Estimate (B)	S.E	Significance
Drought	Age	0.554	1.284	0.666
	Education level	1.063	0.466	0.023*
	Formal training	-0.431	0.504	0.393
Soil erosion	Education level	1.672	0.630	0.008*
	Formal training	2.485	1.041	0.017*
Heat waves	Age	-1.142	1.365	0.402
	Education level	1.582	0.522	0.002*
	Formal training	-0.593	0.531	0.262
Biodiversity loss	Age	1.887	0.692	0.006*
	Education level	0.587	0.690	0.390
	Formal training	-2.201	0.749	0.003*
Pollution	Age	0.986	0.543	0.069
	Education level	0.403	0.614	0.511
	Formal training	-0.638	0.616	0.300
Floods	Education level	2.890	1.028	0.005*
	Formal training	2.361	1.045	0.024*
Cold spells/Frost	Age	-1.044	1.396	0.455
	Education level	1.574	0.522	0.002*
	Formal training	-1.046	0.554	0.059
Wind storms	Education level	2.890	1.028	0.005*
	Formal training	2.361	1.045	0.024*

*Statistical significant at 5% level ($p < 0.05$)

The finding that more educated farmers had a greater likelihood of reporting drought challenge was consistent with previous findings by Ndambiri et al. (2013) and Roco et al. (2014)

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in Mediterranean Chile. Contrary to this, Udmale et al. (2014) found that less educated farmers reported drought driven water shortage conflicts and suicidal tendencies more than educated farmers. In general, the influence of education to farmers' responses could be explained by the fact that education level, used as a proxy of human capital (Lubungu, 2016), improves farmers' understanding through access to new and relevant information (Roco et al. 2014; Fadina and Barjolle, 2018) and their ability to process the information in order to fight the challenges (Nigussie et al. 2016). Therefore, educated farmers are less likely to be affected by the challenges compared to the less educated.

Soil erosion, a proxy for land degradation was reported by 94% of respondents with 95% of them ranking it as a high to very high constraint. Table 5 shows that education level ($p=0.008$) and formal training ($p=0.017$) were the factors that influenced farmers' responses to soil erosion challenge. Current findings on the challenge are supported by Kumar Shit et al. (2015) where more than 73% of farmers in South Bengal, India were constrained by the challenge with 51% ranking the impact as moderate to severe. Locally, Marandure et al. (2016) reported that over 60% of farmers from the communities of Ncorha and Gxwalibomvu in Eastern Cape indicated that their natural pastures had poor to fair levels of soil erosion. Munyai (2012) identified factors such as high stocking rate (40% of the respondents) and heavy storms (20%) as the causes of soil erosion and these were believed to be compounded by poor rangeland management (Ogunkoya, 2014). In that regard, community knowledge sharing platforms should be upheld for farmers to exchange knowledge on better farm-systems land management and degradation control measures. Results of the logistic regression model with regard to education did not agree with a previous finding by Nigussie et al. (2016) where education level did not increase the likelihood of farmers perceiving the risk of soil erosion. Current results show that the influence from formal

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training was positive. A possible explanation for this may be that formal training delivered a practical and meaningful program that helped farmers to curb the challenge compared to those without training. Therefore, improved access to formal training could be introduced especially among the youths for sustainable land management.

The challenge of heat waves was reported by 90% of the farmers with approximately 40% of them ranking it as a high to very high constraint. The results from the binary logistic model show that education influenced ($p=0.002$) farmers responses to the heat wave challenge (Table 5). According to (LDA 2016b) heat waves have been reported to have negative impact livestock production systems in Limpopo Province. Current findings are supported by the results of Chingala et al. (2017), where 76% of the smallholder farmers in Malawi reported excessive temperature increases for the past 20 years. In contrary, Ogunkoya (2014) found a very small proportion (2%) of the farmers who reported the challenge of heat stress. In a study by Katiyatiya et al. (2014), the farmers attributed heat stress to reduced feed intake/foraging and deaths (70%), excessive panting (57%) and weight loss (48%). Government extension officers should, therefore, advise farmers to provide shading and enough water during the dry season to minimize effects of heat stress on animal production. The observation that education positively influenced the farmers' responses to the challenge of excessive temperatures was similar to that obtained by Ndambiri et al. (2013) in Kenya. More farmers with post-primary education (47%) were found to have observed long periods of temperature compared to less of those with up to primary education (8%). Therefore, improvement in farmers' education level is required to enhance their understanding of weather related challenges.

Biodiversity loss expressed as the reduction of plant species in the grazing lands was reported by most of the respondents (86%) with 33% of them ranking it as a high to very high

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challenge. Based on the logistic regression results, age ($p=0.006$) and formal training ($p=0.003$) influenced farmers' responses to the challenge of biodiversity loss (Table 5). According to Chapin et al. (2014), loss of plant biodiversity negatively affects the quality of natural pastures and hence feed availability for the animals. In a study by Marandure et al. (2016), close to 70% of the farmers ranked biodiversity levels as poor to fair (having <3 desirable plant species) and this was attributed to high levels of soil erosion. Therefore, the slight difference in perceptions by the farmers in Eastern Cape and the current sample could be attributed to the presence of bush encroachers in Limpopo Province (SAPIANews 2013; LEDET 2016). Bush encroachers suppress the growth of other species causing eventual loss of biodiversity and more importantly reduce rangeland grazing capacity (SAPIANews 2013)

Some of the ecological challenges reported were; pollution (71%), floods (69%), winds (68%) and cold spells (65%). Majority of the respondents ($>70\%$) ranked the level of these challenges as low to very low except for strong winds where 82% described its level as high to very high. Wind and cold stress can negatively affect animal production, thus farmers are encouraged to provide natural windbreaks to protect their cattle from wind-chill, especially during winter months.

Production challenges and constraints

Table 6 shows the frequencies and the extent of the production challenges/constraints that were reported by the farmers. Table 7 shows the binary logistic regression coefficients of factors affecting farmers' responses of the production challenges faced. Most of the farmers reported of being constrained by cattle parasites (92% of the respondents) and diseases (89%; Table 6).

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Table 6 Cattle production challenges and constraints faced by emerging cattle farmers in Limpopo province, South Africa (%)

Challenge/ Constraint faced	% of farmers faced with challenge or Constraint	Extent of challenge or constraint			
		Very High (%)	High (%)	Low (%)	Very Low (%)
Parasites attack	92	16	42	40	2
Diseases prevalence	89	7	40	53	0
Cattle feed shortage	86	30	45	25	0
Inadequate water	82	28	23	47	2
Cattle breeding	77	6	48	46	0
Stock theft	73	31	22	47	0
Predation	63	38	26	36	0
Stray animals	50	29	7	64	0

Nearly half of the respondents ranked the challenges as high to very high. About 36% reported to have lost their animals from disease in the 2014/15 season. Based on logistic regression results (Table 7), education level ($p=0.002$) influenced farmers responses to the challenge of cattle parasites. Parasites and diseases increase morbidity and mortality in cattle, especially in the smallholder farming areas (Agholor, 2013; Chaudhary et al. 2013). Mapiye et al. (2009) found a significantly high proportion (65%) of farmers who reported the challenges of parasites and diseases in the Eastern Cape Province of South Africa. Contrary to the findings, earlier on, Musemwa et al. (2008) and Katiyatiya et al. (2014) posited that, Nguni farmers were likely to face fewer parasites and diseases problems due to the breed's resistance. Compounding these challenges could be various factors. Esrada-Pena and Salman (2013) and Rust and Rust (2013) noted changes in climatic conditions while Chaudhary et al. (2013) linked them to poor

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management as a result of lack of skills and reluctance by farmers to carry out routine husbandry practices.

Table 7 Logistic regression estimates for factors influencing the responses of farmers on production challenges/constraints reported

Challenge/Constraint	Variables	Estimate (β)	S.E	Significance
Parasites	Education level	2.281	0.752	0.002*
	Formal training	0.910	0.686	0.185
	Gender	1.258	1.127	0.264
Diseases	Age	0.054	0.021	0.008*
	Education level	2.114	1.265	0.095
	Marital status	-2.350	1.108	0.034**
	Formal training	0.695	1.069	0.516
Cattle feeds	Age	-0.522	1.333	0.695
	Education level	1.157	0.547	0.034*
	Formal training	0.476	0.587	0.417
	Farm size	2.322	1.061	0.029*
Water	Education level	1.061	0.562	0.038*
	Age	-1.416	1.264	0.263
	Formal training	0.579	0.590	0.326
Cattle breeding	Age	0.257	1.448	0.859
	Education level	1.916	0.629	0.002*
	Formal training	-0.834	0.580	0.150
	Farm size	0.589	0.481	0.220
Stock theft	Age	-0.843	1.604	0.599
	Education level	0.169	0.836	0.840
	Farm size	2.290	0.799	0.004*
	Gender	-2.521	1.185	0.033*
	Marital status	0.283	0.868	0.744
	Household size	0.983	0.763	0.197
Predation	Age	-2.245	1.487	0.131
	Farm size	1.035	0.477	0.030*
	Marital status	1.0118	0.722	0.159
	Gender	-1.770	0.969	0.068

*Statistical significant at 5% level ($p < 0.05$)

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The observation that education positively influenced farmers' responses to the parasite challenge was not consistent with findings by Chingala et al. (2017) where the likelihood of perceiving increases in tick loads was higher in less-educated than more-educated farmers. The finding was attributed to the fact that less educated farmers tend to have low income hence could not afford veterinary drugs. With regard to age, current findings could be explained by the fact that older farmers were better able to understand and acknowledge the effects of cattle diseases through experience gained. The experience includes knowledge of the previous cattle disease outbreaks and the effects imposed (LDA 2017).

Natural pastures were the major source of feed for the cattle throughout the year with better forage quantity and quality in the wet than dry season. However, more than 80% respondents were confronted by shortage of feed with 75% of them describing the extent of the challenge as high to very high. Majority (62%) practiced rotational grazing with resting while the remainder used continuous grazing. A greater number (80% of the respondents) attributed the challenge to incessant drought conditions while 11% indicated lack of capital to purchase supplements. Based on the binary logistic regression estimates, educated farmers ($p=0.003$) and those with large farm sizes ($p=0.003$) had a higher likelihood of reporting cattle feed shortages compared to less educated and those with smaller farms. The challenge of feed shortage is generally high during the dry season where the quantity and quality of feeds from the grazing lands is substantially low (Mapiye et al., 2009). Limpopo province is drought prone and has been faced with frequent droughts characterized by heat waves and very low rainfall (LDA 2016b; Mpandeli et al. 2015). Nalubwama et al. (2014) in Uganda reported feed shortage as a major challenge and linked it to heavy dependence of farmers on grazing lands with limited feed conservation and supplementation strategies. Therefore, capacitating farmers with information

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and skills on cattle feed production and management during the dry season is critical. The association observed between reporting feed shortage and farm size could be a result of heavy encroachment and invasion by alien species in large farms. This could be because most farmers still have smaller herds hence selective grazing by the animals and underutilization of the grazing resources could lead to encroachment which reduces availability of grazing feeds.

More than 82% of the respondents reported water shortage constraints and these were severe during the off-rainy season. Over 50% ranked the challenge as high to very high. The main sources of water were boreholes (62%), dams and rivers (17%). To one of the respondents, the challenge was so severe such that the farmer had to drive a distance of 20km every day to fetch drinking water for the cattle. Table 7 shows that education level was the major factor that influenced ($p=0.038$) farmers' responses to the water scarcity challenge. Generally, unavailability of adequate water throughout the season has since been reported to be a serious constraint to farming in the province (LDA 2016b) and this is typical of the whole country where the resource has become a huge national crisis (Agri-SA 2016). Shortage of water could have been heightened by low rainfall and high temperature regimes which occurred over a long period in Southern Africa (Chingala et al. 2017). It is therefore important for the local government and development institutions to consider establishment of more dams and boreholes and offer training to farmers on sustainable on-farm systems of water harvesting and conservation techniques.

Seventy seven percent of the farmers reported that they were constrained by various cattle breeding challenges. Above 50% reported the extent of the challenges as high to very high. Figure 2 shows the various challenges and proportions of farmers affected. Major breeding challenges reported were lack of camps (46%) and poor breeding management skills (29%).

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Compounding the challenge of lack of breeding camps was unavailability of fencing materials. Based on logistic regression estimates, educated farmers were likely to report the challenge than less educated farmers ($p= 0.002$; Table 7). Previous findings by Mapiye et al. (2009) showed that cattle farmers in both communal and small-scale production systems were severely affected by breeding challenges. Lack of camps could hamper effective breeding management and leads to incidences of uncontrolled breeding (FAO 2011). It could also lead to poor reproductive management such as calving incidences during the dry seasons when feed availability from the natural pastures is lowest. In terms of breeding management skills, previous findings from Khapayi and Celliers (2016), supports current results as more respondents (60%) were found to have inadequate skills. Based on the findings, maintenance of fencing infrastructure by farmers and the provision of new fencing material is essential. This should be complemented with the provision of training and ongoing knowledge exchange systems among the farmers to improve their breeding knowledge and skills.

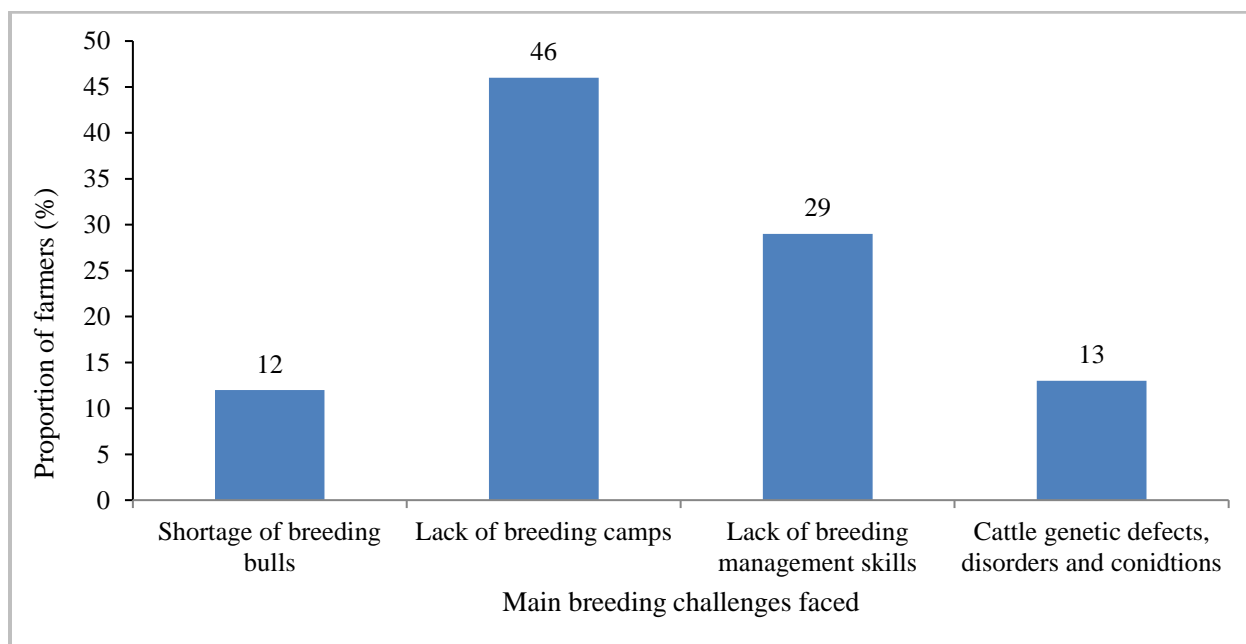


Figure 2 Specific cattle breeding challenges faced by the emerging farmers

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Nearly three quarters of the respondents were confronted by the challenge of stock theft (Table 6). About 53% perceived the extent of the challenge as high to very high. Reporting the challenge of stock theft was significantly influenced by two factors namely; (p=0.033) and farm size (p=0.004) and gender (p=0.033) (Table 7) with male farmers and those owning large herds experiencing high incidences of stock theft. Current findings were consistent with those of Pelsler et al. (2004) and Ogunkoya (2014) who reported stock theft and pilfering as a chronic challenge among the smallholder cattle farming communities. Currently, the challenge was attributed to unavailability as well as the poor state of fencing facilities. However, it could be because most farmers were located within the communal areas where poverty and unemployment was very high (Statistics South Africa, 2016). Overall, stealing of cattle reduces household consumption and sales of cattle and their byproducts (Musemwa et al. 2008) and may increase the spread of diseases (LDA 2017). To help reduce the challenge, the current efforts to foster collaborative patrols and communication between farmers and the police should be strengthened. Farmers are also encouraged to build strong fences around their farms to secure the animals.

The association between farm size and stock theft could be because larger farms had some of the camps located far away from homesteads and offices hence this could increase the risks of pilfering. Previously, Lombard et al. (2017) in the Free State province also reported a positive influence of farm size to stock theft while Pelsler et al. (2004) in Malawi noted that 18.3% of the respondents had livestock stolen from grazing lands. The positive influence of gender could be because cattle herd management and activities are predominantly carried by males (Tangka et al. 2000). These activities include, herding, gathering, routine counting and search of the missing animals (Tangka et al. 2000) hence men are likely to be more responsive when reporting stock theft.

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About 63% of the farmers reported predation challenges due to wild animals. Nearly two thirds ranked the extent of the challenge as high to very high. Wild animals such as leopards and jackals were found to be the predominant predators. They targeted calves, isolated and sick animals in the grazing areas. Based on the logistic regression results, reporting the challenge of predation was influenced by farm size ($p=0.030$ Table 9). Current results concur with findings by (Kgathi et al. 2012) where a higher proportion (60%) of the farmers from Shorobe village, Northern Botswana lost their livestock from predation. The result that farm size significantly influenced responses to the predation challenge could be attributed to the fact that large farms have some camps that are difficult to monitor as explained under stock theft. It is therefore important for farmers to constantly monitor sick animals and have certainty over which cattle are pregnant and calving dates since these are easy targets for predation.

Institutional challenges

The study identified institutional challenges/constraints confronting the farmers and the results are presented in Table 8. Factors that influenced farmers' responses are presented in Table 9. More than 90% of the respondents reported that they were failing to access financial support with above 80% stating the extent of the challenge as high to very high. None of the factors significantly influenced farmers' responses ($p>0.05$) regarding the challenge of finance (Table 9). Lack of accessibility to finance by smallholder farmers was also reported by (DAFF 2012a; Khapayi and Celliers, 2016). Compounding the challenge could be poor financial management skills and lack of collateral by the farmers (MacLeod et al. 2008; DAFF 2012a; Lowitt et al. 2015). Therefore, current findings point to the importance of establishing stronger relationships between financial institutions and the farmers. This could be enhanced through training

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Table 8 The institutional and infrastructural challenges and constraints faced by emerging cattle farmers in Limpopo Province, South Africa

Challenge/ Constraint faced	% of farmers faced with Challenge or Constraint	Extent of challenge or constraint			
		Very High (%)	High (%)	Low (%)	Very low (%)
Lack of financial support	94	45	38	16	2
Lack of production infrastructure	87	20	54	26	0
Poor access to extension services	81	20	38	42	0
Lack of marketing infrastructure	81	24	52	24	0
Poor access to training	80	12	5	45	2

farmers with management skills, speeding up the process of issuing title deeds and hence promoting financial knowledge flows and collaborative efforts among farmers.

Lack of extension support services was reported by 81% of the farmers. Above half (58%) of them described the level of the challenge as high to very high. The main sources of information were government extension services (53%) and other farmers (30%). Despite extension being the main source of information, majority of the farmers expressed dissatisfaction on the efficiency of the system. They reported very minimal farm visits and the fact that interactions with extension officers were through the phone or by visiting extension offices. According to the logistic regression model, educated farmers had high likelihood ($p=0.001$) of reporting the challenge of extension compared to the less educated (Table 8). Findings by Moloji (2008) conform to present results where 96% of the market-oriented smallholder farmers reported lack of government extension support. Insufficient support from the extension could

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Table 9 Logistic regression estimates for factors influencing the responses of farmers on institutional and infrastructural challenges/constraints reported

Challenge	Variables	Estimate (β)	S.E	Significance
Finance	Age	0.005	0.026	0.850
	Marital status	-1.598	1.409	0.257
	Education level	0.163	0.104	0.117
	Title deeds	0.649	1.489	0.662
	Farm size	0.574	1.526	0.707
Production infrastructure	Age	0.45	0.212	0.003*
	Gender	-1.731	1.019	0.089
	Education level	0.568	1.027	0.580
	Title deeds	-0.324	0.9658	0.735
	Farm size	-0.345	1.026	0.736
Extension	Age	0.35	1.298	0.856
	Education level	1.784	0.542	0.001*
Marketing infrastructure	Age	0.135	1.300	0.917
	Gender	1.511	1.117	0.176
	Education level	1.664	0.572	0.004*
	Formal training	0.312	0.594	0.599
Training	Age	0.693	0.627	0.372
	Education level	0.560	1.225	0.571

*Statistical significant at 5% level ($p < 0.05$)

restrain the farmers from taking advantage of the various developmental opportunities instituted to them (Moloi, 2008) and was found to reduce access to farming practices and climate change information in South Benin (Fadina and Barjolle, 2018). However, compounding the challenge of poor extension could be shortage of manpower as well as lack of support resources (Aliber

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and Hall, 2012) such as funding and transport facility for the extension officer visits (MacLeod et al. 2008). Therefore, basing on the findings, the use of farmer-based knowledge management and information sharing strategies at grassroots level is encouraged.

Eighty percent of the respondents had poor access to training (Table 8) with 19% of them ranking the extent of the challenge as a high to very high. Based on the logistic regression model, none of the factors significantly ($p>0.05$) moderated farmers' responses to lack of training challenge (Table 9). The importance of acquisition of formal skills on cattle production, and the development of marketing strategies was previously reported by (Khaphayi and Celliers, 2016; Mtega et al. 2016). Access to formal training by farmers facilitates the adoption and implementation of innovation which could subsequently improve cattle productivity (Salami et al. 2010). In that regard, poor access to training by farmers could be one of the key factors behind the non-performance of rural beef cattle farmers in South Africa (Agholor, 2013). Compounding the challenge could be factors related to individual farmers such as low income, lack of information and the fact that majority of them are old aged. This could also be attributed to low initiatives from government in making sure that farmers access public and private training resources and facilities. Therefore, establishment of strong public-private partnerships to improve access to training, especially by women and young market-oriented smallholder farmers is critical.

Infrastructural challenges

Table 8 shows that 87% of the respondents had poor access to production infrastructure. These include inadequate or damaged boundary fences, and dipping/spraying facilities, handling pens and dams. Nearly three quarters (74%) ranked the extent of the constraint as high to very high.

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Table 9 shows that reporting the challenge of poor access to community production infrastructure was positively influenced by the farmers' age ($p=0.003$). Lack of access or poor condition of production infrastructure impedes production, marketing, processing and distribution of agricultural products (Salami et al. 2010; DAFF 2012a). For example, the absence of and/or poor condition of fences could trigger breeding and grazing management challenges as well as straying and stock theft. Lack of infrastructure could be attributed to challenges such as lack of secure land titles and investment finance by the farmers (MacLeod et al. 2008; Lowitt et al. 2015) and community disputes (LDA 2016b). These deter the farmers and other development agents from making infrastructural developments on their farms or farming communities. The influence of age on farmers' responses regarding the challenge of production infrastructure could be because adult farmers have a better understanding of the economic and social importance of accessing community farming infrastructure which might relatively come with experience. However, older farmers could have accumulated more financial and infrastructural resources hence are less likely to report the challenge compared to young farmers.

More than 80% of the farmers were faced with difficulties in accessing marketing infrastructure (Table 8). Majority (76 %) ranked the extent of that challenge as high to very high. Farmers cited poor access to feedlots, abattoirs, loading and offloading ramps, auction pens and roads in some communities. Reporting the challenge of poor access to community marketing infrastructure was influenced by education ($p=0.004$; Table 9). Previously, Musemwa et al. (2008) posited that Nguni cattle producers in South Africa were likely to be affected by physical marketing infrastructure challenges. Current findings conform to Agholor (2013) where more than two thirds of the farmers reported shortage of marketing infrastructures in their farming areas. According to Baloyi (2010); Sikhweni and Hassan (2013), access to marketing

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infrastructure ensures successful participation in high-value markets by the farmers. Therefore, the current challenge poses severe restraints to the marketing of cattle by the smallholder farmers (Salami et al. 2010; DAFF 2012a; Khapayi and Celliers, 2016). However, in some communities, the challenge is not due to unavailability of the physical structure but can be ascribed to the poor and dysfunctional state of the property (Montshwe, 2006; Musemwa et al. 2008). Therefore, in areas where the government or other developmental agencies have provided the structures, maintenance and upgrading is essential and should be the sole responsibility of the farmers.

Marketing challenges

Access to market and marketing information emerged as a key challenge confronting market-oriented smallholder farmers (Table 10). Across the study, about 90% reported the challenge with above 80% ranking it as high to very high. Major sources of market information were buyers and auctioneers (31%), extension services (28%) and other farmers (22%). Table 11 shows that education level of the respondents positively ($p=0.038$) moderated the farmers' responses to the challenge of lack of information. The finding of poor access to market information concurs with results by Baloyi (2010) where 76% of the respondents were confronted by the challenge. Access to marketing information promotes access to formal markets (Thamaga-Chitja and Morojele 2014) and this forms a key precondition for the graduation of subsistence farmers to commercial producers (Salami et al. 2010). However, poor access to information has been speculated to have reduced the marketing ability of farmers and also their interests to participate in high-value markets (Sikhweni and Hassan, 2013; Khapayi and Celliers, 2016). Musemwa et al. (2008) ascribed lack of market information to poor availability and use of information sources such as radios, televisions and internet. Apart from this, lack of information

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and access to formal markets especially amongst farmers working in groups could be compounded by institutional and socio-cultural factors (Thamaga-Chitja and Morojele 2014). Thus, lack of trust, the anticipated widespread of ‘free-riders’, and the fact that ‘communal sharing and working’ clashes or mismatches the profit oriented way of business by the farmers (Gadzikwa et al. 2006) could be such factors. However, sharing of information among smallholder farmers has remained an integral part of rural life (Thamaga-Chitja and Morojele, 2014). In that regard, policies and strategies that encourage farmers to team-up when marketing and constantly share information among them remain key and should be upheld.

Table 10 Marketing challenges and constraints faced by emerging cattle farmers in Limpopo province

Challenges/constraints faced	% of farmers faced with	Extent of the challenges or constraints			
		Very High (%)	High (%)	Low (%)	Very low (%)
Poor access to markets and marketing information	94	45	38	16	2
High transactional costs	87	20	54	26	0
Unreliable markets	81	20	38	42	0

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Table 11 Logistic regression estimates for factors influencing the responses of farmers on marketing challenges/constraints reported

Challenge	Variables	Estimation (β)	S.E	Significance
Access to markets and market information	Gender	0.589	0.926	0.524
	Marital status	0.362	0.692	0.601
	Education level	0.983	0.468	0.038*
Transactional costs	Education level	1.250	0.542	0.021*
	Marital status	-1.278	0.805	0.112
	Gender	2.358	1.271	0.064
	Age	1.032	1.408	0.464
	Formal training	0.547	0.598	0.360
Unreliable markets	Education level	-0.553	0.427	0.196
	Marital status	0.288	0.653	0.659
	Age	0.694	1.295	0.592
	Gender	0.205	0.846	0.808

*Statistical significant at 5% level ($p < 0.05$)

Eighty seven percent of the respondents identified market transactional costs as a challenge with nearly three quarters ranking it as a high to very high challenge. Respondents mentioned that transport cost constitutes the highest proportion of the total marketing costs with the mean distance to the market being 42 km. Majority (54%) organize for their transport while 26% relied on buyers. Based on the binary logistic regression estimates, educated farmers had a higher ($p=0.021$) likelihood of reporting high marketing transaction costs than less educated farmers. High marketing transaction costs reduces the efficient operation of markets and participation by farmers in lucrative markets (DAFF 2012a; Khapayi and Celliers, 2016). Some

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of these costs include; transport to the market, negotiations, government levy, market levy and accessing information (Baloyi, 2010; DAFF 2012a; Lubungu, 2016). Ultimately, in incidences where transaction costs outweigh the benefits, producers stop using such marketing channels (Musemwa et al. 2008). Invariably, the challenge of transport could be linked to other factors such as poor infrastructure, imperfect information and institutional challenges which include the absence of formal markets (DAFF 2012a). Reducing the presence of these factors/constraints allows farmers to recover their individual production and marketing costs thereby improving the chances of participating in formal markets (Lubungu, 2016).

More than 80% of the farmers were faced with the challenge of market unreliability and 58% of them indicated the extent of the challenge as high to very high. More than 70% of the respondents were not satisfied with market prices being offered by most of the buyers such as an average of R4584 (equivalent to USD320) per live animal. They also suggested incidences of inconsistency pricing of live animals, inappropriate classification and pricing of carcasses. Based on the logistic regression model, none of the factors significantly ($p > 0.05$) moderated farmers' responses to lack of market reliability challenge (Table 11). The current findings are consistent with previous results by Khapayi and Celliers (2016) which showed that 45% of the farmers reported challenges of poor reliability, lack of timeliness and biases from the markets. Lack of timely and reliable marketing information is regarded as a severe challenge in South Africa's smallholder farming community (Montshwe, 2006; DAFF 2012a; Sikhweni and Hassan, 2013). It has forced some smallholder farmers to switch from formal to informal markets (Montshwe, 2006) such as on-farm or direct selling to consumers. This points to key vulnerability challenges such as the exposure of farmers to speculators or middlemen who always take advantage of knowing their situations (Montshwe, 2006). Therefore, government, through local authorities

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should enforce policies and marketing contractual arrangements that allow farmers to be part of the price discovery and classification of their animals and animal products.

Despite many limitations reported for the surveyed areas, drought, parasites, lack of finance and poor access to markets were the most important challenges. Responses on drought supports the view that it is an important natural disaster in Southern Africa (LEDET 2015). Its prevalence could reduce feed and water availability as well as fuel biodiversity loss (Agri-SA 2016). On the other hand, parasite challenge could expose the animals to secondary infection (diseases) while poor access to finance reduces the ability of farmers to re-invest. Furthermore, lack of markets and market information could negatively impact on the economic and social growth of the farmers and farming communities. In this regard, a holistic and participatory sustainability approach is required to provide solutions to these challenges. That may enable farmers to co-create solutions to their problems, fully exploit existing opportunities and envisage possible future scenarios, with a special emphasis on the sustainability of both individual farms and the whole smallholder sector.

Conclusion

The major limitations confronting the farmers included drought, diseases and parasites, poor access to markets, lack of finance, feed shortages, water scarcity, and lack of production infrastructure. Overall, education level strongly influenced farmers' perception of many challenges. The results thus suggest that educated farmers were more likely to respond positively to drought, biodiversity loss, parasites, cattle feeds, poor access to extension and market transactions costs challenges. There was a strong positive association between farmers' age and perceptions of production infrastructure and cattle disease constraints. Similarly, farm size

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positively influenced farmers' perception of stock theft and cattle feed constraints. Thus, policies and programs that improve access to training and appropriate knowledge by farmers, especially the youths and women in developing countries should be promoted. This would entail, revisiting and reforming the extension systems and more importantly making use of technological tools and models that improve knowledge creation and sharing among farmers themselves.

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Compliance with ethical standards

Ethical clearance (SU-HSD-000505) for the current research was provided by Stellenbosch University Human Research (Humanities) Ethics Committee.

Conflict of interest

The authors declare they have no conflict of interest.

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