South African Journal of Animal Science 2023, 53 (No. 1)

Assessing the efficiency of smallholder wool farmers in the changing paradigms of the Free State province of South Africa

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(Submitted 29 June 2022; Accepted 23 January 2023; Published 11 April 2023)

Abstract

The South African population is predicted to increase to almost 66 million by 2030. This necessitates paradigm shifts to improve agricultural efficiency. However, South African wool production has continuously declined over the past three decades. The study analysed the efficiency of smallholder wool farmers and identified the determinants of technical inefficiency in wool production in Thaba 'Nchu and Botshabelo in the Mangaung Metro (Free State province, South Africa). A multistage sampling technique was used to select 351 participants. A stochastic frontier model was employed to analyse the efficiency of wool farmers. The results indicate that increases in feed and veterinary costs negatively affect the efficiency of smallholder wool production. Wool quality and use of social media were found to have a negative and statistically significant influence on the variation in the inefficiency of wool production (i.e., as these variables increase, inefficiency decreases). Poor extension services and poorly managed farmers' associations increase the inefficiency of smallholder wool producers. Furthermore, only 7% of smallholder farmers were efficient, and most smallholder wool farmers were not producing at full capacity; there is thus much room to improve production. To increase the efficiency of smallholder wool production in Mangaung, it is recommended that farmers are trained to improve the quality of their wool and, consequently, increase the wool price. Further recommendations include improvement of extension services, better management of farmers' associations, production of feed by farmers, and utilisation of free, government-supplied veterinary services.

Keywords: inefficiency estimates, stochastic frontier analysis, technical efficiency, wool productivity
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Introduction

Wool farming plays an important role as a main source of livelihood for many smallholder farmers in South Africa (Meissner *et al*., 2013). However, there has been a continuous decline in national wool production over the past three decades, which has become a serious challenge for the South African government (Cape Wools SA, 2019). The National Wool Growers Association (NWGA), with support from the Department of Agriculture, Forestry, and Fisheries (DAFF) as well as the Agricultural Research Council (ARC), ran a development programme that primarily operated in the communal areas of the former Ciskei, Transkei, and Free State. The programme focused on the improvement of communal herds through the provision of quality rams as breeding stock; wool production, storage, and marketing training; and provision of resources, such as equipment and shearing sheds that are in line with industry standards (Aucamp, 2007).

The South African population is predicted to increase to almost 66 million by 2030 (World Population Review, 2022). This increase in population induces industrial growth and requires changes in paradigms to cater for the growing human demand for agricultural products (including wool). Byerlee *et al*. (2009) argue that part of the change in paradigm that is needed is recognition of agriculture's multiple functions in supporting development in the emerging context, including triggering economic

URL: http://www.sasas.co.za
ISSN 0375-1589 (print), ISSN 2221-4062 (online)
Publisher: South African Society for Animal Science http://dx.doi.org/10.4314/sajas.v53i1.14

growth, being integral to environmental sustainability, and narrowing income disparities. Farmers are required to utilise modern technology and farming practices to increase productivity and to help improve their efficiency (Asefa, 2011).

Previous research has examined farm-level efficiency and productivity in wool production (Fraser & Hone, 2001), returns and economic efficiency of sheep farming in semi-arid regions (Suresh *et al*., 2008), determinants of profit efficiency among smallholder sheep farmers (Nyam *et al*., 2021), and efficiency analysis of small-scale wool production in the former Transkei (Haese *et al*., 2001). However, there is a dearth of research conducted on the efficiency of smallholder wool farming in the Mangaung area – specifically Thaba 'Nchu and Botshabelo – in the Free State province of South Africa. This lack of evidence on the efficiency levels of smallholder wool farmers in the different sheep production systems limits policymaking for the optimal allocation of resources to improve the efficiency of wool farming in these areas. The purpose of this study was to analyse the determinants of technical efficiency of smallholder wool production in the Mangaung Metropolitan area of South Africa.

Materials and Methods

The study was located in Thaba 'Nchu and Botshabelo in the Mangaung Metropolitan Municipality area. Botshabelo is located approximately 55 km to the east of Bloemfontein along the N8. Thaba 'Nchu is situated approximately 12 km further to the east of Botshabelo. Most of the land in the Thaba 'Nchu and Botshabelo rural areas is state-owned, with approximately 37 rural villages located on trust land under traditional leadership. The Mangaung area consists of Karoo Supergroup geology, with grasslands being the dominant vegetation type. The area has a high production potential for wool farming. The main source of rural water supply is groundwater (Mangaung Metropolitan Municipality, 2020). Figure 1 shows a map of Mangaung Metropolitan Municipality, including Thaba 'Nchu and Botshabelo, where the study was conducted.

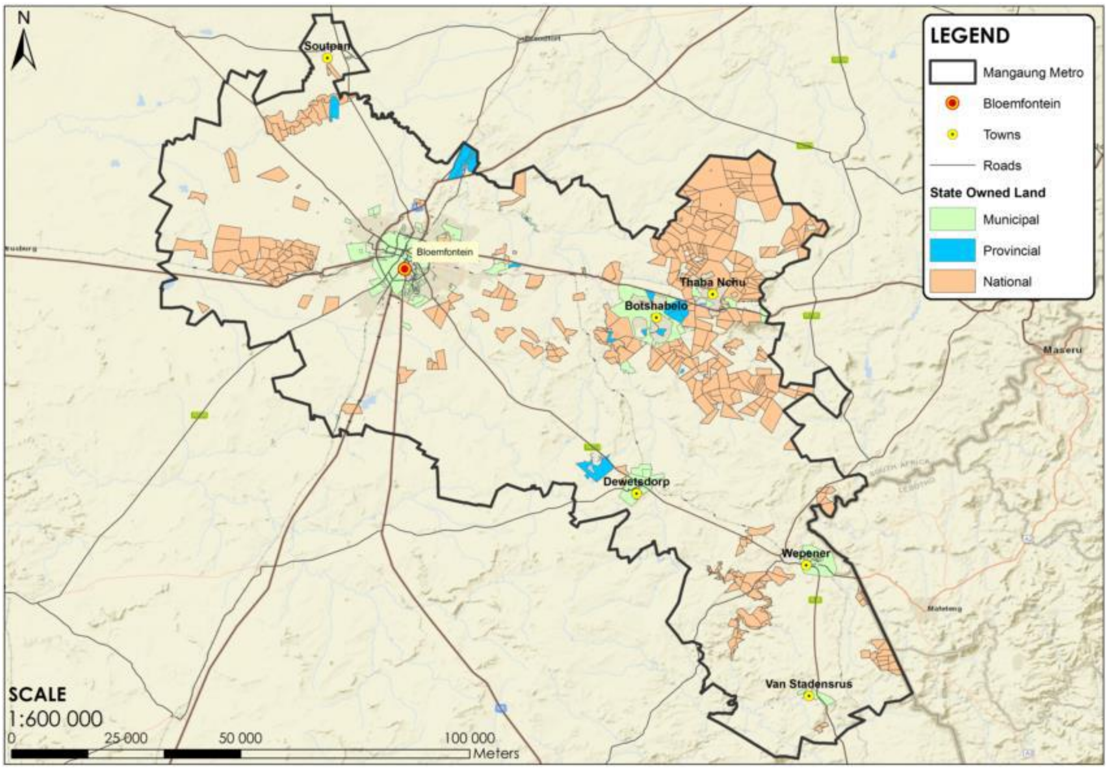

Figure 1 Mangaung Metropolitan Municipality map (Mangaung Metropolitan Municipality, 2020, p. 13).

A multistage sampling technique was employed to select the respondents. The first stage involved a purposive selection of the Mangaung district based on the predominance of wool or sheep farmers. In the second stage, Thaba 'Nchu and Botshabelo wards were purposively selected based on the preponderance of wool farmers. The third stage involved a simple random sampling of wool farmers. This type of sample technique mean that each subject of the sampling frame has an equal probability of being selected (Etikan & Bala, 2017).

A subset of a larger group is called a population (Fink, 2003). The minimum sample size that was to be analysed was 319 small-scale farmers, which is 17.2% of the population (1847) of small-scale farmers in Mangaung. A sample size calculator from the Raosoft website (Raosoft, 2004) was used to determine the sample size needed in order to be able to generalise findings to the population. A total of 351 smallholder wool farmers were interviewed in a conducive environment such as community hall and shearing sheds. The environment allowed free exchange of ideas, thoughts, and information among the enumerators and farmers to enable successful data collection by considering the physical, psychological, social, and cultural needs of all the farmers.

The respondents were randomly selected based on being small-scale wool farmers (decision makers) in Thaba 'Nchu and Botshabelo. According to Lindner *et al*. (2001), procedures for control of non-response errors are not necessary when a response rate is above 85%. For this study the response rate achieved was 100%, since the enumerators were filling in the questionnaires on behalf of the farmers. Data was collected from November 2021 to February 2022.

The study used a quantitative research design and conducted cross-sectional surveys. An exploratory survey that applied both questionnaires and interviews was utilised. The questionnaire was created using the Evasys software. In order to adopt an efficient way of working, the questionnaire was transformed into both web survey and hard copies (Best and Krueger, 2008). Primary data were collected using semi-structured questionnaires. All 351 respondents were interviewed, and their answers were recorded on the questionnaire by the enumerators. The questionnaire was 40 minutes long but not limited to that time.

A stochastic frontier analysis (SFA) framework was employed in assessing the technical efficiency of wool production in the study area. The conventional SFA function of wool production is expressed in Equation (1):

$$Q_i = f(h_i;\beta)\exp(v_i - u_i) \tag{1}$$

where Q_i represents the quantity of wool produced by the i^{th} farm (*i = 1, 2, …N*), h_i represents a *(1xk)* vector of production inputs of the i^{th} farm, and β is a *(kx1)* vector of unknown parameters to be assessed. As posited by Aigner *et al*. (1977), v_i represents the stochastic noise, which is symmetrically distributed with a mean of zero and unknown variance, $N(0,\sigma_v^2)$. In the same vein, u_i are non-negative random variables that are accountable for technical inefficiency of farmers in production (Battese &Coelli 1995).

According to the production frontier function as indicated in Equation (1), this study outlines the technical efficiency of the i^{th} wool farm as the ratio of the observed wool average output, in line with the production inputs (x_i) and its hypothesised technical inefficiency (u_i), vis-à-vis, conforming possible output if the technical inefficiency effect does not exist ($u_i = 0$) in wool production. The technical efficiency of an i^{th} farm can thus be specified as:

$$TE_i = \frac{f(Q_i / u_i, h_i)}{f(Q_i / u_i = 0, h_i)} = \exp(-v_i) \tag{2}$$

where TE_i shows a technical efficiency score which is restricted within the interval (0, 1). A value of 1 indicates a fully technically efficient farm and a value of 0 indicates a fully technically-inefficient farm. This study follows the method of Caudill and Ford (1993) to parameterise the variance of the pre-truncated inefficiency error term, u_i. Following Kumbhakar and Lovell (2000), the parameterisation was explored to ascertain how socioeconomic and policy factors affect the performance of wool farmers. The inefficiency effect (u_i) can be specified as:

$$u_i = k_i\delta + p_i \tag{3}$$

where k_i is *(mx1)* vector of independent variables elucidating technical inefficiency of wool farmers, δ is *(1xm)* vector of parameters to be estimated, and p_i is an error term of the inefficiency effect.

Results and Discussion

Approximately 80.7% of the smallholder wool farmers in Thaba 'Nchu and Botshabelo reside on communal/tribal land. The results showed that the Woodbrigde and Yorksford communal areas have the highest numbers of smallholder wool farmers in the east of Bloemfontein (16.8% and 10.5%, respectively). Most of these farmers speak Sesotho (47.6%), followed by Setswana (29.4%). A substantial number (40%) of these farmers are aged between 36 and 59 years, followed by 60 years and older, which accounts for 31.7% of all farmers in the area in which the study was conducted. The smallholder wool farming industry in Thaba 'Nchu and Botshabelo is dominated by males, who constitute almost two-thirds of the farmers in these two areas. This is indicative of the need to recruit more females into wool farming.

The efficiency of smallholder wool farmers' production is influenced by different factors. It must be noted that the respective sample normalised all the output and input value means in order to enable the researcher to explain the first-order coefficients as partial elasticities, as suggested by Coelli *et al.* (2005). Feed cost (logFeedcost) and veterinary cost (logVeterinarycost) have partial production elasticities of -0.21 and -0.18, respectively (Table 1). These results imply that if feed and veterinary costs are each increased by 100%, the corresponding cost would decrease output by 21% and 18%, respectively. Therefore, increases in feed and veterinary costs negatively affect the efficiency of smallholder wool production. The sum of the first-order elasticities of the production inputs was -0.54, suggesting that an average farm from the study area experiences an increasing return-to-scale. Thus, if all the costs were jointly decreased by 100%, wool production would increase by 54%. Adu *et al.* (2013) and Danso-Abbeam *et al.* (2012) observed similar findings in Ghana's maize and cocoa industries.

Table 1 Stochastic frontier analysis of the efficiency of wool production in the Free State province of South Africa

Lnwooloutput	Coefficient	Standard error	*P*-value	Significance
logLabourcost	-0.139	0.108	0.197	
logFeedcost	-0.210	0.087	0.016	**
logVeterinarycost	-0.186	0.100	0.064	*
logOperatingcost	-0.071	0.110	0.518	
Constant	5.552	0.946	0.000	***
Inefficiency model				
Business ownership	-2.698	2.645	0.308	
Access to printed media	1.939	1.410	0.169	
Non-farm income	2.721	1.590	0.087	*
Piece jobs	2.781	2.136	0.193	
Highest level of education	0.308	0.970	0.751	
Access to information	9.023	4.704	0.055	*
Farmers' associations	3.133	1.852	0.091	*
Quality of wool	-2.742	1.574	0.082	*
Social Media	-6.327	3.792	0.095	*
What is your age	-2.237	1.391	0.108	
Source of income	-0.708	0.688	0.304	
Extension services	6.308	3.784	0.096	*
Access to grazing land	12.981	8.194	0.113	
Access to TV	0.742	0.813	0.362	
Constant	-63.231	35.724	0.077	*
Mean efficiency score	**0.95**			
Mean dependent var	4.122			
Prob > Chi^2	0.011			
Akaike crit. (AIC)	959.751			
Chi-square	12.994			
lnsig2v	0.354	0.0842	0.0000	***
sigma_v	1.194	0.050		

*** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$

The estimated coefficients of the determinants of technical inefficiency among wool farmers in the study area are also reported in Table 1. It was important that the variables used in the model represent the factors influencing technical inefficiency. Hence, a negatively signed variable increases farmers' technical efficiency and *vice versa*. Identifying these sources of technical inefficiency is imperative for effective policymaking.

The coefficient of non-farm income is positive and significant (Table 1). This implies that the more non-farming income smallholder wool farmers get, the more inefficient their wool production is likely to be. This can be attributed to farmers investing more time in other income-generating activities to the detriment of wool production. Non-farming income was derived from the following sources: 57.3% of the farmers indicated that they received social grants, 34.1% received an old-age pension, 30.3% earned monthly salaries from paid employment, 40.3% earned income from piece jobs, 15% generated income through their own business (other than farming), while others received money from their family members. This non-farming income was found to have an inverse relationship with the efficiency of smallholder wool production.

The results also indicated that the variables for poor extension services and poorly managed farmers' associations (which provide farmers with agriculture-related information to support decision-making) have positive coefficients and are significant. The poorer the extension services rendered to smallholder wool farmers, the higher the probability of inefficiency of farmers' production, a finding supported by Zewdie *et al.* (2021). Similarly, when farmers' associations were poorly managed, the inefficiency of smallholder wool production increased. These results indicate that there is a need for improved extension services and better management of farmers' associations in order to improve the efficiency of smallholder wool production in Thaba 'Nchu and Botshabelo.

The results from Table 1 indicate that the coefficient of wool quality is negative and has a statistically significant influence on the variation in the efficiency of wool production. This implies that the better the quality of wool, the higher the probability of production efficiency (i.e., inefficiency decreases). This can be attributed to the fact that better wool quality means a better wool price and increased farming income. Most (66.6%) of the smallholder farmers in the study indicated that the quality of the wool they produce is extremely important, while 2% of farmers indicated that they do not consider the quality of wool to be important at all (Table 2). This shows that there is a need to educate farmers on the importance of wool quality in terms of the overall efficiency of their wool production.

Table 2 Smallholder farmers' perceptions of wool quality

		Frequency	Percent
Valid			
	Not important at all	7	2,0
	Slightly important	5	1,4
	Important	57	16,4
	Fairly important	38	11,0
	Extremely important	231	66,6
	Total	338	97,4
Missing	System	9	2,6
Total		347	100,0

The results indicate that the coefficient of social media is negatively signed and has a statistically significant influence on the variation in the efficiency of wool production. This implies that increased access to information through social media improves the efficiency of wool production. This is not unexpected, as social media is a medium through which valuable industry-related information – such as different production techniques and marketing information – can be shared, which supports farmers in producing wool more efficiently. The most frequently used means of communication utilised in making farming decisions was the cellular phone. This finding aligns with a study by Nyam *et al*. (2021), who also found a positive relationship between access to information via extension and the technical efficiency of sheep production in South Africa. The smallholder wool farmers in Thaba 'Nchu and Botshabelo use their cellular phones to communicate by means of phone calls, SMSs, and text messages on applications such as Facebook, WhatsApp, and Telegram. Approximately 43.8% of the farmers indicated that they use their cell phones daily. However, most farmers (56.2%) indicated that they never use WhatsApp or Telegram groups to assist in farm management. This might be due to the fact that half of the farmers do not have cell phones and most of the communal areas have poor or no internet connection.

Figure 2 shows the technical efficiency scores for the sampled wool farmers in the study area. The technical efficiency scores ranged between 0.12 and 1.00, with a mean efficiency of 0.95. The average technical efficiency score of 0.95 suggests that the average wool farm in the sample requires ~5% additional resources to get to the frontier. In other words, wool producers in the study lost an average of 5% of output due to technical inefficiency. These results are comparable with those found in a study by Danso-Abbeam *et al.* (2017) on the adoption of agrochemical management practices among smallholder farmers in Ghana, where they found mean efficiency scores of 0.91 and of 0.83 for both adopters and non-adopters of agrochemicals, respectively.

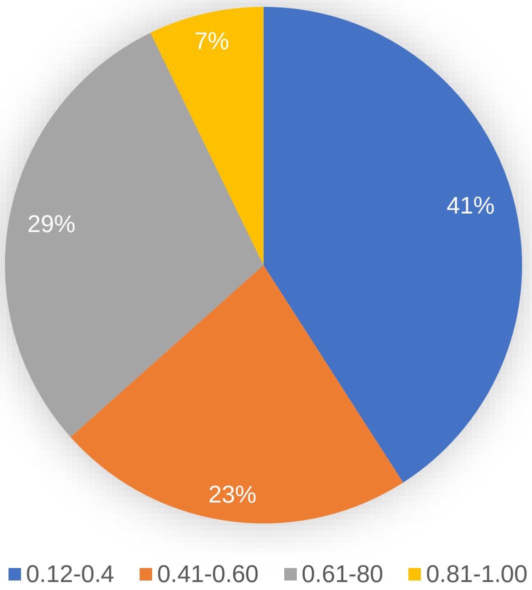

Figure 2 Percentage distribution of wool farmer efficiency scores

According to Farrell (1957), a farm is technically efficient if it has the ability to obtain maximal output from a set of inputs, given the production technology. Approximately 7% of smallholder wool production farms in this study were found to be efficient, with scores ranging between 0.81 and 1. The inefficiency of the majority (93%) of the farms was due to a lack of skills (particularly shearing and wool classing skills) and lack of resources. Most of the smallholder wool farmers in Thaba 'Nchu and Botshabelo do not know how to classify their wool correctly and other farmers are not using the recommended packaging. Most farmers do not have proper shearing sheds, which means they shear their sheep in an environment that is not conducive to effective shearing and classing of wool. Furthermore, when farmers do not have a market for their wool or safe and clean storage facilities, they sell it to local traders at very low prices. These factors all lead to the production of poor-quality wool, low selling price, and thus low income. An initiative that demonstrated how these factors could be addressed is the development programme that was ran by the NWGA (with support from DAFF and ARC), which has helped to improve the efficiency of smallholder wool production through supporting farmers in more effective wool marketing, genetic improvement of flocks, better animal nutrition, training farmers in production management, and providing marketing support (Aucamp, 2007).

Conclusions

The purpose of this study was to analyse the efficiency of smallholder wool farmers and identify the determinants of technical inefficiency in wool production in Thaba 'Nchu and Botshabelo. The results indicate that poor extension services and poorly managed farmers' associations increase the inefficiency of smallholder wool production. Furthermore, 93% of the smallholder wool farmers in Thaba 'Nchu and Botshabelo were inefficient. Additionally, wool quality and the use of social media are positively related to the efficiency of wool production. These findings support the notion that most smallholder wool farmers are not producing at full capacity and have much room for improving their wool production. Therefore, the study recommends that smallholder wool farmers are trained in the correct methods to improve wool quality and, consequently, increase the wool price they can obtain. The study also recommends the improvement of extension services, better management of farmers' associations, production of feed by farmers, and utilisation of free government-supplied veterinary services to improve the overall efficiency of smallholder wool production in Thaba 'Nchu and Botshabelo.

Acknowledgements

The authors would like to express sincere gratitude and appreciation to the Regional Universities Forum for Capacity Building in Agriculture and National Research Foundation for funding the study. The authors are grateful to extension officers, smallholder farmers, and enumerators for assistance in data collection.

Authors' Contributions

ADN (ORCiD: 0000-0001-5614-0123) collected data, analysed the data, interpreted the results, and wrote the manuscript. JWS (ORCiD: 0000-0002-0812-2657) and AEN (ORCiD: 0000-0002-3764-1683) designed and assessed the study. TOO (ORCiD: 0000-0002-3517-0435) analysed the data and assisted with methodology.

Conflict of Interest Declaration

The authors declare that they have no conflict of interest.

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