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ANALYSIS OF BEEF CATTLE PRODUCTION IN ESWATINI: A GENDER-BASED COMPARATIVE DESCRIPTION AND DETERMINANTS

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ABSTRACT: *This study conducted a gender-based description analysis of beef cattle production and its determinants in Eswatini. Data were collected from 397 farmers through personal interviews and analyzed using descriptive and inferential statistics and multiple regression. The gender comparative assessment revealed a low average herd size for females ($p<0.01$). Males indicated superiority in numbers of cows and calves ($p<0.01$), heifers ($p<0.05$), steers ($p<0.1$) and crossbreeds ($p<0.05$). Significant differences were also observed regarding calving rate ($p<0.05$), capital and medicine ($p<0.01$) labor ($p<0.05$), credit and member association ($p<0.1$). Age, education and employment indicated significant differences at $p<0.01$ and $p<0.05$, respectively. Females had lower off-take rate ($p<0.05$), which undercut market participation ($p<0.01$). Determinants of production, significant at $p<0.01$, include location, extension, capital, labor and market participation. Gender, experience and off-take rate revealed significance at $p<0.05$. Extension adjustments and redress of cooperativism are recommended for improved productivity, with more attention given to female farmers.*
KEYWORDS: beef cattle production, smallholders, determinants, Eswatini

INTRODUCTION

Agriculture is the mainstay of the economic framework in agrarian economies (Igwe and Esonwune, 2011), pivotal in rural and national economic transformation (Enkono *et al.*, 2013). The sector provides a threefold functional purpose through subsistence (Besharat and Amirahmadi, 2011; Duguma and Debsu, 2019), economic (Mabe *et al.*, 2010; Raza and Siddiqui, 2014) and social (Düvel, 2002; Kechero *et al.*, 2013) functions that culminate with the up-liftment of livelihoods. In Eswatini, agriculture is regarded as the backbone of the economy, providing raw materials for the manufacturing sector (Xaba and Masuku, 2013). Subsistence-wise, agriculture provides for food security through food and manure production and draft power (Birthal and Rao, 2004; Kechero *et al.*, 2013). Socially, livestock allow for gains in social status (Alemayehu *et al.*, 2010; Tibi and Aphunu, 2010) and are used for traditional ceremonies (Department of Veterinary and Livestock Services, 2004)

The dominance of the livestock subsector in developing economies has been reported by several authors (Baidoo *et al.*, 2016; Birthal and Rao, 2004; Chand and Raju, 2008). In Eswatini, 53% of the 8.5% agriculture sector contribution to gross domestic product was sourced from the livestock subsector in 2019 (Central Statistical Office, 2019). Recent statistics indicate that the livestock subsector is dominated by beef cattle farming, accounted for 48% of red-meat livestock (Figure 1) and reared by smallholder farmers in rural areas that held 90% of the national herd (Department of Veterinary and Livestock Services, 2018b). This transforms beef cattle production into an

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indispensable strategic tool for food security, poverty alleviation and economic development (Baidoo *et al.*, 2016; Muhammad-Lawal and Atte, 2016; Smith *et al.*, 2013). In this regard, the government of Eswatini incorporated the subsector into the national economic recovery strategy (Department of Veterinary and Livestock Services, 2018a).

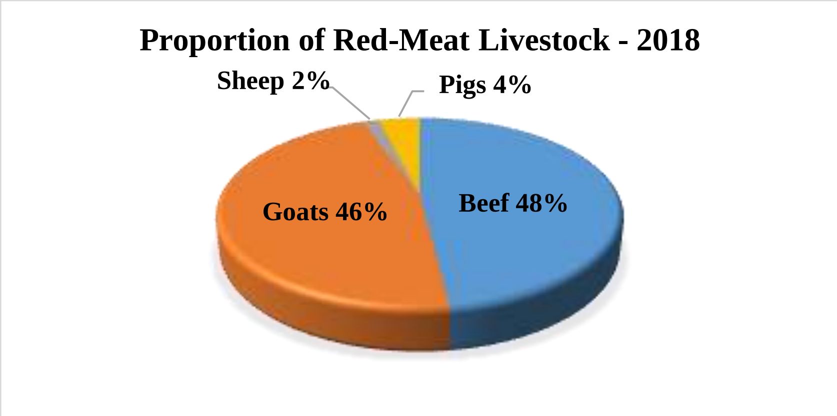

Figure 1: Diagrammatical presentation of the proportion of red-meat livestock.

Source: Adapted from Department of Veterinary and Livestock Services (2018b)

Generally, the livestock subsector continues to experience a global rapid demand expansion (Chand and Raju, 2008; Delgado *et al.*, 2001; Ilea, 2009) due to the combined effect of population growth, increase in family income and consumer preference shifts towards animal-based protein (Binswanger-Mkhize, 2009; Rutto *et al.*, 2013). The domestic meat consumption per capita further indicates that red-meat consumption is highest (26.9kg/person) compared chicken (4.7kg/person/year) and fish (4.2kg/person/year) (FAO-Fortune of Africa, 2018). Regional comparison places Eswatini at second highest consumption of red meat, behind South Africa (58.6kg/person/year) and just ahead of Botswana (26.2kg/person/year), Zimbabwe (21.3kg/person/year), Lesotho (18.3kg/person/year) and Mozambique (7.8kg/person/year).

FAO (2009a) projected additional an 200 million tons of meat demand by 2050, out of which 72% is expected to be consumed in developing countries (FAO, 2009b). This places beef cattle farmers at a prime position for economic benefit through intensive production and marketing. However, farmers in Eswatini have not yet benefited from this prospective agribusiness opportunity, especially female farmers who often lag behind males in agricultural production. Beef cattle production and marketing remain low (World Bank, 2011), with dwindling national herd size in an unorganized production-marketing institutional framework. The 2019 herd population (Department of Veterinary and Livestock Services, 2018b) reflects a 31% decline since 1992 (Department of Veterinary and Livestock Services, 2004), exacerbating low levels of production and inconsistent marketing (Marandure *et al.*, 2016). This hampers the incorporation of smallholder farmers into pro-poor value chains, relegating the agriculture sector into a low-income enterprise and undermining rural and national economic advancement. Therefore, this study conducted a gender-based description

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analysis of beef cattle production and its determinants in Eswatini. Understanding the underlying drivers of production provides basis for policy adjustments required for the stimulation of rapid response to demand surges (Besharat and Amirahmadi, 2011), promoting domestic economic activity and minimizing net food imports (Gerber *et al.*, 2005). Moreover, the gender-based comparative assessment is fundamental in literature build-up that advocates for inclusive rural economic growth, bridging gender-based economic disparities in rural areas.

METHODOLOGY

Study area

The study was conducted in Eswatini, a 17,364 km^2 agrarian country landlocked between South Africa and Mozambique with a population of about 1.2 million (Worldometer, 2020). The country is divided into four administrative regions, to which recent statistics indicate a near-even distribution of beef cattle (Department of Veterinary and Livestock Services, 2018b). Figure 2 shows the study area with and the regional distribution of the herd population (nc).

Recent statistics reported 63% poverty rate (Central Statistics Office, 2010) with a 40% unemployment rate (Ministry of Labour and Social Security, 2013/14). In this regard, agriculture provides a prospective avenue for both rural and national economic growth, especially for farmers located in rain-sufficient agro-ecological zones (Highveld, Middleveld and Lubombo). Subsistence agriculture remains the linchpin economic activity practised by about 70% of the population in rural areas.

Figure 2: Administrative regions and distribution of the beef herd population. Source: Adapted from Super Coloring (2020) and Department of Veterinary and Livestock Services (2018b).

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Sampling and data collection

The simplified formula for proportions (Yamane, 1967) was applied to the target population of smallholder farmers (N=48,595) to determine the sample size (S=397). The computation of the sample size is shown in Equation 1.

$$S = \frac{N}{1+Ne^2} = \frac{48{,}595}{1+48{,}595(0.05)^2} \approx 397 \ldots\ldots (1)$$

Where: *S* is the sample size; *N* is the total population of smallholder farmers in the study area; and *e* is the level of precision set at 0.05.

In order to allow for balanced proportional sampling among the strata, a twofold sampling procedure was applied. First, the farmers were categorized according to the four administrative regions to identify regional populations. Computation of percentage proportion was applied using Equation 2 to determine subsamples for the different strata.

$$n = \left(\frac{Rp}{N}\right) \times S \ldots\ldots (2)$$

Where: *n* is the subsample for each stratum; *Rp* is the population of farmers in each region; *N* is the total number of smallholder beef cattle farmers in the study area; and *S* is the overall sample size.

The second stage of the sampling procedure involved the application of simple random sampling to draw the respondents from each region. The distribution of the sample over the study area is presented in Table 1.

Table 1. Sample size determination.

District	Population	Percentage Proportion	Sample
Hhohho	13,290	27.35	109
Lubombo	9,649	19.86	79
Manzini	14,520	29.88	118
Shiselweni	11,136	22.92	91
Total	**48,595**	**100**	**397**

A pre-tested structured questionnaire was verbally administered through personal interviews to collect data from the sampled farmers. The technique allowed for clarifications in cases of literacy and numeracy challenges to ensure accurate data collection (Gill *et al.*, 2008). Data collected include socio-economic characteristics of the farmers, herd size, herd composition, annual capital investment, amount of inputs used, institutional factors, market participation and level of off-take.

Analytical framework and empirical model

Conceptually, the level of cattle farming is a function of farmer and household socio-economic characteristics (Ishaya *et al.*, 2018; Olujenyo, 2008), institutional factors, input resources used (Kidoido *et al.*, 2002), market participation or market-orientedness (Dlamini and Huang, 2019b) and so on. Equation 3 presents the literature-based reduced model for our conceptual framework:

$$NC = f(FHC, IF, PR, MF) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where, *NC* represents the level of cattle production measured as the number of cattle kept by the farmer; *FHC* denotes a vector of farmer and household socio-economic characteristics; *IF* is the vector of institutional factors that enhance cattle production; *PR* represents a set of resources used in the production process; and *MF* is a vector of marketing factors inducing a production pull-factor on cattle farming.

The evaluation of such functional relationships in social science is assessed through multiple regression models (Nkonki-Mandleni *et al.*, 2019), out of which the Ordinary Least Squares (OLS) is relevant for linear relationships where the dependent variable is continuous (Duguma and Debsu, 2019). The OLS regression model allows for the computation of the coefficients associated with each independent variable, reflecting the rate of change in the dependent variable ascribed to a unit change in the independent variable under consideration. The general formula of the multiple regression model is specified as (Rutherford, 2001):

$$Y_i = \alpha + X_i\beta_i + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where: Y represents a continuous dependent variable; X is the vector of independent variables; i represents the ith farmer; α is the regression constant; β is a vector of parameter estimates associated with the independent variables; and ε is the error term.

Descriptive analysis was based on descriptive statistics (means, standard deviation, frequency counts and percentages). Inferential statistics (*t*-test and chi-square test) were applied to identify statistical differences for the gender-based comparative assessment. The multiple regression model was adopted for the description of the determinants of beef cattle production. The empirical multiple regression model was specified as:

$$HerdSize = \beta_0 + \beta_1 Gender + \beta_2 Education + \beta_3 HouseholdSize + \beta_4 Experience + \beta_5 Location + \beta_6 ExtensionVisits + \beta_7 Capital + \beta_8 Labor + \beta_9 PastureAvailability + \beta_{10} BreedType + \beta_{11} OffTakeRate + \beta_{12} MarketParticipation + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Description of variables used in the empirical model and *a priori* expectations

Dependent variable

Herd size: The number of beef cattle kept by the farmer was used as the dependent variable, capturing the level of farm production. Output production creates marketable

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surplus through which farmers gain economic benefit. In a study on socio-economic determinants of cattle production in Nigeria, Ishaya *et al.* (2018) used herd size as a dependent variable to measure the level of cattle production.

Independent variables

The summary of the hypothesized relationships between variables used for the beef cattle production regression model is presented in Table 2.

Gender: Levels of agricultural production in developing economies largely depends on gender. In Eswatini, beef cattle farming is traditionally attributed to the male gender, enhancing productive superiority for males and widening rural gender-based economic disparities. Furthermore, female farmers in developing countries are confronted by a unique set of challenges that undermine their productivity (FAO, 2011). Incorporation of the gender variable allows for recommendations in support of inclusive rural economic development. A positive association with the dependent variable is anticipated with respect to the male gender (Xaba and Masuku, 2013).

Education: Education captures the impact of farmers' technical capacity and know-how in the production process and decision-marketing, expected to have a positive effect on productivity (Looga *et al.*, 2018; Obasi *et al.*, 2013). However, Duguma and Debsu (2019) argued that education shifts farmers' focus toward quality over quantity, imposing a negative effect on herd size. Moreover, educated farmers are often engaged in off-farm employment, reducing the time allocated for agricultural production. Hence, an indeterminate relationship with the dependent variable is envisaged.

Household size: Household size captures the level of labor availability for cattle production (Kechero *et al.*, 2013), imposing a positive effect on herd size. Since cattle are mainly liquidated to meet family cash needs, large household size could also be a cash-mount-pressure factor, depleting herd size. Hence, an indeterminate relationship is hypothesized.

Experience: Experience improves farmers' productivity and decision-making capacity in the production processes and farm management, thus hypothesized to impose a positive effect on herd size (Kidoido *et al.*, 2002).

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Table 2. Description and measurement of model variables and a priori expectations.

Variable	Measurement	Expected sign
Dependent variable		
Herd size	Number beef cattle held by the farmer	
Independent variables		
Gender	0 = Female, 1 = Male	+
Education	Years of formal schooling	+/-
Household size	Number of people living in the household	+/-
Experience	Years in beef cattle farming	+
Location	0 = Hhohho, 1 = Lubombo, 2 = Manzini, 3 = Shiselweni	+/-
Extension	Number of extension visits	+
Capital	E (Emalangeni – the currency of Eswatini)	+
Labor	Man-days	+
Pasture availability	0 = Insufficient, 1 = Sufficient	+
Breed type	0 = Nguni, 1 = Crossbreed	+
Off-take rate	Slaughters and sales as a proportion of herd size	+/-
Market participation	0 = No, 1 = Yes	+/-

Location: Geographical location of farming households induces heterogeneity in climatic conditions and availability of production resources such as communal grazing land. The suitability of wet and warm climatic conditions creates competition between crop and animal husbandries (Nkonki-Mandleni *et al.*, 2019), affecting the levels and management systems of livestock production. Therefore, an indeterminate relationship is expected.
Extension: Extension services allow for knowledge and skills transfers for improved farm productivity through labor capacitation programs, new technology and management system awareness. Based on previous findings on farm output level (Duguma and Debsu, 2019; Obasi *et al.*, 2013), extension service is expected to relate positively to herd size.

Capital: Agricultural production systems demand capital investment for input solicitation. Production inputs such as medicines and supplementary feed are integral for cattle farming, especially in the era of climate change that is marked by escalated cases of disease outbreaks and recurrent droughts (feed scarcity). Therefore, capital is expected to relate positively to herd size.

Labor: Labor captures the exact amount of time (man-days) invested into the production process, improving farm level of output (Badar *et al.*, 2007). Thus, expected to induce a positive effect on herd size (Kidoido *et al.*, 2002).

Pasture availability: Communal grazing pastures are part of the institutional framework governed by traditional authorities. Since smallholders heavily rely on communal natural pastures (Department of Veterinary Services/FAO, 1994; Hutabarat *et al.*, 1997), a positive relationship is hypothesized.

Breed type: Cattle breeds vary in reproductive performance, inducing heterogeneity in the level of farm output. Hybrids, specifically, exhibit heterosis advantage over pure breeds (Williams et al., 2010). Therefore, crossbreed herds are expected to be larger compared to Nguni breed herds, indicating a positive effect of the breed type variable.

Market participation: Involvement in cattle marketing captures the effect of livestock markets as a pull-factor of cattle production (Duguma and Debsu, 2019), thereby, increasing herd size. However, since beef cattle act as a "bank" for farmers, market participation also indicates farmers' response to household financial pressure, thus depleting the household herd. Therefore, an indeterminate relationship is envisaged.

Off-take rate: The rate of off-take captures the quantity of available marketable surplus (Enkono *et al.*, 2013), indicating efficiency in the production process. However, high off-take rate may also reflect household financial pressure that induces forced cattle sales. Therefore, an indeterminate effect on the dependent variable is hypothesized.

Pre-analysis diagnostics

For the specification of the OLS regression model, multicollinearity and heteroscedasticity must be addressed to ensure unbiased regression parameter estimates (Okello *et al.*, 2019). Among continuous variables, the bivariate correlation matrix and variance inflation factor (VIF) analyses were conducted to identify and eliminate collinear variables (Baidoo *et al.*, 2016). The test yielded VIF values <10 (range: 1.05-2.03), indicating that multicollinearity was not a problem for the empirical model (Akpan *et al.*, 2013). Contingency table analysis based on contingency coefficients (CC) and the chi-square test were conducted to identify and eliminate collinear categorical explanatory variables. Moreover, STATA Version 15 was applied to suppress collinear independent variables. The problem of heteroscedasticity was curbed through the STATA in-built function of robust standard error.

RESULTS AND DISCUSSION

Gender-based descriptive analysis

Herd dynamics, productivity and off-take performance

Summary statistics for the comparative assessment based on farmers' herd composition is presented in Table 3. Male farmers reveal a higher average herd size (19 cattle) compared to females (13 cattle), significant at $p<0.01$. This reflects superior productive ability by male farmers over females, alluding to higher economic benefit for males if such farmers engage in cattle marketing. Moreover, the results indicate that males stand better economic welfare gains, revealing agriculture-based sources of gender-based economic disparity in rural areas. This suggests a strong need for empirical research that provides support-evidence for the institutionalization of gender-inclusive agri-economic growth programs.

Table 3. Descriptive comparison of farmers' herd dynamics and offtake rate (S=397).

Continuous variables				
Variable	**Overall Mean**	**Group Mean**		***t*-value**
		Female	**Male**	
Herd size	17.496(0.305)	13.809(0.289)	19.312(0.301)	-4.651***
Cows	7.186(0.268)	5.756(0.238)	7.891(0.274)	-3.907***
Heifers	2.312(0.344)	1.847(0.324)	2.541(0.351)	-2.199**
Steers	1.625(0.311)	1.321(0.289)	1.774(0.319)	-1.873*
Oxen	1.584(0.317)	1.344(0.300)	1.703(0.325)	-1.312
Calves	3.761(0.304)	2.771(0.296)	4.248(0.297)	-4.528***
Calving rate	0.740(0.102)	0.681(0.121)	0.769(0.090)	-2.676***
Offtake rate	0.077(0.081)	0.066(0.084)	0.082(0.078)	-1.996**
Categorical Variables				
Variable	**Overall Frequency**	**Group Frequency**		χ^2
		Female	**Male**	
Breed type	Nguni=235(56.7) Cross = 162(40.8)	Nguni=88(22.2) Cross = 43(10.8)	Nguni=147(37.0) Cross = 119(30.0)	5.1566**
Total	**397(100)**	**131(33.0)**	**266(67.0)**	

Standard deviation in parenthesis for continuous variables. Percentage frequency in parenthesis for dummy variable. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The male gender reveals superiority in all herd composition features. Similar to findings by Marandure *et al.* (2016), the herd of sampled farmers is mainly composed of cows, followed by calves, heifers, steers and oxen. Cows, significant at $p<0.01$, infer to superior herd multiplicative potential for male farmers compared to females, through conception and calving. The reproductive superiority of male-owned herds is expressed by the significantly ($p<0.01$) higher calving rate, reflecting the capacity of male farmers in cattle breeding and calf management. This is evident in the significantly higher numbers of calves ($p<0.01$), heifers ($p<0.05$) and steers ($p<0.1$) in the herd. The ultimate economic benefit from cattle farming is captured through the off-take rate, which is a proxy for economic welfare gains to which males also reveal superiority over females ($p<0.05$). This emphasizes that male-owned household farms stand to be more productive compared to female-managed household farms. Moreover, the superior reproductive capacity of male-owned herds is explainable by the significantly ($p<0.05$) higher number of male farmers that keep hybrid cattle compared to females. This allows for more male farmers to gain from breeding stock reproductive capacity due to the heterosis effect compared to females (Williams *et al.*, 2010). Intra-group analysis further indicates that more males (45%) keep crosses compared to 33% among the females' subsample.

Input use

The gender comparative analysis descriptive statistics for input variables used in cattle production is presented in Table 4. Capital used indicates significantly ($p<0.1$) higher annual investment into cattle production by males over females. Capital allows for the solicitation of direct inputs and services for improved production, thus rendering strong productive ability to males over females. Labor, man-days, reflects that males dedicate more time into the production process than females, significant at $p<0.05$. This increases the males' capacity to produce and manage large herd sizes compared to their female counterparts. The results further indicate that males use significantly ($p<0.01$) more drugs and medicine for cattle treatment compared to female farmers, allowing for higher productivity and output production. Duguma and Debsu (2019) reported a positive effect of access to veterinary services on livestock productivity.

Table 4. Descriptive comparison based on production inputs used by farmers (S397).

Variable	Overall Mean	Group Mean		*t*-value
		Female	Male	
Capital	1,376.373(0.393)	1,121.191(0.392)	1,502.045(0.382)	-0.081***
Labor	146.156(0.253)	134.038(0.259)	152.124(0.248)	-2.153**
Medicine	523.877(0.423)	326.756(0.383)	620.955(0.429)	-4.128***

Standard deviation in parenthesis. *** $p<0.01$, ** $p<0.05$.

Institutional support

Table 5 presents a comparison of farmers based on institutional factors of production. The results indicate that a small proportion of the total sample (13%) have access to farm credit. This suggests a need for further research to identify hindrances to credit access. Agricultural funding is fundamental in farm productive performance, especially for the generally poor smallholder farmers in developing economies. The comparative analysis indicates that significantly ($p<0.1$) more males (7.3%) have access to farm credit compared to females (5.8%), improving males' productive capacity. The results further indicate a small proportion (5.5%) of the sample that bears cooperative membership. The results are in line with Ishaya *et al.* (2018), who found a smaller proportion of sampled farmers to be co-operators in Nigeria. Although cooperatives were introduced in 1976 in Eswatini (Hlatshwako, 2009), lack of cooperative resilience undermines the adoption of cooperativism as a viable model for economic growth (Dlamini and Huang, 2019a). The comparative assessment also indicates an even gender balance in cooperative membership, with significantly ($p<0.1$) more non-cooperated males (64%) over females (30%). Cooperativism is a widely approved model for agri-economic transformation, hence, the low rate of adoption among farmers presents a strong need for further empirical enquiry.

Table 5. Descriptive comparative analysis based on institutional factors (S=397).

Categorical variables				
Variable	**Overall Frequency**	**Group Mean**		χ^2
		Female	**Male**	
Pasture availability	Ins. = 212(53.4) Suf. = 185(46.6)	Ins. = 65(16.4) Suf. = 66(16.6)	Ins. = 147(37.0) Suf. = 119(30.0)	1.1239
Total	**397(100)**	**131(33.0)**	**266(67.0)**	
Farm Credit	No = 345(86.9) Yes = 52(13.1)	No = 108(27.2) Yes = 23(5.8)	No = 237(59.7) Yes = 29(7.3)	3.4152*
Total	**397(100)**	**131(33.0)**	**266(67.0)**	
Association	No = 375(94.5) Yes = 22(5.5)	No = 120(30.2) Yes = 11(2.8)	No = 255(64.2) Yes = 11(2.8)	3.0453*
Total	**397(100)**	**131(33.0)**	**266(67.0)**	
Continuous variable				
Variable	**Overall Mean**	**Group Mean**		***t*-value**
		Female	**Male**	
Extension	36.020(0.002)	36.015(0.001)	36.023(0.002)	-0.387

Ins. – Insufficient, Suf. – Sufficient. Percentage frequency in parenthesis for dummy variables. Standard deviation in parenthesis for continuous variable. * $p< 0.1$.

Farmers socio-economic characteristics

The control variable, gender, indicates domination of males (266 farmers - 67%) over females (131 farmers - 33%) among the sampled farmers. The results are similar to Marandure *et al.* (2016), who report domination of the males in South Africa's beef cattle subsector. The traditional norm, in rural subsistence farming, of ascribing large livestock to the male gender induces the dominance of males in cattle farming. Females only assume their right to household livestock ownership after the quietus of the male household head (Dlamini and Huang, 2019b), inferring to a superior productive potential for males over females. This further equips males for intensive production (Farinde and Ajayi, 2005). Table 6 presents gender-based descriptive comparative statistics for the farmers based on continuous demographic characteristics. Age reveals significantly ($p<0.01$) higher average age for females compared to males. Olujenyo (2008) reported an effect of age on agricultural productivity, citing technology and management stereotypes for older farmers. Such farmers uphold traditional methods of production and management, implying lower farm productivity for the older female farmers (Obasi *et al.*, 2013).

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Table 6. Descriptive comparison based on farmers' continuous demographic features (S=397).

Variable	**Overall Mean**	**Group Mean**		***t*-value**
		Female (s_F = 131)	**Male (s_M = 266)**	
Age	57.602(0.110)	60.221(0.086)	56.312(0.118)	3.091***
Household size	8.000(0.202)	8.076(0.197)	7.962(0.205)	0.454
Education	9.395(0.281)	8.252(0.316)	9.959(0.254)	-3.891***
Experience	19.971(0.315)	19.386(0.348)	20.259(0.298)	-1.268

Standard deviation in parenthesis. *** $p < 0.01$.

Education shows a significantly ($p<0.01$) higher average for males over females. Literacy allows for skill transfer and competitiveness in the cattle production process. This alludes to higher productive ability and level of farm output for males compared to females.

Table 7 presents the summary statistics for the gender descriptive comparison based on categorical socio-economic variables. The results indicate that significantly ($p<0.05$) more males (40%) earn non-farm income compared to females (15%). A detailed intra-group analysis indicates that 59% of the male subsample earn non-farm income compared to 45% among the female subsample. Considering the seasonal need for cattle vaccination and treatment, income is a fundamental aspect of cattle farming. This alludes to higher productive potential for males over females.

Table 7. Descriptive comparison based on farmers' socio-economic categorical variables (S=397).

Variable	**Overall Frequency**	**Group Frequency**		χ^2
		Females	**Male**	
Location	Hho = 109(27.5)	Hho = 29(7.3)	Hho = 80(20.2)	3.6681
	Lub = 79(19.9)	Lub = 25(6.3)	Lub = 54(13.6)	
	Man = 118(29.7)	Man = 42(10.6)	Man = 76(19.1)	
	Shi = 91(22.9)	Shi = 35(8.8)	Shi = 56(14.1)	
Total	**397(100)**	**131(33.0)**	**266(67.0)**	
Market participation	No = 196(49.4)	No = 81(20.4)	No = 115(29.0)	12.1470***
	Yes = 201(50.6)	Yes = 50(12.6)	Yes = 151(38.0)	
Total	**397(100)**	**131(33.0)**	**266(67.0)**	
Employment	No = 179(45.1)	No = 70(17.6)	No = 109(27.5)	5.5018**
	Yes = 218(54.9)	Yes = 61(15.4)	Yes = 157(39.5)	
Total	**397(100)**	**131(33.0)**	**266(67.0)**	

Hho - Hhohho, Lub - Lubombo, Man - Manzini, Shi - Shiselweni. Percentage frequency in parenthesis. *** $p<0.01$, ** $p<0.05$.

The results also show that more males, than females, are involved in cattle marketing activities (significant at $p<0.01$). Furthermore, only 38% of the female subsample marketed cattle compared to 57% of the male subsample. Market participation is a production pull-factor, advancing the availability of marketable surplus. This reveals that males generally have more marketable surplus, capturing farmers' effectiveness and efficiency in producing marketable surplus. This implies more welfare gains for males compared to females.

Econometric analysis

The empirical multiple regression model revealed acceptable goodness of fit statistics ($R^2 = 0.773, F(14, 382) = 110.170, p = 0.000$). The coefficient of determination indicates that the model explains 77% variation in the dependent variable collectively explained by the independent variables. The regression model estimates are presented in Table 8, indicating percentage change in the dependent variable attributed to a unit change in each independent variable, *ceteris paribus*.

Gender, significant at $p<0.05$, indicates that being a male increases the chances of increasing herd size by 4%. Common in developing countries, large livestock production is traditional ascribed to the male gender, bestowing productive capacity to males over females (Ishaya *et al.*, 2018; Olujenyo, 2008). A one-year increase in farmer's experience reflects a 6% increase in the number of cattle held by a farmer, significant at $p<0.05$. Experience enhances farmers' skills advancement and decision-making in the production process. Farmers not located in the Shiselweni region stand better chances to increase herd size by 7% relative to farmers in the Hhohho region (reference group), significant at $p<0.01$. In view of the negative sign associated with the Lubombo region, the results infer to an increase in herd size for farmers in Manzini relative to those in the Hhohho region. The Manzini region has larger portion of areas with fertile soils under wet and warm climatic conditions, promoting palatable sweetvelds. This accords comparative advantage to farmers in the Manzini region compared to those in other regions. Nkonki-Mandleni *et al.* (2019) revealed a relationship between livestock production and suitable agro-ecological districts.

Table 8. OLS regression estimates for the determinants of cattle farming (S=397).

Variable	Coef.	Robust Std. Err.	*t*-value
Gender (0=Female, 1=Male)	0.039	0.017	2.37**
Education (Years)	-0.029	0.031	-0.93
Household size (Number)	0.069	0.042	1.65
Experience (Years)	0.058	0.028	2.06**
Location (1=Lubombo)	-0.026	0.023	-1.13
Location (2=Manzini)	0.022	0.020	1.09
Location (3=Shiselweni)	-0.067	0.026	-2.54***
Extension (Number)	4.312	1.426	3.02***
Capital (Emalangeni)	0.274	0.033	8.37***
Labor (Man-days)	0.404	0.044	9.29***
Pasture availability (0=Insufficient, 1=Sufficient)	-0.026	0.016	-1.67
Breed type (0=Nguni, 1=Crossbreed)	0.013	0.017	0.79
Off-Take rate (Ratio)	-0.668	0.324	-2.07**
Market participation (0=No, 1=Yes)	0.221	0.022	9.86***

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Constant	6.002	2.200	2.73***
Number of Obs.	397		
F(14, 382)	110.170		
Prob > F	0.000		
R-squared	0.773		

*** *p 0.01*, ** *p<0.05*, * *p<0.1*.

A one extra extension visit induces a 431% increase in herd size, significant at $p<0.01$. Majority farmers stick to the mandatory dip tank extension consultation; hence extra consultation induces huge effect on the dependent variable. Extension services enhance farmers' production efficiency through capacitation and advice on new technology and management systems, strengthening agriculture, food security and poverty alleviation (FAO, 2012). Labor relates to a 40% increase in herd size associated with a unit increase in man-days used in the production process, significant at $p<0.01$. Labor is a critical production resource that promotes agricultural output. A one Emalangeni unit increase in invested capital induces a 27% increase in herd size, significant at $p<0.01$. This indicates the importance of access to farm credit for the poor smallholder farmers (Dlamini and Huang, 2019b), fundamental in input solicitation (Duguma and Debsu, 2019).

Participating is cattle marketing relates to a 22% increase in the chances of improving the herd size, significant at $p<0.01$. This reveals the potential of agricultural markets in creating a production pull-force for cattle production. Market engagement depends on the rate of off-take, which indicates a 67% decline in herd size for a unit increase ($p<0.05$). Off-take includes cattle slaughters and sales (Enkono *et al.*, 2013) that deplete herd size as farmers liquidate marketable surplus to meet immediate family cash needs.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The major findings of the study revealed significantly lower productivity, levels of input use, farm output performance, market participation and off-take rate for female farmers compared to males. Significantly more males, compared to females, keep hybrid cattle, benefiting from heterosis effect for improved productivity. Moreover, significantly more males earn non-farm income, inducing higher levels of input use compared to female farmers. The results further indicate lower levels of access to farm credit and cooperative membership by farmers, undercutting farm productivity and market performance. The subsector is male-dominated, with significantly more educated males compared to female farmers. The significant socio-economic determinants of cattle production include gender, farmers' experience and farm location. Institutionally, the number of extension visits revealed association with herd size. Level of input use, invested capital and labor, significantly influence herd size. Market participation was revealed to be a production pull-factor in cattle farming, while off-take rate indicated negative association with herd size.

Recommendations for policy

Synthesis of the findings suggests a strong need for institutional support for females to improve their productivity and competitiveness in beef cattle farming. This is imperative in bridging the gender-based poverty disparity in rural areas, contributing to the food security and poverty alleviation for all. Policy adjustments on strengthening extension services and access to farm credit are also recommended for improved beef cattle farming. Redressing cooperativism is suggested to stimulate a cooperated production and marketing system that advances intensive production, establishing an organized production-marketing system that allows for meaningful welfare gains for farmers.

Recommendation for further research

Further empirical enquiry on access to farm credit and adoption of agricultural cooperatives is integral for the development of an institutionally supported and organized production-market policy framework. This will provide the basis for institutional funding of farmers to improve farm productivity, thus amelioration of rural livelihoods through cattle farming. Further research on production efficiency is recommended to improve farm productivity, farmers' income and rural livelihoods.

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