

A CLIP COMPOSITION CASE  
STUDY OF COMMUNAL  
WOOL PRODUCTION  
IN THE EASTERN  
CAPE, SOUTH  
AFRICA

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A CLIP COMPOSITION CASE STUDY OF  
COMMUNAL WOOL PRODUCTION IN  
THE EASTERN CAPE,  
SOUTH AFRICA

By

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# **DECLARATION**

I, Susanna Maria Dreyer, student number 212255096, hereby declare that this dissertation for the degree of Master in Agriculture to be awarded is my own work, except where explicitly stated otherwise in the text, and that this work has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

**Susanna Maria Dreyer**

# ABSTRACT

Susanna Maria Dreyer: A clip composition case study of communal wool production in the Eastern Cape, South Africa.

Under the mentorship of: Louis du Pisani  
Retief Celliers  
Antonie Geyer

Previous studies conducted on wool production in the communal areas of the Eastern Cape have concluded future research should focus on whether the observed differences in average wool price received between shearing sheds are due to differences in clip preparation (i.e. classing) or differences in the quality of the wool being produced (i.e. genetics). The objective of this study was to establish whether there are indeed geographical differences in the average wool price received by communal wool producers in the Eastern Cape and, if so, whether this difference in earnings is attributable to differences in the quality of wool produced and/or clip preparation.

The current research explored eight years of wool production records of communal wool farmers (2009/10 to 2016/17) obtained from BKB, the largest wool broker in South Africa. Statistical analyses included descriptive statistics, analysis of variance, parametric tests (i.e. t-test) and multiple regression analysis. The conclusions drawn from this study are: (1) that there are indeed statistically significant differences in the average wool price received between the different geographic areas of the Eastern Cape communal regions, and (2) that the primary determining factor is wool quality, while (3) clip preparation also plays an important but secondary role.

The study identified specific geographic areas where developmental interventions are most critical, with specific emphasis on improving the genetic composition of the wool sheep flocks. Specific strategies are recommended, namely: (1) Removing inferior-quality rams and replacing them with superior-quality rams to prevent any inferior nondescript rams from breeding and producing progeny; (2) Replacing the inferior-quality nondescript ewes in specific areas with superior-quality ewes, and (3) Improving the survival rate of lambs and thereby contributing towards expediting the rate of genetic improvement of the communal wool sheep flocks.

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# **DEDICATION**

I dedicate this dissertation to my late father, JOHANNES ALBERTUS VAN ROOYEN, and late father-in-law, ANTON DREYER, who would have been extremely proud of this academic achievement.

# TABLE OF CONTENTS

|   |          |
|---|----------|
| DECLARATION .....                                 | i        |
| ABSTRACT .....                                    | ii       |
| ACKNOWLEDGEMENTS .....                            | iii      |
| DEDICATION .....                                  | iv       |
| GLOSSARY OF TERMS SPECIFIC TO THE WOOL TRADE..... | xi       |
| <br>  |          |
| <b>CHAPTER 1: INTRODUCTION .....</b>              | <b>1</b> |
| 1.1 Background to the study .....                 | 1        |
| 1.2 Rationale for the study .....                 | 3        |
| 1.3 Significance of the study .....               | 3        |
| 1.4 Problem statement.....                        | 4        |
| 1.5 Research aims and objectives.....             | 5        |
| 1.6 Research questions .....                      | 5        |
| 1.7 Hypothesis of the study .....                 | 6        |
| 1.8 Limitations and delimitations .....           | 6        |
| 1.9 Summary .....                                 | 7        |
| <br>  |          |
| <b>CHAPTER 2: LITERATURE REVIEW .....</b>         | <b>8</b> |
| 2.1 Introduction.....                             | 8        |
| 2.2 Historic background to communal areas.....    | 8        |
| 2.3 Wool production in the communal areas .....   | 9        |
| 2.4 Institutional constraints and challenges..... | 11       |
| 2.5 The study area .....                          | 13       |
| 2.5.1 Location and land area .....                | 13       |
| 2.5.2 Climate .....                               | 13       |

|   |           |
|---|-----------|
| <b>2.5.3 Landscape and vegetation .....</b>                   | <b>14</b> |
| 2.5.3.1 <i>The forest biome .....</i>                         | 17        |
| 2.5.3.2 <i>The thicket biome .....</i>                        | 17        |
| 2.5.3.3 <i>The savannah biome .....</i>                       | 18        |
| 2.5.3.4 <i>The grassland biome .....</i>                      | 18        |
| <b>2.6 Marketing channels for communal wool growers.....</b>  | <b>19</b> |
| <b>2.7 The potential of wool production .....</b>             | <b>21</b> |
| <b>2.8 Key physical attributes of grease wool .....</b>       | <b>22</b> |
| 2.8.1 Fibre diameter .....                                    | 22        |
| 2.8.2 Variation in fibre diameter.....                        | 22        |
| 2.8.3 Clean yield .....                                       | 23        |
| 2.8.4 Tensile strength .....                                  | 23        |
| 2.8.5 Staple length .....                                     | 23        |
| 2.8.6 Variation in staple length .....                        | 24        |
| 2.8.7 Vegetable matter content.....                           | 24        |
| 2.8.8 Hauteur .....   | 24        |
| 2.8.9 Style.....  | 25        |
| 2.8.10 Greasy colour.....                                     | 25        |
| 2.8.11 Breed .....  | 26        |
| <b>2.9 Heritability of wool attributes .....</b>              | <b>26</b> |
| 2.9.1 Heritability of fibre diameter .....                    | 28        |
| 2.9.2 Heritability of staple length and tensile strength..... | 28        |
| 2.9.3 Heritability of variation in fibre diameter .....       | 28        |
| <b>2.10 Summary .....</b>                                     | <b>29</b> |
| <br>  |           |
| <b>CHAPTER 3: RESEARCH METHODOLOGY AND DESIGN.....</b>        | <b>30</b> |
| 3.1 Introduction.....   | 30        |
| 3.2 Research design .....                                     | 30        |
| 3.3 Research population and sampling .....                    | 32        |

|   |  |           |
|---|--|-----------|
| <b>3.4</b>                                      | <b>Data collection .....</b>   | <b>32</b> |
| <b>3.5</b>                                      | <b>Data manipulation .....</b>   | <b>33</b> |
| <b>3.5.1</b>                                    | <b>Stratification of numerical data .....</b>  | <b>34</b> |
| 3.5.1.1   | <i>Grease price .....</i>  | <i>34</i> |
| <b>3.5.2</b>                                    | <b>Stratification of categorical data .....</b>  | <b>35</b> |
| 3.5.2.1   | <i>Geographic regions .....</i>  | <i>35</i> |
| 3.5.2.2   | <i>Breed.....</i>  | <i>36</i> |
| 3.5.2.3   | <i>Clip composition .....</i>  | <i>37</i> |
| 3.5.2.4   | <i>Style .....</i>   | <i>37</i> |
| <b>3.6</b>                                      | <b>Statistical methods applied .....</b>   | <b>38</b> |
| <b>3.6.1</b>                                    | <b>Descriptive statistics .....</b>  | <b>38</b> |
| 3.6.1.1   | <i>Measures of central tendency .....</i>  | <i>38</i> |
| 3.6.1.2   | <i>Measures of variability .....</i>   | <i>39</i> |
| <b>3.6.2</b>                                    | <b>Hypothesis testing.....</b>   | <b>40</b> |
| 3.6.2.1   | <i>Formulating the null and alternative hypotheses .....</i>   | <i>41</i> |
| 3.6.2.3   | <i>Computing the test statistic .....</i>  | <i>42</i> |
| <b>3.6.3</b>                                    | <b>Multiple regression analysis .....</b>  | <b>43</b> |
| <b>3.6.4</b>                                    | <b>Analysis of variance .....</b>  | <b>46</b> |
| <b>3.7</b>                                      | <b>Model validation.....</b>   | <b>47</b> |
| <b>3.7.1</b>                                    | <b>Method of least squares .....</b>   | <b>47</b> |
| <b>3.8</b>                                      | <b>Summary .....</b>   | <b>50</b> |
| <br><b>CHAPTER 4: FINDINGS AND RESULTS.....</b> |  | <b>51</b> |
| <b>4.1</b>                                      | <b>Introduction.....</b>   | <b>51</b> |
| <b>4.2</b>                                      | <b>Research question 1: Are there statistically significant differences in price levels achieved by the five NWGA production regions?.....</b> | <b>51</b> |

|   |   |           |
|---|---|-----------|
| <b>4.3</b>  | <b>Research question 2: What are the contributing factors to the observed differences in price levels among the NWGA regions?.....</b>                      | <b>54</b> |
| 4.3.1   | Breed .....   | 58        |
| 4.3.2   | Style .....   | 59        |
| 4.3.3   | Mean fibre diameter.....  | 60        |
| 4.3.4   | Vegetable matter base .....   | 62        |
| 4.3.5   | Variation in fibre diameter.....  | 63        |
| 4.3.6   | Clean yield percentage .....  | 65        |
| 4.3.7   | Hauteur .....   | 68        |
| 4.3.8   | Variation in staple length .....  | 70        |
| 4.3.9   | Mean staple length .....  | 72        |
| 4.3.10  | Tensile strength .....  | 75        |
| <b>4.4</b>  | <b>Research question 3: Can the observed differences be attributed to the genetic composition of the sheep? .....</b>                                       | <b>77</b> |
| <b>4.5</b>  | <b>Research question 4: Can the observed differences be attributed to the standard of wool classing practices applied by the shearing communities?.....</b> | <b>79</b> |
| <b>4.6</b>  | <b>Summary .....</b>  | <b>80</b> |
| <br><b>CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS .....</b> |   | <b>81</b> |
| 5.1   | Introduction.....   | 81        |
| 5.2   | Discussion .....  | 81        |
| 5.3   | Future studies .....  | 82        |
| 5.4   | Recommendations .....   | 82        |
| <b>APPENDIX .....</b>                                       |   | <b>84</b> |
| <b>REFERENCES .....</b>                                     |   | <b>87</b> |

## LIST OF FIGURES

|                     |  |    |
|---------------------|--|----|
| <b>Figure 2.1:</b>  | The study area – Communal areas of the former homeland Transkei and Ciskei regions in the Eastern Cape Province .....    | 12 |
| <b>Figure 2.2:</b>  | The Köppen climate classification zones within the study area .....  | 15 |
| <b>Figure 2.3:</b>  | Mean annual rainfall over study area .....   | 15 |
| <b>Figure 2.4:</b>  | Marketing channels available to communal and commercial wool growers .....   | 20 |
| <b>Figure 3.1:</b>  | The National Wool Growers Association's service regions .....  | 36 |
| <b>Figure 3.2:</b>  | Scatter diagram depicting residuals vs predicted values from the regression equation.....                                | 49 |
| <b>Figure 3.3:</b>  | Scatter diagram depicting observed vs predicted values .....   | 49 |
| <b>Figure 4.1:</b>  | Mean grease price across all breed and wool categories per NWGA region .....   | 52 |
| <b>Figure 4.2:</b>  | Pareto chart showing the relative importance of the independent explanatory variables in the logit regression model..... | 56 |
| <b>Figure 4.3:</b>  | Regional breed composition of the study area.....  | 58 |
| <b>Figure 4.4:</b>  | Regional style composition of the study area .....   | 59 |
| <b>Figure 4.5:</b>  | Population means of mean fibre diameter per NWGA region .....  | 61 |
| <b>Figure 4.6:</b>  | Population means for coefficient of variation in fibre diameter per NWGA region .....                                    | 64 |
| <b>Figure 4.7:</b>  | Population means of clean yield per NWGA region .....  | 66 |
| <b>Figure 4.8:</b>  | Population means associated with the estimated hauteur per NWGA region .....   | 69 |
| <b>Figure 4.9:</b>  | Population means associated with staple length coefficient of variation .....  | 71 |
| <b>Figure 4.10:</b> | Population means associated with mean staple length per NWGA region.....   | 73 |
| <b>Figure 4.11:</b> | Population means associated with tensile strength per NWGA region .....  | 76 |

## LIST OF TABLES

|  |    |
|--|----|
| <b>Table 2.1:</b> Summary of vegetation biomes and veld types in the study area .....                                    | 16 |
| <b>Table 3.1:</b> Number of participating shearing communities per NWGA region .....                                     | 35 |
| <b>Table 3.2:</b> Dummy variables used to represent breed type .....   | 37 |
| <b>Table 3.3:</b> Dummy variables used to represent style category .....   | 38 |
| <b>Table 4.1:</b> One-way ANOVA table showing statistical parameters for mean grease price<br>per NWGA region.....       | 51 |
| <b>Table 4.2:</b> T-test scores and p-values comparing mean grease price of the NWGA regions.....                        | 53 |
| <b>Table 4.3:</b> Summary output of logit regression model.....  | 54 |
| <b>Table 4.4:</b> ANOVA table showing statistical parameters for mean fibre diameter .....                               | 60 |
| <b>Table 4.5:</b> T-test scores and p-values comparing mean fibre diameter.....  | 61 |
| <b>Table 4.6:</b> ANOVA table showing statistical parameters for mean coefficient of variation<br>in fibre diameter..... | 63 |
| <b>Table 4.7:</b> T-test scores and p-values comparing mean fibre diameter coefficient of variation .....                | 64 |
| <b>Table 4.8:</b> ANOVA table showing statistical parameters for clean yield .....                                       | 65 |
| <b>Table 4.9:</b> T-test scores and p-values comparing mean clean yield.....   | 67 |
| <b>Table 4.10:</b> ANOVA table showing statistical parameters for hauteur .....  | 68 |
| <b>Table 4.11:</b> T-test scores and p-values comparing hauteur .....  | 69 |
| <b>Table 4.12:</b> ANOVA table showing statistical parameters for variability in staple length .....                     | 71 |
| <b>Table 4.13:</b> T-test scores and p-values comparing mean fibre diameter coefficient of variation .....               | 72 |
| <b>Table 4.14:</b> ANOVA table showing statistical parameters for mean staple length.....                                | 73 |
| <b>Table 4.15:</b> T-test scores and p-values comparing mean staple length .....   | 74 |
| <b>Table 4.16:</b> ANOVA table showing statistical parameters for tensile strength.....                                  | 75 |
| <b>Table 4.17:</b> T-test scores and p-values comparing tensile strength.....  | 76 |
| <b>Table 4.18:</b> Genetically influenced wool characteristics.....  | 78 |
| <b>Table 4.19:</b> Wool characteristics determined by the degree of classing applied.....                                | 79 |

# GLOSSARY OF TERMS SPECIFIC TO THE WOOL TRADE

**Animal breeding:** Animal breeding involves selective breeding of animals with the intention to improve desirable (and heritable) qualities in the next generation.

**AWEX:** Australian Wool Exchange Ltd

**AWEX-ID:** AWEX-ID is an appraisal system created in Australia in 1995 as a method of appraising and recording the non-measured characteristics of greasy wool, using a logical coding system. The number of non-measured characteristics, appraised subjectively on any one sale lot or line of wool, is dependent upon: (1) the category of wool (such as fleeces, pieces, bellies, locks); and (2) the objectively measured test results. The system is often used by both buyers and sellers to assist in determining presale valuations on sale lots. A full and credible description for greasy wool is possible by combining the AWEX-ID system with presale objectively measured wool attributes.

**Back wool:** Wool shorn from the back of a sheep that deviates in appearance, quality and vegetable matter (VM) contamination from the rest of the fleece. Back wool is inclined to be weathered and brittle.

**Bellies and pieces:** Wool removed from the belly area of the sheep and portions removed from the fleece that deviate from the overall characteristics of the fleece.

**BKB Limited:** Foremost wool brokering organization in South Africa.

**Broken fleeces:** Neck-fold wools, breech wool or portions of the fleece containing excessive vegetable matter.

**Carbonising:** Carbonising is a chemical process used to remove vegetable matter (VM) from grease wool. It is a costly process which is used when grease wool contains a high VM percentage, typically 2% and more, which cannot be removed by mechanical methods.

**Carding:** A technique whereby teathed cards are used to separate the fibres, to spread them into a web (not in parallel lines as in combed wool) and to remove any short fibres as well as impurities. This process disentangles and intermixes fibres to produce a continuous web or sliver suitable for subsequent processing. Also see **Carding wool types**.

**Carding waste:** See **Noil**.

**Carding wool types:** Wool suitable for the woollen system of yarn production whereby wool is carded but not combed. It is shorter (less than 40mm) than combing or worsted trade wools.

**Character:** Clarity and evenness of the crimp or wave in a staple of wool.

**Classing:** See **Grading**

**Clean price:** Clean price is based primarily on value-determining characteristics that determine the end use of the raw fibre. The two most important factors in value determination are fibre diameter and length. Characteristics that also affect clean price, but to a lesser extent, are uniformity, fibre strength, colour, crimp definition, softness and certain contaminants, such as the amount and type of vegetable matter and non-scourable branding paint. To determine grease price, a measure of yield is necessary (also see **Grease price**).

**Clean yield:** The amount of usable clean wool that is derived from greasy wool after scouring, expressed as a percentage. Raw wool contains 30% or more in weight of impurities in the form of waxes, suint, vegetable matter and dirt. See also **Schlumberger dry clean yield**.

**Clip:** The total amount of wool shorn from a particular flock or from flocks in a particular region or country, in one growing season.

**Coefficient of variation:** The coefficient of variation (CV) is a measure of relative variability. It is the standard deviation (SD) expressed as a percentage of the mean.

**Coefficient of variation in fibre diameter:** An objective measurement that describes the spread of fibre diameters found in a distribution.

**Coefficient of variation in staple length:** An objective measurement that describes the spread of staple length found in a distribution.

**Combing:** A technique whereby fibres are passed through a series of straight metal teeth to lay the fibres parallel to one another. The fibres are then placed together in a long line, called a combed sliver, which is used to spin a smooth, even thread. During this process, long fibres are separated from shorter ones (noils) and tangles are removed. At the same time, practically all remaining foreign matter is removed from the fibres.

**Combing wool:** Wool suitable for conversion to yarn on the worsted system. Generally, fibres with a staple length of 40mm or longer. Also see **Worsted system**.

**Contamination:** Contamination can be classified as being of wool or non-wool origin. Wool origin contamination takes the form of urine-stained, pigmented and medullated fibres. Contamination of non-wool origin includes vegetable matter and other animal fibres (e.g. dog or horse hair, alpaca fibre), as well as man-made products such as nylon wool packs, polypropylene, plastic, other yarns and fabrics.

**Crimp:** The natural waviness of the wool fibre. It varies with the diameter of the fibre; the finer the wool, the closer the crimp or wave formation.

**Crimp definition:** Relates to how well-defined and even the crimps are (also referred to as character).

**Crimp frequency:** The number of crimp waves per centimeter of staple length.

**Density:** Refers to the number of fibres per square unit measurement of the sheep's body.

**Double cuts:** Short snippets of wool that were cut twice by the shearer.

**Duerden Standard:** Refers to the relationship between fibre diameter and number of crimps per inch (25mm). The number of crimps per inch increases as fibre diameter decreases.

**Fault:** Unwanted traits in greasy wool which result in discounts applied to the price of wool. Faults such as contamination with vegetable matter, deviating fibres or a break in the wool result in a decrease in grease price.

**Fibre:** A single strand of wool within a staple.

**Fibre diameter:** Refers to fineness and is a measurement of thickness of the individual fibres, measured in microns.

**Fleece weight:** The weight of the entire raw fleece shorn from the sheep.

**Fleece wool:** The portion of the fleece that remains after the backs, broken fleeces, bellies and pieces and locks have been removed.

**Grading:** Wool fleeces differ in many measurable characteristics such as fibre diameter, yield percentage, staple length, tensile strength, colour and vegetable matter contamination. The process of grouping fleeces according to any or all of these characteristics is called grading. (Also referred to as classing)

**Grease or greasy wool:** Raw wool in its natural state before scouring.

**Grease price:** Grease price is calculated by multiplying the clean price with the yield percentage. The formula is as follows: **Clean Price x Yield = Grease Price.**

**Handle or handling:** Refers to the tactile sensation of wool when a wool technician manually handles it. Fine wool has a soft handle while a harsh handle indicates coarser wool.

**Hauteur:** Hauteur is an estimation of the mean fibre length in the top. This estimation depends largely on the mean staple length and tensile strength of raw wool.

**IWTO:** Acronym for the International Wool Textile Organisation. The recognized global authority for standards in the wool textile industry. IWTO has represented the interests of the global wool trade since 1930.

**Kemp:** Chalky-white, brittle and weak fibre which does not accept dye due to its hollow structure.

**Locks:** Dung- and urine-stained wool, matted wool, double cuts and sweaty wool that are skirted from the fleece and packed separately.

**Lot, sale lot or line of wool:** Any number of wool bales, graded and prepared for sale as a single parcel in accordance with accepted trade specifications.

**Mean fibre diameter:** Refers to the mean fibre diameter (measured in micron) of a sale lot with individual fibres varying between less than 10 microns to more than 35 microns.

**Medullated fibres:** See **Kemp**

**Micron:** A unit of measurement equal to one thousandth of a millimeter.

**Natural selection:** The process whereby animals which are better adapted to their environment have a higher chance of survival and produce more offspring than less adapted animals. The next generation thus, on average, will be more adapted than the current generation.

**Newtons per Kilotex (nkt):** See **Tensile strength**

**Noil:** Refers to unwanted short fibres removed during the combing process in the production of the top. The percentage of noils will increase as tensile strength decreases.

**Nondescript breeds:** Sheep breed indigenous to the study area, developed through indiscriminate breeding and intermixing of different breeds.

**NWGA:** Acronym for the National Woolgrowers' Association

**Point of break (POB):** A measurement of the position along the staple (base, mid or tip) where it will most likely break given enough force. Measured in conjunction with tensile strength.

**Schlumberger dry yield:** A commercial yield estimate which predicts the amount of top and noil that can be combed from a grease lot. This yield percentage is the most commonly used in the South African wool industry.

**Scourable wool:** Wool that can be washed clean of all impurities and colour.

**Scouring:** Cleaning raw wool and removing impurities such as dirt, sweat and grease by means of washing with water and soap.

**Staple:** Term referring to naturally formed clusters of wool fibres throughout the fleece which are held together by cross-fibres.

**Staple length:** Staple length determines the end use of wool – that is, whether it is processed through the worsted system (weaving) or the woollen system (carding). Longer wools (50 mm and longer) are processed through the worsted system. Carding types usually have a much shorter fibre length (below 40 mm).

**Suint:** Excretions from sweat glands deposited in the wool.

**Style:** A subjective summation of the physical characteristics of wool which are of some importance to processors. The major components of style relate to the formation of the crimp (crimp frequency, crimp definition), the structure of the fleece (tip shape, staple structure), dust content (degree of dust penetration), weathering to the staple tip and wool colour

**Tender wool:** Wool fibre that breaks under pressure (less than 32 nkt) anywhere along the staple, which causes problems during processing. Also see **Tensile strength**

**Tensile strength:** A measure of the force required to break a wool staple of a given thickness (kilotex), recorded as Newtons per kilotex (nkt). Also referred to as staple strength.

**Top:** A continuous strand of partially processed wool which has been scoured, carded and combed up to an intermediate stage in the process of worsted yarn. See also **Noil** and **Carding waste**.

**Unscourable wool:** Wool that cannot be washed clean of all impurities and colour.

**Vegetable matter:** Term referring to all plant material (grass, seeds, leaves and twigs) present in the wool.

**Vegetable Matter Base:** Quantity of burrs, grass seeds, thistles, hardheads, straw, chaff and small pieces of stick and bark from the tested sample of wool. Vegetable matter base is expressed as a percentage of the weight of the greasy core sample.

**Wool brokers:** The agents who sell the wool grower's wool on a commission basis. They act as auctioneers for their client's wool on the open-cry system, the main method by which wool is sold in South Africa. Wool brokers also provide other vital services to the wool grower, including providing farm supplies, advice, market information and intelligence, and assistance with clip preparation and ram selection, to name a few.

**Worsted system:** See **Combing** and **Staple length**

**Yield percentage:** The amount of usable clean wool that is derived from greasy wool after scouring, expressed as a percentage. Raw wool contains 30% or more in weight of impurities in the form of waxes, suint, vegetable matter and dirt. See also **Schlumberger dry clean yield**.

*Sources:* Australian Wool Testing Authority, 2018; BKB, n.d.; Gorham, 2012; Oldenbroek and Van der Waaij, 2014.

# CHAPTER 1: INTRODUCTION

## 1.1 Background to the study

The sheep and wool sector is one of the oldest agricultural industries in South Africa. It plays an important economic role as an earner of foreign exchange for the country and provides employment to 250 000 people (Grwambi, 2005:2; Makapela, 2008:1; Mvinjelwa, 2013:26). There are an estimated four million wool sheep in communal ownership, producing approximately eight million kilograms of wool per year (De Beer, 2018:14; Van Wyk, 2014). The wool industry has records of more than 1 400 organised wool-producing communities in the Eastern Cape and KwaZulu-Natal. Each community has an average of 30 to 40 individual members, supporting at least 240 dependents (De Beer, 2018:14-15).

Wool production in the communal areas of the Eastern Cape Province are well documented by various studies (D'Haese, Vink, Van Huylenbroeck, Bostyn and Kirsten, 2003b; Jordaan, 2011; King, 2002; Makapela, 2008; Mvinjelwa, 2013; Mvinjelwa, Mapekula, Maphosa and Muchenje, 2014). Eric Rosenthal (n.d:82) reported that both the Transkei and Ciskei wool clips presented a great challenge in developing a marketing policy in line with market requirements. Immense fragmentation of the clips, transport difficulties, lack of knowledge and the average to poor quality of most of the wool produced are amongst those factors presenting problems. According to Jordaan (2011:193), wool production was previously considered ancillary to mutton production and the income-generating potential of wool, as a renewable and sustainable cash resource, was not highly rated. The quality of wool and consequently wool prices, yield per animal and reproductivity of the sheep were all poor. Moreover, shearing and classing infrastructure and technical know-how was limited and the small quantities that individual wool growers could offer were insufficient to exploit commercially (Jordaan, 2011:193).

According to Jari and Fraser (2012:56), small-scale wool growers in the Transkei/Ciskei regions had limited access to a profitable market outlet for their wool. Traditionally, individual farmers used to shear their sheep themselves in unfavorable conditions and sell the wool unsorted to local traders (also called speculators) at low prices (Grwambi, 2005:8). The local traders were perceived as an easy market outlet and because transport is often a problem, wool farmers operating in remote regions are often forced to sell their wool at far below market-related prices (D'Haese, Verbeke, Van Huylenbroeck, Kirsten and D'Haese, 2005:1449).

In response to this, the National Wool Growers' Association (NWGA) initiated a focused Wool Sheep Training and Development Project in 1997 to address the various challenges and constraints faced by communal wool growers. This project is funded by the Wool Trust and implemented by the NWGA on contract with Cape Wools SA (CWSA). Partnerships with national, provincial and local government, as well as commercial producers, international donors, commercial banks, input suppliers, tertiary institutions and the private sector, drive this initiative (De Beer, 2018:14). The main objective of the project is to improve both the quality and quantity of wool produced in the communal areas, together with increased market participation by smallholder farmers (De Beer and Terblanché, 2015:105). According to De Beer (2018:14), the project focuses on five key areas: 1) organizing wool producers into wool growers' associations to collectively harvest, class and pack their wool, which enables them to access the formal wool market, 2) training and mentorship, 3) market readiness and access, 4) genetic improvement of communal flocks, and 5) infrastructure development.

In 2002, the NWGA launched the Genetic Improvement Scheme to improve the genetic composition of communal sheep herds by replacing the nondescript communal rams with commercially-bred Merino rams (De Beer, 2016). The breeding scheme is funded by the Department of Rural Development and Land Reform (DRDLR) and entails 3 000 genetically superior rams being placed in the communal areas on an exchange basis each year (De Beer, 2016; Van Wyk, 2017). This means that a commercially-bred Merino ram is placed in the breeding population for every nondescript communal ram removed. Since 2002, almost 40 000 rams have been placed in communal herds through the breeding scheme (De Beer, 2016).

Studies show that upgrading the nondescript communal breeds with pure-bred Merino rams contributes significantly towards the improvement of sheep performance (King, 2013b; Makapela, 2008; Mvinjelwa, 2013). Wool production and income in the Transkei/Ciskei regions showed a significant increase over the past 20 years due to the interventions mentioned above (King, 2013b:45). Wool volumes from the communal areas, traded through the formal market, increased more than ten-fold from 222 610 kilograms in 1997/98 to 5 422 122 kilograms in 2017/18 (Du Pisani, personal communication, October 31, 2018). This represents an improvement in cash value from R1,5 million to almost R132 million. During the same period, the price ratio between commercially produced and communal wool improved from about 50 per cent to more than 60 per cent. This indicates an improvement in the quality of wool being produced (Brits, 2014:27).

## **1.2 Rationale for the study**

South Africa is a developing country with a high unemployment rate of 26.7 per cent (Masutha, 2018). Baiphethi and Jacobs (2009:459) stress the need to significantly increase the productivity of subsistence/smallholder agriculture and ensure long-term food security. This can be achieved by encouraging farmers to pursue sustainable intensification of production by improved inputs. According to Jordaan (2011:193), wool production is a renewable, sustainable raw cash product with the potential to become a significant income-earner for many communal livestock farmers in South Africa. However, amongst other constraints, poor infrastructure, limited wool production knowledge and restricted access to formal market channels have seriously limited its potential as a significant source of income.

Studies show that the quality and quantity of wool produced in communal areas are characteristically poor, resulting in low financial returns (King, 2013a; Makapela, 2008; Mapiliyao, Pepe, Chiruka, Marume and Muchenje, 2012; Mvinjelwa, 2013). Communal wool growers generally struggle to achieve their full potential due to well-documented problems and constraints. There is a need to determine methods of identifying cost-effective ways to improve access to market inputs by, among other things, increasing market participation and assisting farmers to earn cash to purchase inputs and invest in infrastructure, thereby improving food security (Baiphethi and Jacobs, 2009:459).

## **1.3 Significance of the study**

Due to population pressure, production increasingly takes place on diminishing and marginal land prone to degradation (King, 2002:9). Increased productivity will reduce pressure on marginal lands (Baiphethi and Jacobs, 2009:459), as the increased productivity per animal will allow wool growers to keep fewer animals without reducing income.

Rhodes University researcher Dr. Dave Tapson has been conducting an independent survey since 2004 on the social impact of enhanced wool production in the communal areas (De Beer, 2018:15). Some of the significant results include:

- The number of households with children going to bed hungry has declined from 41 per cent in 2004 to 24 per cent in 2015.
- The number of households with savings accounts has increased from 49 per cent in 2004 to 84 per cent in 2015.

- The number of households having to borrow money for school fees has decreased from 77 per cent in 2005 to 48 per cent in 2015.

The findings underscore the potential of wool production as a unique enterprise that has persisted for centuries, with the potential to expand rapidly without losing focus or momentum.

## 1.4 Problem statement

The growth performance of sheep and the quantity of wool produced per sheep in the communal areas are low, resulting in low returns from both meat and wool production (Mvinjelwa, 2013:75; Mvinjelwa *et al.*, 2014:914). According to the study conducted by Makapela (2008:XV) in the Hewu district (Whittlesea), communal sheep produce between 2 kg and 3 kg per animal over a 12-month growing period. That is far below the performance of commercially raised sheep, which produce 4 kg to 5 kg per animal over a 12-month growing period. Makapela (2008:95) also found that although the lambing percentage is relatively high at 95 per cent, the weaning percentage in communal areas is cause for concern at 18 per cent. Farmers indicated that the most important reasons for the high lamb mortality rates are poor veld conditions, poor mothering characteristics and predation (Makapela, 2008:81). As stated by King (2013a:45), wool production in the communal areas is generally characterized by low production yields, poor quality, contamination and low prices.

Some of the major reasons attributed to the low wool production and quality are listed below (D'Haese, Calus, Van Huylenbroeck, 2001:644; Jordaan, 2011:203; King, 2013b:41; Makapela, 2008:XV-XVI; Nkonki, 2006:20):

- Lack of private land tenure, restraining private incentive for development such as infrastructure for wool production.
- Lack of individual financial means for development (including lack of collateral for loans).
- Poor genetic quality of sheep.
- Poor nutrition of sheep, mainly resulting from continued overgrazing.
- Limited control over the movement of animals because there are no fences.
- Communal wool growers fail to meet market standards required by processors down the supply chain.

Du Pisani and Coetsee (2015) conducted a preliminary analysis on the productivity of 568 shearing sheds in the communal areas of the Eastern Cape. Their study indicated that top-performing shearing sheds achieved wool prices of between 3 and 4 times more than the poorest-performing sheds. The researchers calculated that if this difference in shearing shed earnings could be overcome, communal farmers could possibly earn between R72 million and R120 million more per annum (Du Pisani and Coetsee, 2015). A study by Mvinjelwa (2013:66) found that a research need exists to establish whether the observed differences in earnings between shearing sheds are due to differences in clip preparation (i.e. classing) or due to differences in the quality of wool being produced (i.e. genetics).

## **1.5 Research aims and objectives**

The aim of this study is to perform statistical analyses on the data set of wool production records from the communal areas of the Eastern Cape Province and thereby answering the proposed research questions listed below.

## **1.6 Research questions**

The composite study area consists of five regions into which the communal areas of the Eastern Cape are divided by the NWGA. These are as follows: Region 20, Region 21, Regions 23, Region 24 and Region 25 (see **Figure 3.1**). The primary assumption of this study is that statistically significant differences exist in the price levels achieved by the NWGA regions.

The main research question of the study, therefore, is:

**Are there statistically significant differences in price levels achieved by the respective NWGA regions?**

The sub-questions supporting the main research question are:

- i) If so, what are the factors contributing to the observed differences in price levels?**
- ii) Can the observed differences be attributed to the genetic composition of the sheep?**
- iii) Can the observed differences be attributed to the standard of wool classing practices applied by the respective shearing communities?**

## **1.7 Hypothesis of the study**

Statistically significant differences exist in price levels achieved by the respective NWGA regions and these differences are the result of genetically influenced wool attributes and/or the degree of classing applied by the shearing communities.

## **1.8 Limitations and delimitations**

The research was delimited to official production records pertaining to eight wool-selling seasons, namely: 2009/10, 2010/11, 2011/12, 2012/13, 2013/14, 2014/15, 2015/16 and 2016/17. The production records which provided the empirical data for the study were obtained from BKB, South Africa's foremost wool-brokering organization. From the composite study area of the former Transkei and Ciskei, the research population was delimited to a total of 1 103 shearing communities (commonly referred to as shearing sheds) which participated in the study. The participant shearing sheds represent the five regions (i.e. Regions 20, 21, 23, 24 and 25) into which the communal areas of the Eastern Cape are divided by the NWGA.

Wool prices largely depend on several economic and market-related parameters such as exchange rates, supply and demand, buyer confidence (access to credit), fashion trends, commodity prices and the prices of competing textiles. In this study, apart from the exchange rate, the economic factors influencing the price of wool are not discussed in further detail because they are beyond the control of the wool grower.

Wool buyers add premiums or discounts to the price of wool to account for the presence or absence of faults in the wool and variations in fibre diameter, clean yield, staple length, tensile strength and vegetable matter base. The premiums and discounts applicable to varying qualities of grease wool are extremely complex and were, therefore, not considered by the prediction model. The length and strength test measurements were omitted from the regression model since not all the data points had test results available for mean staple length, coefficient of variation for staple length and tensile strength. Length and strength tests are only performed on wools 50 mm and longer. Staple length and tensile strength are closely correlated with mean fibre length in the top (hauteur), which are included in the prediction model.

## **1.9 Summary**

This chapter serves as an introduction to the study, presenting an overview of the background to the study, the rationale for the study, the research problem being investigated, significance of the study and the empirical framework within which the inquiry was conducted. Also presented in this chapter are the research questions and objectives, hypothesis of the study and the delimitations and limitations to the research.

The primary aim of this study is to establish whether statistically significant differences exist in price levels achieved at formal auction by the various NWGA regions for their communally produced wool. Secondly, the study aims to identify contributing factors to the possible differences observed. Finally, the study aims to determine whether the observed differences are the result of genetically influenced wool attributes and/or the wool classing practices applied by the shearing communities.

## CHAPTER 2: LITERATURE REVIEW

### 2.1 Introduction

The former homeland regions of the Eastern Cape (Transkei and Ciskei) are among the poorest regions of South Africa (Perret, 2002:1). King (2013a:41) reported that the former Transkei and Ciskei are occupied by approximately 4 million people living in pastoral communities that are characterized by a subsistence economy. Households depend primarily on agricultural activities for food security (D’Haese *et al.*, 2005:1446), underpinned by state welfare grants and urban remittances (Shackleton, Shackleton and Cousins, 2001:581).

Sheep farming is widespread in the rural areas of the former Transkei and Ciskei. Households generally keep sheep for own consumption and as a long-term investment of savings (Bobi, 2014:18). Wool was originally considered ancillary to the production of mutton and, as a result, the income-generating potential of wool, as a renewable and sustainable resource, was not highly rated (Jordaan, 2011:193). Consequently, wool produced in the communal areas was mainly characterized by low production efficiency and poor quality and was generally sold to local wool traders at very low prices (D’Haese, Vink, Van Huylbroeck, Bostyn and Kirsten, 2003a:74). Wool production holds the potential to contribute significantly to sustainable household income and food security if the quality and quantity of wool production is improved (D’Haese *et al.*, 2001:641).

### 2.2 Historic background to communal areas

The Natives Land Act 1913 segregated “Africans” and “Europeans” on a territorial basis by designating about 8 per cent of the country’s farm land as reserves (Adams, Cousins and Manona, 1999:18). The Land Act of 1913 prohibited “natives” from buying or renting land outside the scheduled reserves (Jari and Fraser, 2012:113), which became the only areas that could legally be farmed by Africans (Adams, Cousins and Manona, 1999:18). This land dispossession was instrumental in creating a surplus of migrant labour for the mines and the agricultural sector (Cotula, Toulmin and Hesse, 2004:8) and simultaneously eliminating competition from black farmers (Adams *et al.*, 1999:18). The 1936 Native Trust Act confirmed this territorial segregation by legislatively extending the reserve areas to constitute 13 per cent of South Africa’s land surface (Bennett, Ainslie and Davis, 2010:341; Hendricks and Fraser, 2003:8; Nel and Davies, 1999:258).

According to the study conducted in 2010 by Bennett, Ainslie and Davis (2010:341), some 12.7 million people – about 30% of the national total – still live in these former homeland areas. Although the formalities of the apartheid legislation, as well as the Land Act, had been dismantled by 1994, many of the realities of separate development remain 20 years after the dawn of democracy (Pienaar and Von Fintel, 2015:39).

### **2.3 Wool production in the communal areas**

According to D’Haese, Van Huylenbroeck, Doyer and Calus (2007:11), the former homelands are characteristically poor compared to other South African regions. Farming communities in remote areas are characterized by severe poverty and have limited access to basic services. Market access is the most common problem in rural communities since farmers are commonly constrained by limited means of transport, knowledge, communication and marketing facilities – resulting in prohibitively high marketing and transaction costs (D’Haese, Van Huylenbroeck, Doyer and Calus, 2007:11).

One of the many challenges faced by communal farmers is the communal land tenure system (D’Haese *et al.*, 2001:642; Jordaan, 2011:212). Pastures are not fenced off or divided into camps. Animals roam freely and cannot be prevented from mixing and, as a result, grazing patterns cannot be properly managed (D’Haese *et al.*, 2001:644). Most of the communal rangelands are perceived to be degraded. Major contributors to degradation of rangelands are deforestation and loss of vegetation cover due to overgrazing and overstocking (Mokhahlane and Obi, 2011:235).

Many sheep are stolen or killed by predators because there are no fences or camps. Communal farmers suffer immense losses annually due to stock theft – and even shorn wool is stolen (Van Wyk, 2014). Livestock are often not clearly branded or tagged and are usually marked with paint on their backs. This marking method contaminates the wool – resulting in price discounts due to additional processing costs along the value chain.

The lack of fencing also prevents farmers from implementing selective breeding. Communal management of flocks complicates the genetic management of the flock, with other non-wool breeds interbreeding with the woolled Döhne Merinos – leading to a low-quality clip (D’Haese *et al.*, 2007:14). Furthermore, sources indicate that farmers do not separate breeding ewes from rams and generally practice natural breeding. This extended breeding approach increases mating opportunities. Mapiliyao *et al.* (2012:3213) concluded that uncontrolled breeding practices compromises planning for mating periods and selection quality criteria because any animal can mate with any another animal regardless of family relation or genetic quality. As a result, ewes tend to lamb throughout the year. Alternatively, under controlled mating, lambing could coincide with periods of better feed availability or planned supplementary feeding (Mapiliyao *et al.*, 2012:3213).

A number of surveys have been conducted in the communal areas, collecting wool production data (D’Haese Vink, Van Huylbroeck, Bostyn and Kirsten, 2003; King, 2002; Perret, Carstens, Randela and Moyo, 2000). The main problems identified in terms of wool production were low production yields, poor-quality wool produced, contamination of wool and low prices. King (2013b:45) ascribes the low income that communal farmers receive to a number of factors, such as genetically inferior sheep producing poor-quality wool. King (2013a:41) argues that although heavy stocking rates and continuous grazing management of communal grazing land impair production performance and thus wool production, the genetic quality of communal nondescript sheep contributes to lower income derived from communally bred sheep.

According to Goqwana, Goqwana, Machingura, Mdlulwa, Mkhari, Mmolaeng and Selomane (2008), local authorities realized the importance of promoting livestock production and the need to improve the nondescript breeds in the former Transkei and Ciskei areas. These communally-bred nondescript sheep are genetically inferior and produce equally poor-quality wool. De Beer (2012:3) stresses that the genetic potential of sheep with regards to reproduction and growth rate, as well as the quality and quantity of wool produced, are essential to a holistic approach towards increased production from wool-bearing sheep.

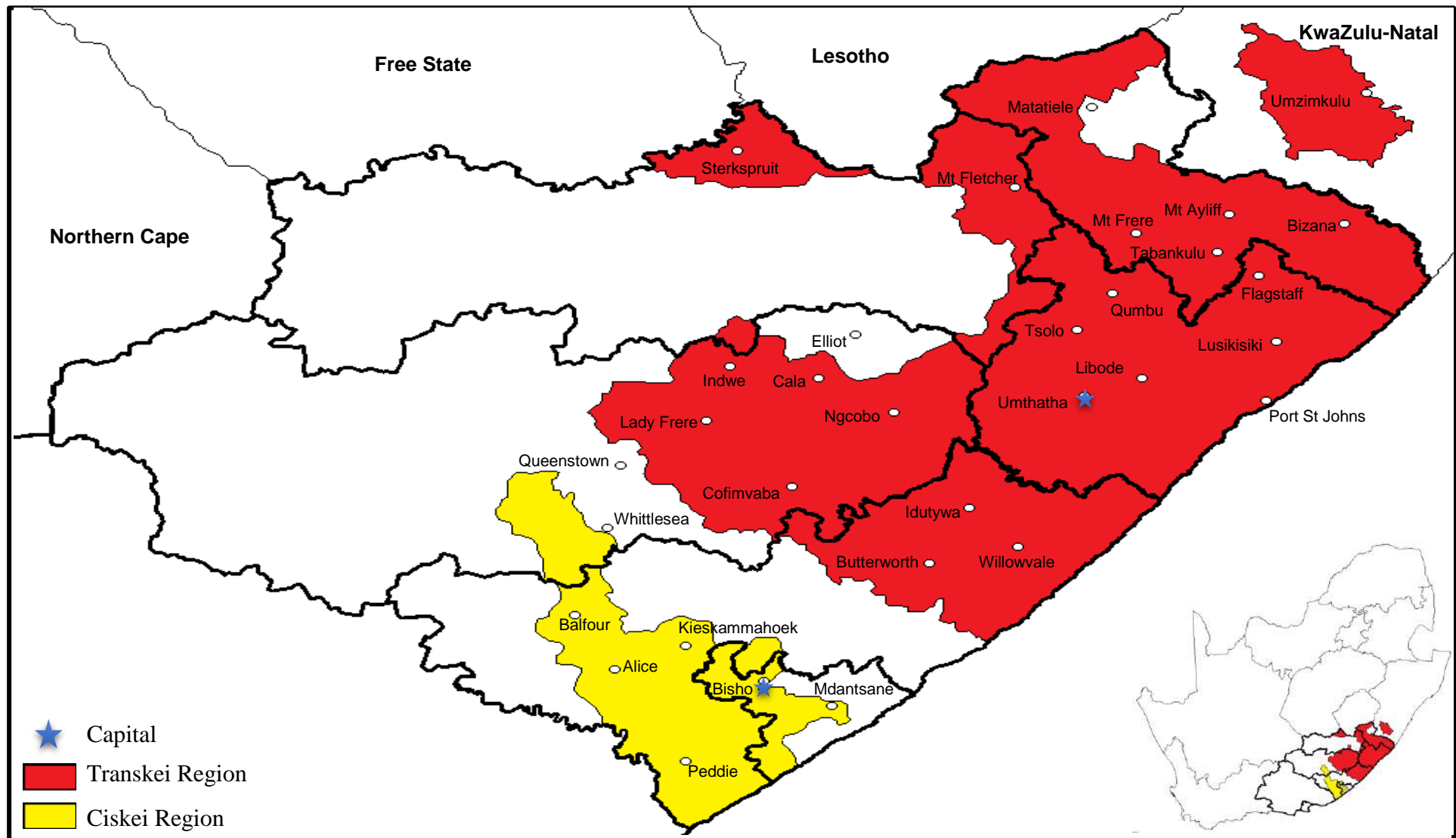
## 2.4 Institutional constraints and challenges

Smallholder and emerging farmers face difficulties in accessing markets and, as a result, markets do not serve the interests of the smallholder and emerging farmer (Jari and Fraser, 2012:62). In South Africa, less developed rural economies and smallholder farmers find it difficult to participate in commercial markets due to a range of technical and institutional constraints. Grwambi (2005:37) concluded that the dearth of infrastructural facilities, the lack of transport and access to credit limits market participation by rural households.

Other impairment factors such as a lack of market information, insufficient expertise regarding and use of grades and standards, inability to conclude contractual agreements and poor organizational support have led to inefficient use of markets – resulting in commercialization bottlenecks (Jari and Fraser, 2009:1130). In turn, insufficient or unfavorable marketing opportunities lead to lower sales of livestock and wool (Vetter, 2013:4). Furthermore, smallholder farmers lack vertical linkages in the marketing channels, resulting in their exclusion from and the use of formal markets (Panda and Sreekumar, 2012:215; Ramoroka 2012:9).

According to D’Haese *et al.* (2003:1413), investments needed to access the formal market on an individual basis are beyond the means of smallholder farmers. Asset specificity combined with market-related uncertainty and the low frequency of exchange raise transactional costs and make individual marketing of wool by small-scale farmers less profitable. Consequently, small-scale farmers either sell their wool to local traders or market their wool collectively through the formal market. Farmers benefit from selling their wool to local traders because of direct and immediate payment, thus reducing uncertainty. The uncertainty and physical costs arising from grading, sorting, packaging and transport are borne by the trader. However, these traders pay only 20 to 40 per cent of the market-related value to the farmers for their wool (Dugmore, 2016:57).

A study conducted by Ngqangweni, Kirsten and Delgado (2001:63) revealed that communal farmers can produce efficiently, even when subjected to the same opportunity cost assumptions that apply to commercial farmers. Ngqangweni *et al.* (2001) concluded that more research needs to focus on analyzing potential linkages between the African smallholder sector and the rest of the rural economy to establish whether investments in the sector hold any potential for sustainable income and employment growth.



**Figure 2.1:** The study area – Communal areas of the former homeland Transkei and Ciskei regions in the Eastern Cape Province and KwaZulu-Natal

## 2.5 The study area

The Eastern Cape is located on the south-eastern seaboard of South Africa and is the second-largest province, covering an area of 170 600 km<sup>2</sup>, which represents 14 per cent of South Africa's land mass. The climate varies from mild conditions (i.e. 14°C to 23°C) along the coastal areas to slightly more extreme conditions of 5°C to 35°C over the inland areas, with the mountain areas experiencing winter snows and summer rainfalls (Mokhahlane and Obi, 2011:247).

### 2.5.1 Location and land area

**Figure 2.1** depicts the study area, which encompasses the former homeland regions of Transkei and Ciskei. The Ciskei region covers 7 560 km<sup>2</sup> (Cadman, 1986:7) and stretches in a north-westerly direction from the coastline on the Indian Ocean up to the lower part of the escarpment of the subcontinent in the Winterberg mountain range (Forbes and Trollope, 1991:147).

The Transkei region covers an area of 45 000 km<sup>2</sup> (Mauder, 1982:573) bordered by the Umtamvuna River in the north and the Great Kei River in the south, with the Indian Ocean and the Drakensberg mountain range (including parts of the land-locked Lesotho kingdom) serving as the eastern and western boundaries. A further two small segments of the Transkei region occur as landlocked isolates within the Eastern Cape Province and KwaZulu-Natal, respectively.

### 2.5.2 Climate

The climate of Ciskei and Transkei changes progressively from subtropical-oceanic at the coast to temperate steppe in the Hewu/Whittlesea/Matatiela areas and temperate grasslands in the north-eastern areas. Based on the classification by Kruger and Esterhuysen (2004) of the major macroclimate regions of South Africa, four zones are observed in the study area:

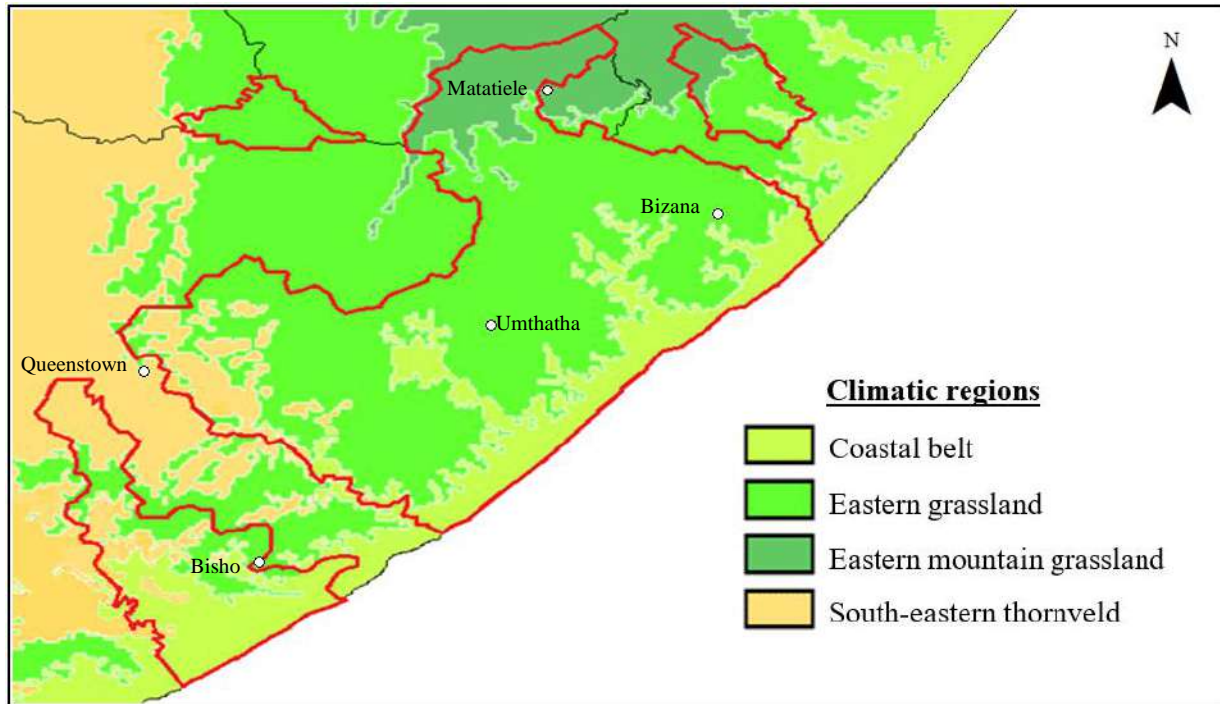
- **Coastal belt:** 0 to 400 m above sea level; oceanic climate; frost-free; perennial rainfall season peak during October to December. Hot summers with strong winds from the north-eastern and south-western sectors.

- **South-eastern thornveld:** 500 m to 1700 m elevation; arid steppe with summer precipitation and dry winters; below-average temperatures, with occasional snow over mountainous areas; frost may occur from May to September; winds are usually north-westerly, although cold snaps during winter are accompanied by unpleasant, cold southerly to south-westerly winds.
- **Eastern grassland:** 400 m to 1700 m above sea level; temperate climate with perennial precipitation and hot summers. Frost occurs regularly during dry winter months. Winds tend to be from the north-eastern or south-western sector. Intense thunderstorms occur frequently during the rainy season.
- **Eastern mountain grassland:** 1500 m to 2600 m elevation. Rainfall varies widely over short distances due to the topography and occurs mainly during summer. Temperatures tend to be cool, especially in the south. The climate is extreme with frost and fog occurring frequently, while snow occurs in mountainous areas.

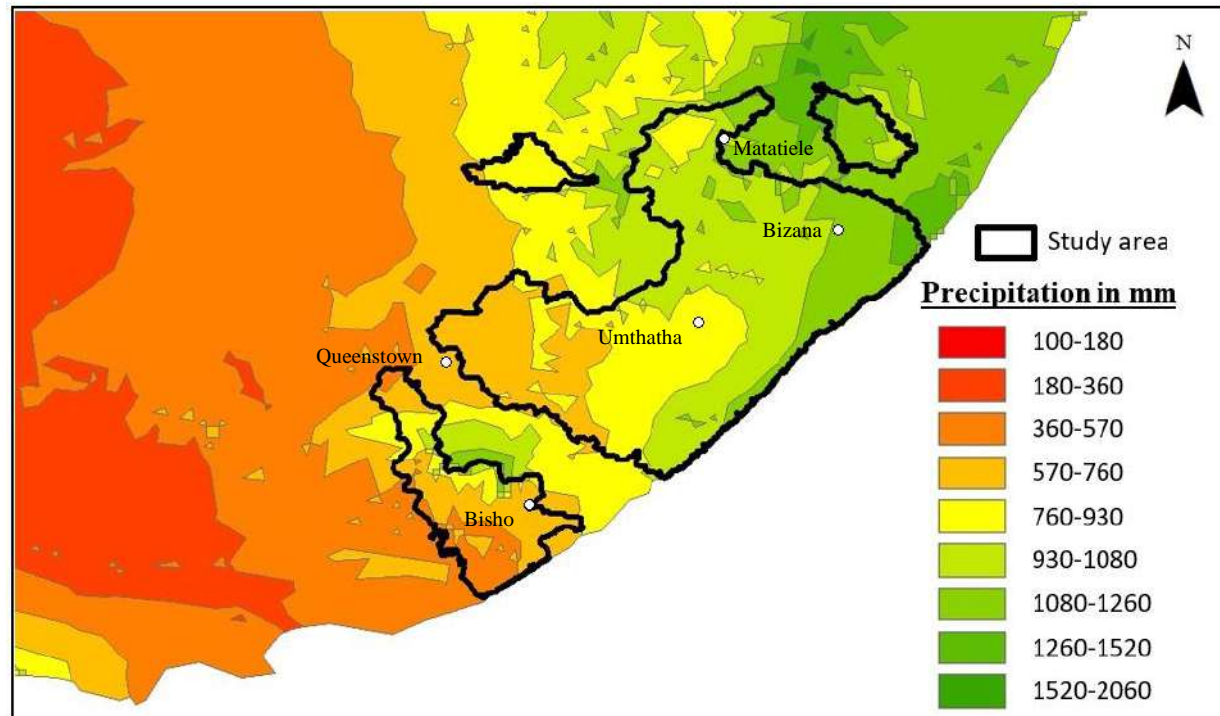
### 2.5.3 Landscape and vegetation

Topographically, Transkei is a broken landscape characterized by mountain ranges and deeply eroded valleys. Three-quarters of the surface is very hilly or mountainous and only 11 per cent is flat or undulating (Fourie, Gatner, Glatthaar and Kleeberg, 1980:72). Ciskei is topographically complex and much of the land consists of steep slopes that separate low-lying land in the Great Fish River valley from the more undulating land on the interfluvial ridge between the Great Fish and Keiskamma rivers (Ainslie, 1999:381).

**Figure 2.2** illustrates the Köppen climate classification zones within which the study area falls. The Kruger and Esterhuysen (2004) classification strongly resembles the Köppen climate system – one of the most widely used climate classification systems. The combination of steep topography and shallow, phosphorus-deficient soils, together with erratic precipitation, means that Ciskei has very low potential for dry-land crop production and must be perceived essentially as land best suited to animal production off veld and pastures (Ainslie, 1999:381; Forbes and Trollope, 1991:147). **Figure 2.3** depicts the mean annual rainfall within the study area.



**Figure 2.2:** The Köppen climate classification zones within the study area  
*Source:* Conradie, Van Reenen and Bole (2015)



**Figure 2.3:** Mean annual rainfall over study area  
*Source:* ARC Institute for Soil, Climate and Water (2016)

The five agro-ecological regions that make up the central Eastern Cape contain four of the major vegetation biomes identified by Acocks (1988). These can further be subdivided into 22 different veld types, according to the veld classification system created by Mucina and Rutherford (2006). **Table 2.1** illustrates the four agro-ecological zones that make up the study area, along with the respective vegetation biomes and veld types.

**Table 2.1:** Summary of vegetation biomes and veld types in the study area

| <b>Agro-ecological zone</b> | <b>Vegetation biome</b> | <b>Veld types</b>                        |
|-----------------------------|-------------------------|--|
| <b>1. Coastal belt</b>      | Forest biome            | Pondoland-Ugu sandstone coastal sourveld |
|                             |                         | Transkei coastal belt                    |
| <b>2. Coastal plateau</b>   | Savannah biome          | Bhisho thornveld                         |
|                             |                         | Ngongoni veld                            |
|                             |                         | Eastern valley bushveld                  |
| <b>3. Valley mountains</b>  | Thicket biome           | Eastern Cape escarpment thicket          |
|                             |                         | Great Fish thicket                       |
|                             |                         | Albany coastal belt                      |
| <b>4. Midland plateau</b>   | Grassland biome         | Southern Drakensberg highland grassland  |
|                             |                         | Karoo escarpment grassland               |
|                             |                         | Queenstown thornveld                     |
|                             |                         | Zastron moist grassland                  |
|                             |                         | Sengu montane shrubland                  |
|                             |                         | Southern KwaZulu-Natal moist grassland   |
|                             |                         | Midlands mistbelt grassland              |
|                             |                         | Drakensberg foothill moist grassland     |
|                             |                         | Amathole montane grassland               |
|                             |                         | Amathole mistbelt grassland              |
|                             |                         | East Griqualand grassland                |
|                             |                         | Mthatha moist grassland                  |
|                             |                         | Tsomo grassland                          |
| Tarkastad montane shrubland |                         |  |

*Source:* Acocks (1988); Low and Rebelo (1996); Mucina and Rutherford (2006)

According to Hebinck and Lent (2007:71), these vegetation biomes differ in their potential to support livestock because of their varying composition in terms of the proportion of grasses, bushes and trees they contain and the relative productivity of the various plant species. Species composition, particularly of grasses, is important and forms the basis for a broad classification of grasslands into sweetveld or sourveld ( Mapiliyao *et al.*, 2012:3210; Mapiye, Chimonyo and Dzama, 2009:530; Mvinjelwa, Mapekula, Maphosa and Muchenje, 2014:914).

Sour rangelands receive between 600 mm and 800 mm of rainfall per annum and are mainly composed of annual grass species, which lose nutritive value and palatability during the dry season. In contrast, precipitation in the sweet rangeland is less than 500 mm per annum and vegetation comprises perennial grasses that remain nutritious and palatable all year round (Ellery, Scholes and Scholes, 1995; Mapiliyao *et al.*, 2012:3210; Mapiye *et al.*, 2009:530).

#### *2.5.3.1 The forest biome*

The veld of both rangeland types can be described as sour to mixed, depending on the rainfall aspect and soil type. Agriculture is predominately crop-orientated, although extensive livestock production is practiced where thornveld and bush intrusion is less problematic (Hebinck and Lent, 2007:72).

#### *2.5.3.2 The thicket biome*

The vegetation of the thicket biome constitutes entirely the valley bushveld associated with the valleys of the Keiskamma, Tyume, Bira, Kat and Great Fish rivers. The vegetation is characteristically scrubby and consists of a combination of thicket and *Acacia karroo* thornveld or *Euphorbia* forest with limited grassveld. The veld type is very sweet and therefore very sensitive to overgrazing, which limits the livestock production potential of the biome (Hebinck and Lent, 2007:73).

#### 2.5.3.3 *The savannah biome*

The savannah biome consists mainly of thornveld, dominated by *Acacia karroo*, with a dense grassveld layer variable in veld type. In some areas this grassveld is sour to mixed veld but is predominately sweet in classification. This characteristic, combined with the generally flat topography, makes it well-suited to livestock production (Hebinck and Lent, 2007:72), which is one of the main land-use activities practiced in the savannah biome (Higgins, Kantelhardt, Scheiter and Boerner, 2007:102; Skarpe, 1991:351).

#### 2.5.3.4 *The grassland biome*

The four veld types that constitute the grassland biome differ considerably in their productivity and therefore in their potential to support livestock. The Highland sourveld and Döhne sourveld are associated with mountainous regions and are dominated by dense and inherently sour grassveld. In contrast to the sweetveld, this type of rangeland is characterized by being resistant and is capable of tolerating quite high levels of grazing pressure without producing any noticeable deterioration of botanical composition, although high pressure does lower productivity. This veld type is productive during the spring and early summer, but rapidly declines during the autumn and remains low throughout the winter (Hebinck and Lent, 2007:73). Livestock production declines markedly at this time and, without supplementary feeding, animals may even die (D'Haese *et al.*, 2005b:38).

The other three veld types in this biome are essentially mixed to sweet veld in nature and tend to be quite sensitive to overgrazing and degradation. The potential of the biome for livestock production can be considered as reasonable, being better suited for livestock farming than the forest and thicket biomes, although not as well suited as the savannah biome (Hebinck and Lent, 2007:74).

## 2.6 Marketing channels for communal wool growers

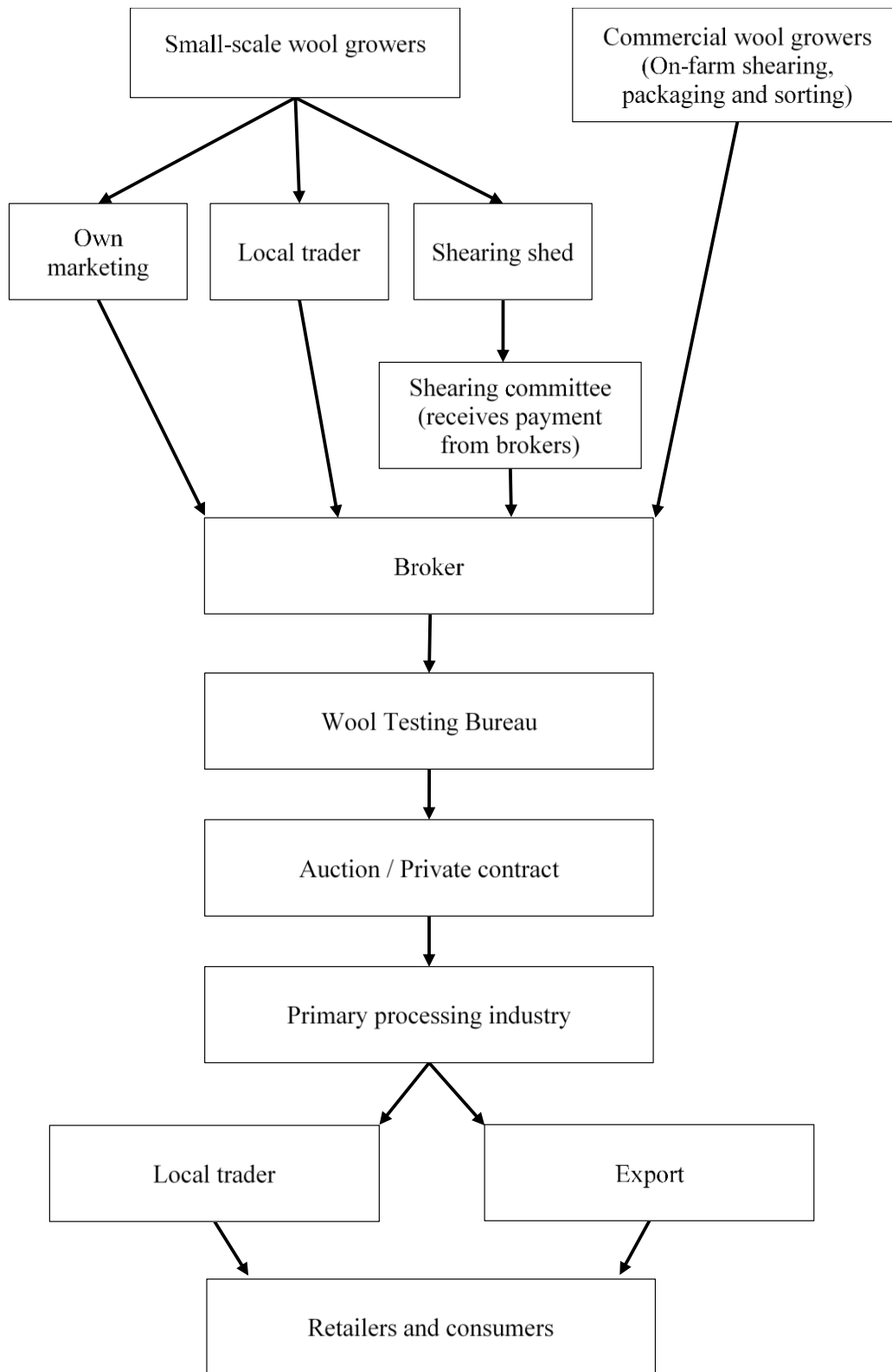
The wool sector, as one of the oldest agricultural industries in South Africa, plays a significant role in terms of foreign exchange earnings. South African wool is largely an export commodity in processed, semi-processed and unprocessed form. Wool is produced and traded in a sophisticated free market environment into the international marketplace, where supply and demand determine price levels (Dlodlo, Hunter, Cele, Botha and Metelerkamp, 2009:47).

The global price for apparel wool is determined by the Australian wool market, the world's largest supplier of apparel wool. South Africa produces approximately 2.3% of the global wool production and is therefore a market follower or price taker (International Wool Textile Organisation, 2015). The primary marketing channel for South African wool is through the open-cry auction system, where the exchange of producers' wool to buyers is facilitated by a public auction. Supply and demand determine price levels and the majority of wool growers and buyers congregate to sell and buy wool. This marketing channel is where the most competition for growers' wool is concentrated and where prices are likely to be closest to fair market value (Jordaan, 2011:209).

Wool produced in the communal areas was traditionally marketed through local traders who bought unsorted grease wool, usually in small quantities, from desperate sellers at very low prices. These traders sorted and classed the wool into commercial qualities and quantities and then marketed it through the formal market system (Jordaan, 2011:209).

D'Haese *et al.* (2005:1449) identified three wool marketing options available to smallholder wool growers:

- Wool growers can organise their own shearing and sell directly to wool brokers.
- The wool can be shorn on the farm and sold to local traders who purchase the wool unsorted at the farm-gate.
- Members of a wool growers' association shear their wool in a shearing shed and pack the wool collectively to market it through the formal marketing system.



**Figure 2.4:** Marketing channels available to communal and commercial wool growers  
*Source:* Nkonki (2006)

Traditionally, individual owners shear the sheep themselves at their homesteads. Alternatively, this activity is often organised communally at a communal shearing shed and the wool is then traded with the brokers. The farmers then also deal with local traders, who pay low prices for the wool. These local traders are perceived as an easy market outlet since they pay in cash straightaway (D'Haese *et al.*, 2005:1449). King (2013b:45) raises the concern that approximately 1.8 million kg of communally produced wool is sold to traders at heavily reduced prices.

Small-scale wool growers who do not operate collectively have limited marketing opportunities. Collective shearing and marketing through a shearing shed provides an option for the farmers to market their wool directly at the formal auction. Secondly, collective shearing can reduce transaction costs and allow the farmers to achieve economies of scale and access a more profitable market (D'Haese *et al.*, 2005:1449). **Figure 2.4** illustrates the marketing channels available to communal and commercial wool growers.

## **2.7 The potential of wool production**

Households in the communal rural areas typically keep livestock for a combination of economic and non-economic reasons (Bobi, 2014:2; D'Haese *et al.*, 2005:1446), such as ritual slaughter, slaughter for meat, bride-wealth and other transactions, occasional sales when money is required and as a form of savings and security (Vetter, 2013:4). Livestock farming by small-scale farmers is an important means of generating income for the improvement of the livelihood of rural people (Mokhahlane and Obi, 2011:231). However, the wool produced is typically of low quality and is often sold to local traders at very low prices (D'Haese *et al.*, 2003:211). Mvinjelwa *et al.* (2014:914) stress that the growth performance of sheep and the quantity of wool produced per sheep in the communal farming areas are low, resulting in low returns from both meat and wool production. This is reflected by the low average price per kilogram of wool produced by the communal farmers.

Wool production has the potential to be a source of cash income that can sustainably contribute to household income if the quality and quantity of the clip produced are improved. As such, wool production has the potential to alleviate rural poverty and stimulate rural economic development and investment opportunities (Coetzee, Montshwe and Jooste, 2006:82). Wool production therefore remains an important activity with great untapped potential for rural economic development in South Africa. Specializing in wool production represents an opportunity for historically disadvantaged farmers in the Eastern Cape to upgrade to fully commercial and economically viable enterprise (Bobi, 2014:1).

## **2.8 Key physical attributes of grease wool**

The pricing of grease wool is very complex and depends on the combined influences of various economic conditions and the physical attributes of the wool. The physical attributes which affect the price of wool are discussed below.

### **2.8.1 Fibre diameter**

Fibre diameter (FD) is the most important price-determining characteristic of grease wool. FD refers to the thickness of the individual wool fibre. The mean fibre diameter is objectively measured in units of micrometers (microns). Finer wools return higher prices, with premiums increasing as fibre diameter decreases (Schlink, 2009:3; Woolcheque, n.d.). Finer wools are usually destined for higher-value end uses such as Italian men's suits and next-to-skin apparel.

### **2.8.2 Variation in fibre diameter**

Fibre diameter coefficient of variation provides a useful statistic for comparing variation in fibre diameter. Variability in wool fibre diameter is important because it affects spinning condition and the uniformity of yarns into which wool is spun. In turn, uniformity affects yarn strength and the appearance, performance and acceptability of fabric. Variability in fibre diameter is considered to be of secondary importance compared to several other measurable raw wool characteristics (Lupton, 1995:111). Wool buyers discriminate against wools with high variability in fibre diameter distribution.

### **2.8.3 Clean yield**

The clean yield percentage is used to estimate the quantity of usable wool fibre present in a given sale lot, expressed as a percentage (Australian Wool Testing Authority, 2018). Wool buyers quote and trade greasy wool in cents per clean kilogram. Wool auctioned in the saleroom is bid on and sold in cents per greasy kilogram. The conversion factor between greasy and clean weights is known as the yield (Australian Wool Exchange Ltd, 2009:7). The Schlumberger dry yield, which predicts the amount of “top” and “noil” that can be combed from a greasy lot (Barry, 2009:11), is most commonly used in the South African wool industry. Low-yielding wools tend to return lower prices whilst high-yielding wools, which are more sought-after, tend to return higher prices.

### **2.8.4 Tensile strength**

Tensile strength (SS) of grease wool can be defined as the measurement of the maximum level of tensile stress that a wool fibre can withstand without breaking. Lots with a fibre length of 50 mm and longer are measured objectively in Newtons per kilotex (nkt). Tensile strength relates to the efficiency of wool processing, because tenderness results in increased fibre breakage and wastage during processing. The percentage of card waste (noils) increases as tensile strength decreases (BKB, n.d.; Woolcheque, n.d.). Compared to a baseline of 35 nkt-type, penalties are large for tender wools (14-21 nkt), with discounts declining as strength increases. Tender wools are discriminated against, with discounts declining as strength increases, while wool testing above 40 nkt attracts premium prices – particularly at the finer end, where discounts and premiums are magnified (Woolcheque, n.d.).

### **2.8.5 Staple length**

Staple length (SL) determines the end use of wool – that is, whether it is processed through the worsted system (weaving) or the woollen system (carding). Longer wools (50 mm and longer) are processed through the worsted system. The worsted system produces fine, even, smooth yarns mostly for apparel, while carding types usually have a much shorter fibre length (below 40 mm). Woollen spun fabrics are used for jackets, coats, skirts, upholstery fabrics, rugs and blankets. Higher prices are paid for longer wools, with discounts increasing as staple length decreases. As with other wool attributes, the finer the wool, the more sensitive is its price to any fault (including too short or overly long wools) (Woolcheque, n.d.).

### **2.8.6 Variation in staple length**

Uniformity of length affects spinning performance during processing (De Beer, n.d:11). The coefficient of variation in staple length is a measurement of the uniformity of length in the lot. Wool buyers discriminate against lots with high variability in staple length. Variation in staple length is largely dependent upon the standard of classing applied by the wool classer at the shearing shed.

### **2.8.7 Vegetable matter content**

Vegetable matter (VM) contamination refers to the quantity of plant material present in a given lot. VM contamination in wool is related to the grazing conditions and the environment in which the sheep exist. The amount and type of VM in greasy wool are factors which result in price discounts. Depending on the severity and type of VM, wool may need to undergo additional processing called carbonising. Carbonising is a relatively complicated and expensive process whereby wool passes through sulphuric acid bowls and ovens before rollers crush the remaining brittle vegetable matter. Carbonising is slow and usually involves higher fibre loss than other processing methods. VM discounts are relatively minor for types testing less than 1.5%. Penalties apply when wools approach the 2 per cent level and rapidly increase when VM measures over 2 per cent, reflecting the higher processing costs and lower throughput for the processor (Woolcheque, n.d.).

### **2.8.8 Hauteur**

Hauteur (H) relates to the average fibre length that will be achieved when the wool has been processed. The estimated hauteur is closely correlated with the mean staple length and tensile strength of grease wool measured prior to processing. Hauteur affects the strength, appearance and surface characteristics of the yarn spun from it, and therefore the quality of the fabric and garments made from the yarn. Premium prices are paid for longer wools in the top, with discounts increasing as the estimated hauteur decreases (Woolcheque, n.d.).

### 2.8.9 Style

In the context of the valuation of wool in the trade, quality is defined as style. The concept of style comprises the definition and evenness of crimp, handle (or handling) and the presence of deviating fibres such as medullated or coloured fibres (De Beer, n.d.:14). Style is a subjective summation of all the physical characteristics of wool that are of some importance to the processor. The major components of style relate to the formation of the crimp (crimp frequency, crimp definition), the structure of the fleece (tip shape, staple structure), dust content (degree of dust penetration), weathering to the staple tip and wool colour (Schlink, 2009:14). Crimp frequency relates to the number of crimps per inch of the staple (Duerden, 1929). Crimp definition, also referred to as character, relates to how well-defined and even the crimps are (Schlink, 2009:14). Good-quality stylish wool, in contrast to that of inferior quality wool, deviates less from Duerden's standard and the crimps are even and well-defined.

For the purpose of this study, three grades of quality are defined, namely:

- **Good-quality** wool, showing a well-defined and regular crimp, a kind handle and the absence of deviating fibres.
- **Average-quality** wool, having an irregular or indistinct crimp with a dull appearance, a slight lack in handle and indication of deviating fibres.
- **Inferior-quality** wool, showing a lack of definition or regularity of crimp, harsh handle and the presence of medullated (kemp) and pigmented fibres.

### 2.8.10 Greasy colour

Greasy colour is important to processors, as only white product can be dyed to pastel shades, whereas off-coloured wools are restricted to darker colours. Wool colour is appraised subjectively as being either scourable or unscourable. Scourable colour will wash out in the early stages of processing (scouring) to give a creamy-white product. Grease wool with unscourable colour will result in an end-product that is off-white or yellow, even after washing. Brighter wools have a wider range of uses and often attract premium prices. Discounts for unscourable colour depend on the severity, with larger discounts for bright yellow colours. As with most faults, the finer the wool, the greater the discount (Woolcheque, n.d.).

### 2.8.11 Breed

Sheep breeds are grouped according to the type of wool they grow. This study focuses on four distinct breed categories that were identified based on the AWEX identification system, namely: 1) Merino, 2) Nondescript, 3) White-wool, and 4) Crossbreed.

- **Merino wool** is defined as a white wool that is by nature free from kemp (medullated fibres), with a fibre diameter of no more than 27 micron and exhibits all the characteristics of wool shorn from the Merino sheep. Merino sheep produce superior quality medium to ultrafine wool with excellent crimp definition, whiteness and handle.
- Wool shorn from sheep indigenous to the communal areas, where control over the movement of animals is limited or non-existent, will hereafter be referred to as **Nondescript wool**. Nondescript sheep breeds generally produce a medium to fine wool with poor to average quality. This breed category is often not free from kemp and pigmented fibres.
- **White-wool** refers to wool other than the Merino-type and is by nature free from pigmented and medullated fibres. White-wool breeds produce medium to strong white wool, which tends to be overly crimped, with a spongy handle or feel in comparison to Merino wool.
- **Crossbreed** wool refers to coarse and coloured wool, which by nature contains medullated and pigmented fibres. Crossbreed is more commonly known in the trade as carpet wools.

*Source:* (BKB, n.d.; De Beer, n.d.)

## 2.9 Heritability of wool attributes

Animal breeding involves selective breeding with the intention of improving desirable and heritable qualities or traits in the next generation. Differences in performance between animals can partly be explained by genetic differences between individuals. A trait is a distinguishing phenotypic characteristic belonging to an individual. Phenotype relates to any heritable trait that is observed or measured in an animal. Phenotype depends on both the genetic composition of the animal and external circumstances, such as level of nutrition (Oldenbroek and Van der Waaij, 2014:15). Heritability (h) indicates what proportion of the total phenotypic variation is due to genetic variation among individuals (Oldenbroek and Van der Waaij, 2014:104).

Visscher, Hill and Wray (2008:256) define heritability as the proportion of total variance in a population for a measurement that is attributable to variation in genetic values. It is possible to estimate the heritability of a trait in a population if phenotypes and genetic relationships (pedigree) are available (Oldenbroek and Van der Waaij, 2014:104).

The calculation of heritability estimates provides a means of quantifying the extent of the genetic contribution to phenotypic variation, with proportion ranging from 0 to 1. James, Ponzoni, Walkley and Whiteley (1990:583) estimate the heritability along with the phenotypic and genetic correlations for wool traits from a data set comprising 805 male and female progenies of 44 south Australian sires.

Findings of the afore-mentioned study were as follows:

- Greasy fleece weight (0.34 ±0.12)
- Clean fleece weight (0.39 ±0.13)
- Clean yield (0.41 ±0.13)
- Mean fibre diameter (0.42 ±0.13)
- Subjectively assessed fleece scores for greasy colour (0.64 ±0.17)
- Character (0.22 ±0.10)
- Handling (0.45 ±0.14)
- Quality (0.51 ±0.15)
- Wool condition (0.26 ±0.11)
- Staple formation (0.20 ±0.10)
- Tip formation (0.25 ±0.10)
- Density (0.44 ±0.13)

These estimates were in general agreement with other published works. The heritability of the measured wool characteristics is intermediate to high – indicating that genetic improvement in these characteristics will result from selective breeding (James *et al.*, 1990:586).

### **2.9.1 Heritability of fibre diameter**

Botha and Hunter (2010) explain that fibre diameter is dependent upon genetic factors (for example breed), as well as environmental (growth) factors, such as nutrition, climate, disease and lambing. Fibre diameter and length are related to feed intake for a sheep, while stress caused by climatic conditions (for example extreme cold), disease, hunger, insects, lambing *etcetera*, decrease diameter, often causing a sudden and localized decrease (break or tenderness) in fibre diameter.

### **2.9.2 Heritability of staple length and tensile strength**

Rose and Pepper (2000) found that staple length and tensile strength are moderately to highly heritable and should respond to selection. Greeff, Lewer, Ponzoni and Purvis (1995) reviewed estimates of genetic parameters for tensile strength of Merino sheep of different genotypes and in different environments. Tensile strength is moderately to highly heritable in both young and mature animals, varying from 0.23 to 0.51.

### **2.9.3 Heritability of variation in fibre diameter**

Wool fibres display considerable variation in fibre diameter, not only along their length (which can vary by up to 10µm) but also between fibres within a staple (mainly affected by genetic factors), between staples within a fleece and between fleeces within a flock (Botha and Hunter, 2010). Stobart, Russell, Larsen, Johnson and Kinnison (1986) found that variation in fibre diameter attributable to body region is only 2% to 15% of the total variation. Dunlop and McMahan (1974) found that the variation in fibre diameter across the body of the sheep accounts for only 6% to 12% of the total variation.

## **2.10 Summary**

Communal wool growers contribute about 8 per cent to the South African national clip of approximately 50 million kilograms per annum. Wool production, as a renewable and sustainable resource, has the potential to be a significant earner of income for rural communities in South Africa. Economic development in sustainable agricultural enterprises will increase food security, reduce poverty and improve the socio-economic status of households in the communal areas. Studies have shown that the quality and quantity of wool produced per sheep by communal sheep farmers are poor, resulting in low returns. Sources ascribe the low-quality wool produced to a wide range of contributing factors – with the most limiting factors being poor nutrition and the genetically inferior quality of the nondescript sheep breeds in the communal areas.

Literature on wool production in the communal areas of the Eastern Cape provides a broad overview of the problems, challenges and opportunities, however lacks geographic specificity. Development agencies require more detailed analyses on what interventions are needed and where to deploy resources to ensure optimum results. This study aims to provide more detailed information on these specific questions.

## CHAPTER 3: RESEARCH METHODOLOGY AND DESIGN

### 3.1 Introduction

This chapter describes the research design and methodology applied in this study, including data collection, validation and manipulation, and data analysis. The purpose of the study is to perform statistical analyses on the data set to answer the proposed research questions listed below.

The research methodology facilitates the attainment of the following research objectives:

- i) To establish whether there are statistically significant differences in price levels achieved by the NWGA regions.
- ii) To identify the contributing factors to which the observed differences in price levels could be ascribed.
- iii) To determine whether the observed differences are resultant of the genetic composition of the sheep.
- iv) To determine whether the observed differences are the result of the standard of wool classing practices applied by the respective shearing communities.

The genetic potential of sheep in terms of reproduction, growth and quality, as well as quantity of wool produced, is an essential element of a larger holistic approach towards increased wool production in communal areas.

### 3.2 Research design

Cavana, Delahaye and Sekaran (2001:107-108) explain that studies can either be exploratory or descriptive, or they can be conducted to test hypotheses. Cooper and Schindler (2003:146) explain that **exploratory studies** tend to have loose structures, with the objective of discovering future research tasks. The immediate purpose of exploration is to develop hypotheses or questions for future research. Exploratory studies are undertaken to better comprehend the nature of the problem that has been the subject of very few studies.

A **descriptive study** is undertaken in order to ascertain and be able to describe the characteristics of the variables of interest in a phenomenon (Cavana *et al.*, 2001:109). The descriptive study tends to be more structured, with a hypothesis and research question(s), and involves precise procedures and data source specifications. The purpose of a descriptive research design is to test the hypothesis and answer the research questions posed (Cooper and Schindler, 2003:146).

Collis and Hussey (2014:43-45) define a research paradigm as a framework that guides how research should be conducted, based on people's philosophies and their assumptions about the world and the nature of knowledge. There are two main paradigms, namely positivist and interpretive.

**Positivism** rests on the assumption that social reality is singular and objective, and is not affected by the act of investigating it. According to Cavana *et al.* (2001:8), positivist research uses precise, objective measurements and is usually associated with quantitative data. Data collection follows rigorous steps and the quantitative data are analyzed using statistical methods. Positivist research is based on deductive reasoning, beginning with a theoretical stance and moving towards concrete empirical evidence.

According to Collis and Hussey (2014:43-44) **interpretivism** is underpinned by the belief that social reality is not objective but highly subjective because it is shaped by our perceptions. Interpretivists believe that the act of investigating social reality influences it.

The current study is a descriptive case study underpinned by a positivist research design and is based on quantitative data. The data set includes collections of objectively measured numerical data (i.e. the grease price, weight and the objectively tested wool attributes) and categorical information (i.e. NWGA region of origin, wool category, breed category and style category).

### **3.3 Research population and sampling**

A population may refer to a body of people or to any other collection of phenomena under consideration for research purposes (Collis and Hussey, 2014:51). A sample is a subset of a population. It comprises some members selected from the population (Cavana *et al.*, 2001:253). The sample size dictates the amount of information available about the population and, therefore, determines the level of confidence the researcher has in the sample estimates. An estimate always has an associated level of uncertainty, which depends upon the underlying variability of the data set, as well as the sample size. The more variable the population, the greater the uncertainty in the estimate. Similarly, the larger the sample size, the more information is available and thereby the uncertainty decreases (Littler, n.d.).

In a positivist study, a sample must be representative of the population from which it is drawn and care should be taken to ensure that the sample is unbiased in the way it represents the phenomena under study (Collis and Hussey, 2014:51). The research population of this study relates to an estimated 40 000 small-scale wool producers operating in the study area. The research sample included 1 103 shearing communities who operated within the study area and marketed their wool through BKB during the period to which the study is delimited.

### **3.4 Data collection**

Depending on the nature of the data being collected and examined, two categories of data can be distinguished: quantitative and qualitative. Quantitative data present numerical or statistical data, while qualitative research presents interpretive data (Du Plooy-Celliers, Davis and Bezuidenhout, 2014:14). Babbie (2013:390) defines qualitative analysis as the non-numerical examination and interpretation of observations, for the purpose of discovering underlying meanings and patterns of relationships. According to Babbie (2013:414), quantitative analysis is the numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect.

According to the source from which the data originate, data can be either primary or secondary in nature. Primary data relate to data collected directly by the researcher and which have been collected for the analysis, which is then undertaken. Data gathered through existing sources are referred to as secondary data. That is data that already exist. Secondary data have undergone at least one level of interpretation between the recording and analysis of the data (Cavana *et al.* 2001:51; Collis and Hussey, 2014:196-197; Johnson and Wichern, 1997:166; Wisniewski, 1997:16).

The data collected to conduct this study are secondary in nature – involving wool production records obtained from South Africa’s foremost wool-brokering organization, BKB Ltd. The records examined and analyzed in this study are limited to wool received from wool growers who operate in the study area. The afore-mentioned production records extend over eight wool-marketing seasons. A wool-marketing season stretches from late August to mid-June the following year. The study was delimited to eight seasons, namely: 2009/10, 2010/11, 2011/12, 2012/13, 2013/14, 2014/15, 2015/16 and 2016/17. A total number of 1 103 shearing communities (commonly referred to as shearing sheds) participated in the study, from which 87 087 data points (*n*) were analyzed.

### **3.5 Data manipulation**

The data set analyzed in this study contained both numerical and categorical data. The numerical element of this data set includes the weight (measured in kilograms) and the objectively measured wool attributes of each lot. The objectively measured wool attributes – measured by the internationally accredited South African Wool Testing Bureau (WTB) – relate to the following:

- Mean fibre diameter ( $\mu$ )
- Coefficient of variation of fibre diameter (%)
- Schlumberger dry clean yield (%)
- Coefficient of variation of staple length (%)
- Mean staple length (mm)
- Tensile strength (nkt)
- Vegetable matter base (%)
- Estimated hauteur (mm)

The categorical element of the data set consists of three sets of categorical variables. The first set referred to the farmer's description of wool category (according to the body areas of the sheep from where the wool is shorn), which is allocated to each line by the wool classer, based on the NWGA's wool classing standards. The second set refers to the AWEX-ID type, which is allocated to each lot by a trained BKB wool appraiser. BKB uses the AWEX-ID system for the appraisal and description of non-measured wool characteristics. The third set of categorical variables indicates the geographical origin (according to municipal district) of the wool.

Categorical variables are not conventionally scaled attributes, which means these variables must be supplied with numerical values to be integrated into a regression equation. Dummy variables were used to represent the categorical data, i.e. 1) region of origin, 2) breed category, 3) wool category, and 4) style category.

### 3.5.1 Stratification of numerical data

#### 3.5.1.1 Grease price

Initially, a multiple linear regression was used to investigate the relationship between the response variable and several independent predictor variables. However, preliminary results indicated that the relationship between the dependent variable and independent variables is non-linear and that a logarithmic (or logit) regression model would be more appropriate to investigate the relationship.

The logit for the response variable (grease price) was calculated using the formula below:

$$fx = Ln\left(\frac{Y_{\max} - \hat{Y}}{\hat{Y}}\right)$$

Where:  $fx$  = Linear regression formula

$\hat{Y}$  = Predicted price

$Y_{\max}$  = Maximum price

$Ln$  = Natural logarithm

### 3.5.2 Stratification of categorical data

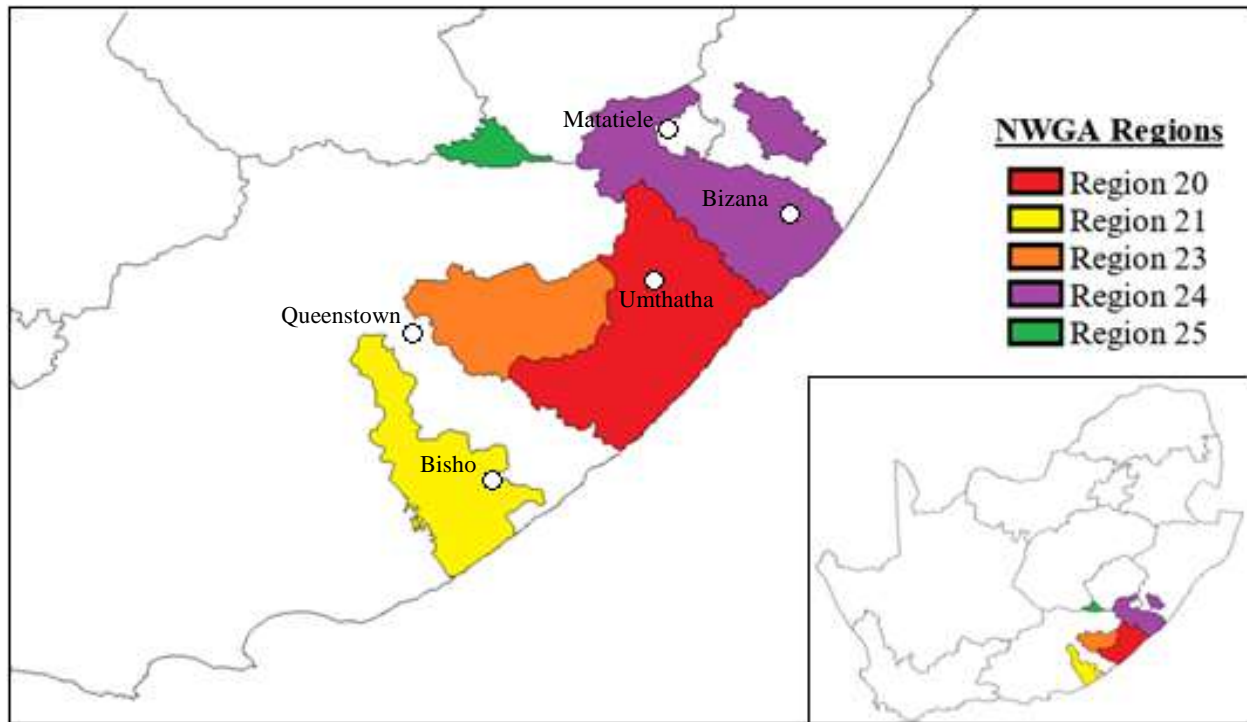
#### 3.5.2.1 Geographic regions

The study area consists of five NWGA regions, i.e. Region 20, Region 21, Region 23, Region 24 and Region 25 (see **Figure 3.1**). All the participating shearing communities were grouped according to the NWGA region they fall under. The wool production records used to conduct this study involves 87 087 data points obtained from the 1 103 shearing communities. **Table 3.1** shows the number of participating shearing communities operating within each NWGA region.

**Table 3.1:** Number of participating shearing communities per NWGA region

| <b>NWGA region</b>  | <b>Number of shearing communities</b> |
|---------------------|---------------------------------------|
| <i>Region 20</i>    | 271                                   |
| <i>Region 21</i>    | 100                                   |
| <i>Region 23</i>    | 439                                   |
| <i>Region 24</i>    | 226                                   |
| <i>Region 25</i>    | 67                                    |
| <b><i>Total</i></b> | <b>1 103</b>                          |

Each lot was categorized into one of the five NWGA regions, based on the municipal district from where the wool originates – as indicated by the original BKB data set. The bulk of the shearing communities reside within NWGA Regions 20, 23 and 24, with the minority residing within Regions 21 and 25.



**Figure 3.1:** Geographical service regions of the National Wool Growers' Association in the Eastern Cape with a small part of Region 24 resorting under Kwazulu-Natal  
*Source:* Du Pisani (2017)

### 3.5.2.2 Breed

The data points were classified into one of four distinct breed categories, based on the AWEX-ID assigned to each sale lot by the BKB wool appraiser. The four identified breed categories are: Merino, White-wool, Nondescript and Crossbreed. Dummy variables then used to introduce the breed category into the logit regression model as an independent variable. The use of dummy values is a useful method of introducing categorical information, contained in variables that are not conventionally measured on a numerical scale, into a regression analysis (Suits, 1957:548).

Three dummy variables were defined, namely:  $B_1$ ,  $B_2$  and  $B_3$ , with the property that  $B_n = 1$  if the wool originated from breed  $n$ ; otherwise  $B_n = 0$ . Merino wool is renowned for returning better prices and is therefore selected as the reference to which the other breed categories are compared. **Table 3.2** represents the breed classification system that was used in the study.

**Table 3.2:** Dummy variables used to represent breed type

|                    | <b>B1</b> | <b>B2</b> | <b>B3</b> |
|--------------------|-----------|-----------|-----------|
| <i>Merino</i>      | 0         | 0         | 0         |
| <i>White-wool</i>  | <b>1</b>  | 0         | 0         |
| <i>Nondescript</i> | 0         | <b>1</b>  | 0         |
| <i>Crossbreed</i>  | 0         | 0         | <b>1</b>  |

### 3.5.2.3 Clip composition

The individual sale lots were divided into one of five wool classing categories as indicated by the BKB wool appraiser with the AWEX-ID system. The wool classing category relates to the South African National Wool Growers Association's wool classing standards and indicates the description of wool in terms of fleeces, backs, bellies and pieces and locks. Wool shorn from skins, dead or plucked wool, yellow stained wool, matted wool and brands (wool stained with paint or marking fluid) were omitted from the study.

### 3.5.2.4 Style

The lots were also divided into one of three style categories, namely good-, average- and inferior-style. Good style wool was associated with the AWEX-ID styles 4 and 5, while average and inferior styles were associated with AWEX-ID styles 6 and 7, respectively. Dummy variables were used to introduce the style category into the logit regression model as an independent variable. Good style was selected as a reference to which the other styles were compared.

Two dummy variables were defined, namely:  $S_1$  and  $S_2$ , with the property that  $S_n = 1$  if the wool quality is considered style  $n$ ; otherwise  $S_n = 0$ . Good-style is selected as the reference category to which the other style categories are compared. **Table 3.3** represents the style classification system that was used in the research study.

**Table 3.3:** Dummy variables used to represent style category

|                       | <b>S1</b> | <b>S2</b> |
|-----------------------|-----------|-----------|
| <i>Good style</i>     | 0         | 0         |
| <i>Average style</i>  | 1         | 0         |
| <i>Inferior style</i> | 0         | 1         |

### **3.6 Statistical methods applied**

Several statistical techniques were used to determine whether statistically significant differences exist in price levels achieved by the various NWGA regions. Key features of these techniques are discussed below.

#### **3.6.1 Descriptive statistics**

Descriptive statistics involve the transformation of raw data into a more manageable form that would provide valuable information to describe a set of factors in a given situation (Cavana *et al.*, 2001:405). The characteristics of central tendency, spread and shape are helpful initial tools for cleaning the data, discovering problems and summarizing distributions (Cooper and Schindler, 2003:474). Descriptive statistics applicable to the data set of the current study may be viewed in the **Appendix**.

##### *3.6.1.1 Measures of central tendency*

The measures of central tendency used in this study are the mean and median. The **mean** is the arithmetic average of a set of data in a sample. It is a convenient way of describing a data set by means of a single value (Collis and Hussey, 2014:244).

The formula for calculating the mean is:

$$\bar{X} = \frac{\sum \chi}{n} = \frac{(X_1 + X_2 + X + \dots + X_n)}{n}$$

Where:  $\bar{X}$  = the mean value of the observations  
 $\chi$  = each observation  
 $n$  = the number of observations  
 $\Sigma$  = the sum of

The **median** is the midpoint of distribution. Wisniewski (1997:93) describes the median as a measure of average representing the middle value of a data set, which has been arranged in size order (ranked from lowest value to highest value or vice versa).

The formula for calculating the median is:

$$\text{Median} = \frac{n + 1}{2}$$

Where:  $n$  = the number of observations

### 3.6.1.2 Measures of variability

The measures of variability used in this study are range, interquartile range and standard deviation. **Range** refers to the difference between the maximum and the minimum value in the distribution. A larger range value implies potentially more variability in a data set compared to a data set with a smaller range value (Collis and Hussey, 2014:248).

**Standard deviation** (SD) is used to quantify the amount of variation or dispersion of values within a data set. It provides an indication of how far away the data points are from the mean. A low SD value indicates that the data points tend to be close to the mean of the data set, while a high SD value indicates that the data points are spread out over a wider range of values (Cavana *et al.*, 2001:410-411; Collis and Hussey, 2014:248-249; Cooper and Schindler, 2003:475; Wisniewski, 1997:95-99).

The formula for calculating sample standard deviation is:

$$s = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}$$

Where:  $s$  = sample standard deviation  
 $\bar{x}$  = the mean value of the observations  
 $x$  = an observation  
 $\sqrt{\quad}$  = the square root  
 $n$  = the total number of observations  
 $\Sigma$  = the sum of

According to Collis and Hussey (2014:248), the **interquartile range** is used to describe the variability of the observations within the data set. The median is the midpoint in an ordered data set. The median is the 50<sup>th</sup> per centile, given that this would be in the middle of the data set. The other two per centiles are the lower and upper quartiles, often denoted as  $Q_1$  and  $Q_3$  respectively. The lower quartile is the 25<sup>th</sup> per centile and the upper quartile is the 75<sup>th</sup>. This implies that, for any set of data, a quarter of the observations will have a numerical value that is below the lower quartile, a quarter between the lower quartile and median, a quarter between the median and the upper quartile, and a quarter above the upper quartile (Wisniewski, 1997:101). The interquartile range measures the spread of the middle 50 per cent of observations and is the difference between the upper and lower quartiles (Collis and Hussey, 2014:248).

### 3.6.2 Hypothesis testing

Hypothesis testing involves making educated guesses about a population, based on a sample drawn from it. Singh and Singh (2015:729) explain that hypothesis testing allows the researcher to draw inferences about the population parameters, using data from a sample. Hinton (2014) states that hypothesis testing follows a logical sequence of stages, from proposing the hypothesis to deciding whether to accept or reject it.

According to Wisniewski (1997:204), conducting a hypothesis test follows a logical sequence:

- Formulating the null and alternative hypotheses
- Determining a significance level
- Computing the test statistic
- Determining critical statistical value
- Interpreting the test statistic

### *3.6.2.1 Formulating the null and alternative hypotheses*

According to Hurlburt (1994:168), the null hypothesis (denoted  $H_0$ ) asserts that there is no difference or effect in the population parameter. Conversely, the alternative hypotheses assert that there is in fact a difference or effect in the population parameter. In this study, the null hypotheses states that no statistically significant differences exist in price levels achieved by the NWGA regions – and the alternative hypothesis states that significant differences do exist in price levels achieved by the NWGA regions.

### *3.6.2.2 Determining a significance level*

Hurlburt (1994:171) defines the significance level or alpha ( $\alpha$ ) as the risk or probability of rejecting the null hypothesis when it is true. There are two cases when a test result leads to an incorrect result or error (Cavana *et al.*, 2001:415, Collis and Hussey, 2014:255; Cooper and Schindler, 2003:525):

- $H_0$  is true, but the test leads to the rejection of the null hypothesis (referred to as a Type I error).
- $H_1$  is true, but the test leads to the acceptance of the null hypothesis (referred to as a Type II error).

Level of significance is the probability of making a Type I error. Collis and Hussey (2014:255) define significance level as the level of confidence that the result of a statistical analysis is not due to chance. The most frequently used levels of significance are 0.05 and 0.01. According to Cavana *et al.* (2001:415), the significance level ( $\alpha$ ) and the confidence level are related concepts. For example, a significance level of 5 per cent ( $\alpha = 0.05$ ) indicates that the confidence level is 95 per cent. A lower significance level (e.g.  $\alpha = 0.01$  or 1 per cent) indicates a higher confidence level (99 per cent) for the decision. In this study, the significance level is set at 5 per cent ( $\alpha = 0.05$ ), which indicates that the confidence level is 95 per cent. This means there is a 5 per cent chance that the null hypothesis is rejected, when, in fact, it is true.

### 3.6.2.3 Computing the test statistic

According to Hurlburt (1994:179),  $Z$ -scores and  $t$ -tests are frequently used parametric tests:  $Z$ -tests are used if the population standard deviation (denoted  $\sigma$ ) is known and  $t$ -test if  $\sigma$  is unknown. Cooper and Schindler (2003:535) state that when sample sizes approach 120 observations, the sample standard deviation becomes a very good estimate of the population standard deviation, beyond 120, the  $t$  and  $Z$  distributions are virtually identical. In this study, the afore-mentioned test statistics are referred to as the  $F$ -ratio.

The test statistic is computed as follows (Hurlburt, 1994:107):

$$t = \frac{\bar{X} - \mu}{\frac{s}{\sqrt{n}}}$$

Where:  $t$  = the test statistic which has  $n - 1$  degrees of freedom

$\bar{X}$  = any standardized variable

$\mu$  = mean value of standardized variable

$s$  = sample standard deviation

$\sqrt{\quad}$  = the square root

$n$  = the total number of observations

#### *3.6.2.4 Determining the critical statistical value*

Cooper and Schindler (2003:529) state that the test statistic is used to determine the critical value from the appropriate distribution table, with  $n - 1$  degrees of freedom. The critical value is the criterion that defines the region of rejection from the region of acceptance of the null hypothesis. Using the known distribution of the test statistic, the  $P$ -value is determined with the standard normal distribution table. Cooper and Schindler (2003:530) define the  $p$  value as the probability of observing a sample value as extreme as, or more extreme than, the value observed, given that the null hypothesis is true.

#### *3.6.2.5 Interpreting the test statistic*

Hurlburt (1994:142) explains that the test statistic is compared with the critical value, which is defined by the significance level  $\alpha$ . If the test statistic is more extreme than the critical value, there is sufficient evidence to reject the null hypothesis in favour of the alternative hypothesis. If the  $P$ -value is less than (or equal to)  $\alpha$ , then the null hypothesis is rejected in favour of alternative hypothesis. Alternatively, if the  $P$ -value is greater than  $\alpha$ , then the null hypothesis is accepted (Collis and Hussey, 2014:255). Therefore, a small  $P$ -value of less than 0.05 would suggest that an independent variable, such as breed or fibre diameter, does have a statistically significant effect on the price of wool.

### **3.6.3 Multiple regression analysis**

Collis and Hussey (2014:281-282) explain that the term regression refers to statistical models where the expected value of one variable  $Y$  is presumed to be dependent on one or more independent variables ( $x_1, x_2, \dots, x_n$ ). A linear regression model is based on an algebraic equation that allows a straight line to be drawn on a graph from information about the slope (the gradient of the line in relation to the horizontal axis) and the intercept (the point at which the line crosses the vertical axis). In a multiple regression model, the outcome in the dependent variable is predicted by more than one independent variable (Cooper and Schindler, 2003:614).

The equation below states the linear relationship between a dependent (response) variable  $Y$  and more than one independent (predictor) variables  $X_n$  (Cooper and Schindler, 2003:614):

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \dots + \beta_nX_n + \varepsilon$$

Where:  $Y$  = the dependent variable

$X$  = the independent variable(s)

$\beta_0$  = the intercept of the regression line on the vertical axis (the value of  $Y$  when all  $X$  values are zero)

$\beta_i$  = the slope of the regression line.  $\beta$  represents the regression coefficient associated with each  $X_i$

$\varepsilon$  = An error term. For purposes of computation,  $\varepsilon$  is assumed to be 0

Drawing on Wisniewski (1997:351-356) and Collis and Hussey (2014:282), the assumptions underpinning a multiple regression analysis can be summarized as follows:

- The response variable is a continuous quantitative variable (measured on a ratio or interval scale), but an independent (predictor) variable can be continuous or a dummy variable. Categorical variables can be used if they are first recoded as dummy variables.
- The predictor variables are independent from each other. There is no perfect multicollinearity between the independent variables. Multicollinearity refers to a situation in which two or more explanatory variables in a multiple regression model are highly linearly related. Perfect multicollinearity exists if the correlation between two independent variables is equal to +1 or -1.
- The regression errors have a constant variance. The errors ( $\varepsilon$ ) are simply the difference between each actual  $Y$  value and the expected  $Y$  value predicted by the regression equation. This assumption effectively means that the errors remain relatively constant over the entire range of data.
- The relationship between the dependent variable and the independent variables is linear.

Initially a multiple linear regression analysis was used to explore the relationship between the response variable (grease price) and several independent explanatory variables. However, preliminary results indicated that the relationship between the response variable and independent explanatory variables is non-linear, which means a key assumption of the linear equation was not met. To overcome this problem, the dependent variable was transformed into a logit, which allows a non-linear relationship to be expressed in a linear form.

According to Babbie (2013:491-492), the technique of log-linear models describes the interrelationships among variables and then compares expected vs observed values of the response variable. Log-linear analysis provides a means of identifying the relative importance of the explanatory variables in the logarithmic calculation.

The logarithmic equation used to conduct this study is as follows:

$$\hat{Y} = \frac{Y_{\max}}{1 + \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n)}$$

- Where:  $\hat{Y}$  = Predicted grease price       $Y_{\max}$  = Maximum observed price  
 $\beta_0$  = Intercept       $X_1$  = Exchange rate (\$)  
 $X_2$  = Mass (kg)       $X_3$  = Mean fibre diameter ( $\mu$ )  
 $X_4$  = Clean yield (%)       $X_5$  = Fibre diameter coefficient of variation (%)  
 $X_6$  = Vegetable matter base (%)       $X_7$  = Estimated hauteur (mm)  
 $X_8$  = White-wool       $X_9$  = Nondescript  
 $X_{10}$  = Crossbreed       $X_{11}$  = Inferior style  
 $X_{12}$  = Average style

In this study, the logarithmic regression analysis was used to establish the relative importance of the independent variables based on the beta coefficients.

### 3.6.4 Analysis of variance

Analysis of variance (ANOVA) is a statistical procedure used for testing the null hypothesis, which states that the means of two or more populations are equal (Hurlburt, 1994:256). The null hypothesis for the analysis of variance is that there is no statistically significant difference among the groups:

$$H_0: \mu_{Region20} = \mu_{Region21} = \mu_{Region23} = \mu_{Region24} = \mu_{Region25}$$

The alternative hypothesis ( $H_a$ ) states that there are significant differences among the group means. In other words, the null hypothesis is false.

The pairwise possibilities of rejecting the equality of means, taken two at a time, are as follows:  
 $\mu_{Region20} \neq \mu_{Region21}$  and/or  $\mu_{Region20} \neq \mu_{Region23}$  and/or  $\mu_{Region20} \neq \mu_{Region24}$  and/or  $\mu_{Region20} \neq \mu_{Region25}$   
and/or  $\mu_{Region21} \neq \mu_{Region23}$  and/or  $\mu_{Region21} \neq \mu_{Region24}$  and/or  $\mu_{Region21} \neq \mu_{Region25}$  and/or  $\mu_{Region23} \neq \mu_{Region24}$  and/or  $\mu_{Region23} \neq \mu_{Region25}$  and/or  $\mu_{Region24} \neq \mu_{Region25}$ .

As stated by Cooper and Schindler (2003:547), ANOVA uses squared deviations of the variance so that computation of distances of the individual data points from their own mean or from the grand mean can be calculated. In an ANOVA model, each group has its own mean and values that deviate from that mean. Similarly, all the data points from all the groups produce an overall grand mean. The total deviation is the sum of the squared differences between each data point and the overall grand mean. The total deviation of any particular data point may be partitioned into *between-group variance* and *within-group variance* (Cooper and Schindler, 2003:547).

According to Pattar, Raybagkar and Garg (2012:349), the variance of the data points for all of the groups is combined into one composite group variance known as the total group variance ( $V_t$ ). The mean value of the variance of each of the five groups, computed separately, is known as the within-group variance ( $V_w$ ). The difference between the total group variance and the within-group variance is known as the between-group variance ( $V_t - V_w = V_b$ ). The within-group variances represent the sampling error in the distributions and are also referred to as the error variance or residual. The between-group variance represents the influence of the variable of interest (Pattar *et al.*, 2012:349).

The F-ratio is computed with the formula below:

$$F = \frac{V_b}{V_w} = \frac{\text{Between group variance}}{\text{Within group variance}}$$

According to Hurlburt (1994:256), the critical values of  $F$  are determined using the  $F$ -distribution table that requires specification of two degrees of freedom. Cooper and Schindler (2003:547) explain that the degrees of freedom for the numerator – the mean squares between groups – is one less than the number of groups ( $k - 1$ ).

The degrees of freedom for the denominator – the mean square within groups – is the total number of observations minus the number of groups ( $n - k$ ). If the calculated  $F$  value is greater than the critical  $F$  value, the null hypothesis is rejected in favour of the alternative – with the conclusion that a significant difference does exist between the group means. Post hoc  $t$ -tests were performed if the analysis of variance identified a significant difference among groups. In this study, two-way analyses of variance were used to determine whether there are statistically significant differences among the group means. The level of significance  $\alpha$  was set at 0.05. Paired  $t$ -tests were conducted to identify which group means differ significantly from each other.

## **3.7 Model validation**

### **3.7.1 Method of least squares**

The method of least squares was used to fit the model to the data set. Cunningham (2016:44) defines the least squares method as a mathematical procedure for finding the best-fitting curve to a given set of data points by minimizing the sum of the squares of the offsets, known as the residuals of the points from the curve. A residual ( $e$ ), also referred to as an error, is the difference between the observed value of the dependent variable ( $Y$ ) and the predicted value ( $\hat{Y}$ ) (Hinton, 2014:299).

The formula for establishing the residual is as follows:

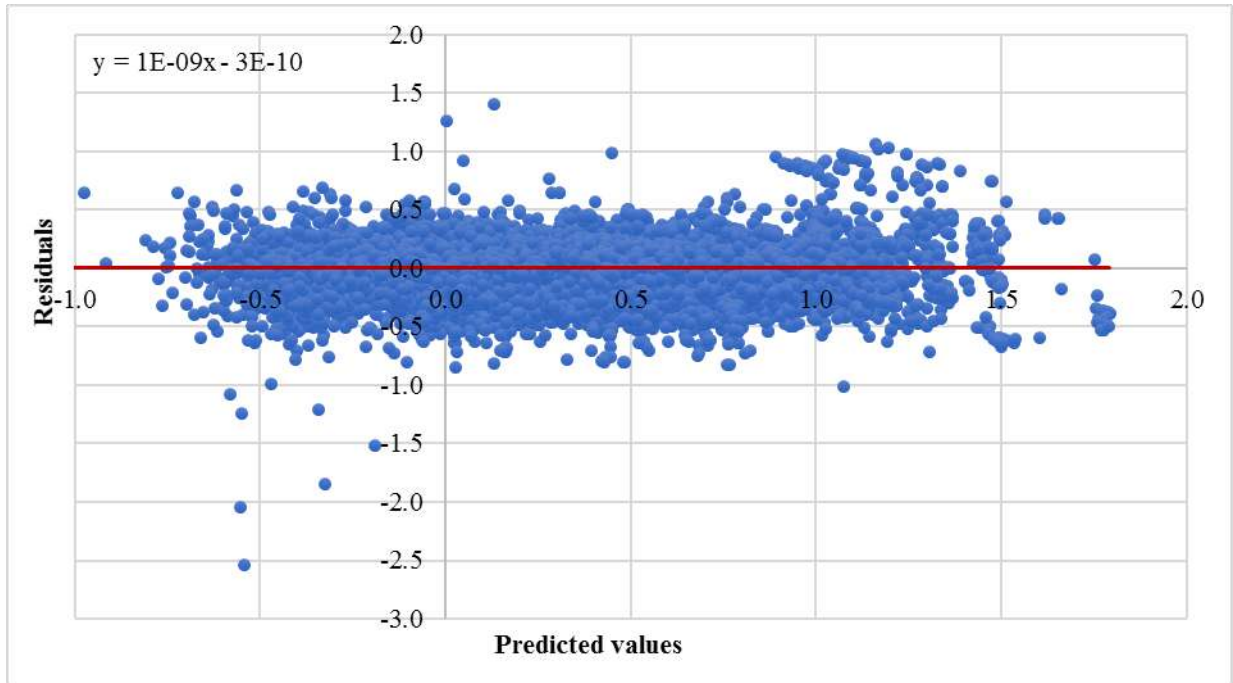
$$e = Y - \hat{Y}$$

The method of least squares is used to determine a regression line, or line of best fit, which will keep these errors to a minimum. **Figure 3.2** depicts a residual analysis in which the residuals,  $e$ , are plotted against  $\hat{Y}$ , the  $Y$  values predicted from the regression equation. The variation in the errors remain relatively constant over the  $\hat{Y}$  range. Therefore, the diagram indicates that the assumption of constant variance of the errors is being met in the analyses of the data set.

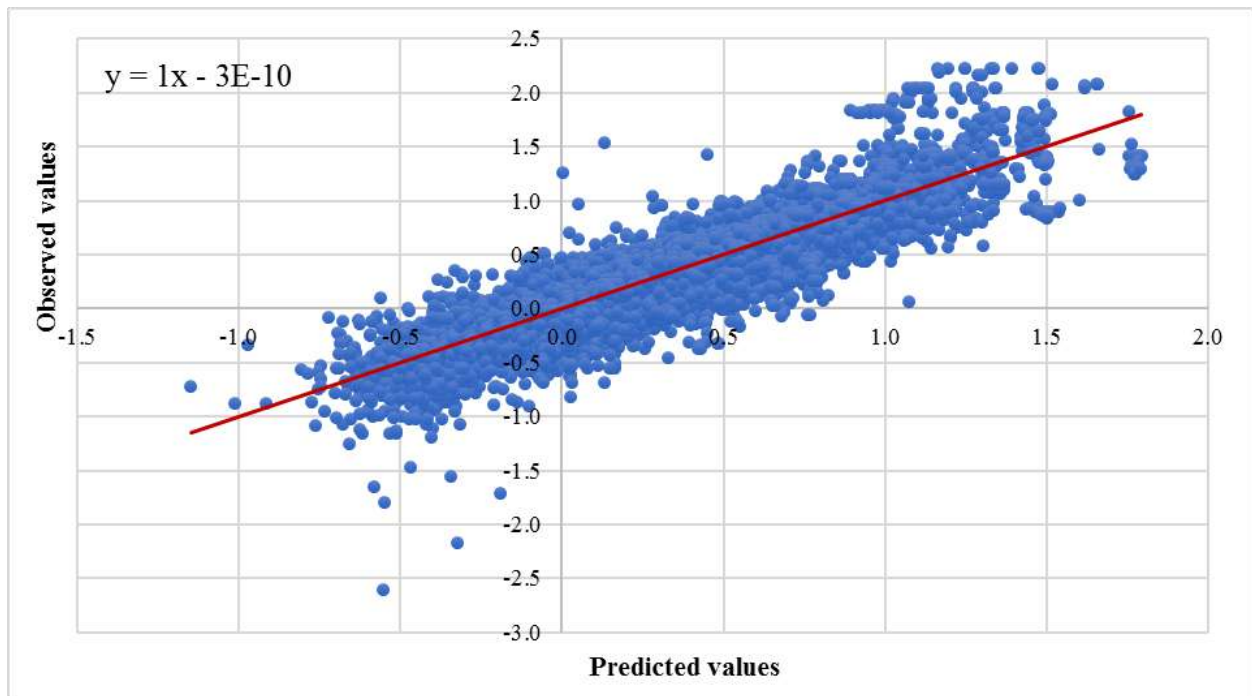
Wisniewski (1997:352) states that not having constant error variance is often an indication that some important explanatory variable has been omitted from the regression equation. The diagram also indicates that there is slight variation in the residuals for higher levels of  $\hat{Y}$  than for the low levels of  $\hat{Y}$  and relatively few outliers. However, the sheer volume of the data set annuls these observed discrepancies.

According to Piñeiroa, Perelman, Guerschman and Paruelo (2008:216), scatter diagrams depicting predicted vs observed values is one of the most common alternatives to evaluate model predictions. The scatter-plot in **Figure 3.3** illustrates the observed values vs the predicted values from the regression model. The analysis of the coefficient of determination ( $r^2$ ), the slope and the intercept of the line fitted to the data provides elements for judging and building confidence on model performance (Piñeiroa *et al.*, 2008:316).

The Pearson correlation coefficient was used to validate the association between the response variable and explanatory variables to build confidence in the prediction model. According to Collis and Hussey (2014:343), the Pearson correlation coefficient is a parametric test used to measure strength and direction of the linear association between two continuous variables. Cavana *et al.* (2001:321) state that the correlation coefficient varies between  $-1$  and  $+1$ . A value of  $-1$  indicates a perfect negative correlation and  $+1$  indicates a perfect positive correlation. A zero value implies literally no correlation between the variables (Wisniewski, 1997:322).



**Figure 3.2:** Scatter diagram depicting residuals vs predicted values from the regression equation



**Figure 3.3:** Scatter diagram depicting observed vs predicted values

The correlation coefficient in this study ( $r = 0.92$ ), indicates a near perfect linear association between the response variable (grease price) and the independent explanatory variables. The coefficient of determination (denoted  $r^2$ ) shows the proportion of the total variance explained by the regression model (Piñeiroa *et al.*, 2008:216). The  $r^2$  is actually the square of the regression coefficient (Hinton, 2014:254). The coefficient of determination in this study ( $r^2 = 0.84$ ) indicates that 84 per cent of the variation in grease price is explained by the variation of the independent explanatory variables.

### **3.8 Summary**

This chapter dealt with the methodology adopted in conducting the research study. Included in this chapter was an overview of the research design selected in this study. A description of the research population and sampling methods was followed by a synopsis of data collection and manipulation procedures applied. This chapter also provided an overview of the statistical methods and model validation techniques applied to conduct the study.

This descriptive study was conducted within the positivist research paradigm based on quantitative data. The estimated 40 000 small-scale wool growers operating in the study area constitute the study population. The research sample comprises 1 103 shearing communities, from which 87 087 data points ( $n$ ) were collected and analyzed. The data set consists of wool production records, obtained from the leading South African wool-brokering company, BKB Ltd, delimited to eight wool-marketing seasons. A logit regression analysis was performed to establish whether statistically significant differences exist in price levels achieved by the NWGA regions. The most important predictor variables were identified, based on the beta coefficients calculated by the regression model. Analyses of variance and t-test analyses were performed on the predictor variables to determine whether these factors are attributive to the observed differences in price levels achieved by the NWGA regions.

## CHAPTER 4: FINDINGS AND RESULTS

### 4.1 Introduction

In this chapter, the results and subsequent findings are presented and discussed with reference to the four research questions (the main research question and 3 sub-questions):

- i) Are there statistically significant differences in price levels achieved by the various NWGA regions?
- ii) If so, what are the contributing factors to the observed differences in price levels achieved by NWGA regions?
- iii) Can the observed differences be attributed to the genetic composition of the sheep?
- iv) Can the observed differences be attributed to the standard of wool classing practices applied by the respective shearing communities?

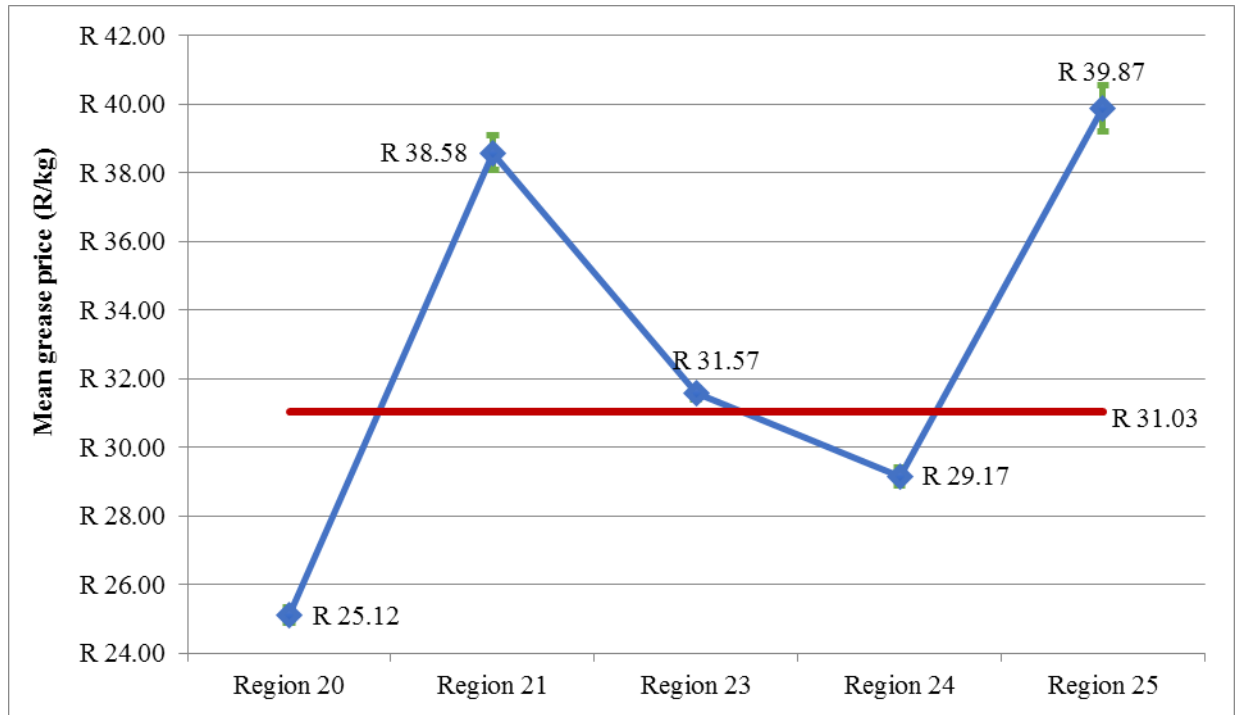
### 4.2 Research question 1: Are there statistically significant differences in price levels achieved by the five NWGA production regions?

A one-way ANOVA analysis was carried out on 87 087 observations to test this hypothesis. Results of the ANOVA analysis on the grease price across all breed and wool categories are depicted below in **Table 4.1**.

**Table 4.1:** One-way ANOVA table showing statistical parameters for mean grease price per NWGA region

| <i>Groups</i>              | <i>Count</i>  | <i>Average (R)</i> |            | <i>Variance</i> |                |                   |
|----------------------------|---------------|--------------------|------------|-----------------|----------------|-------------------|
| <i>Region 20</i>           | 14 890        | 25.12              |            | 186.85          |                |                   |
| <i>Region 21</i>           | 7 818         | 38.58              |            | 519.13          |                |                   |
| <i>Region 23</i>           | 41 370        | 31.57              |            | 329.33          |                |                   |
| <i>Region 24</i>           | 18 413        | 29.17              |            | 335.46          |                |                   |
| <i>Region 25</i>           | 4 601         | 39.87              |            | 539.67          |                |                   |
| <i>Source of Variation</i> | <i>df</i>     | <i>SS</i>          | <i>MS</i>  | <i>F</i>        | <i>P-value</i> | <i>F critical</i> |
| Between Groups             | 4             | 1 402 384          | 350 595.93 | 1 048.39        | 0              | 2.37              |
| Within Groups              | 87 087        | 29 123 150         | 334.41     |                 |                |                   |
| <b>Total</b>               | <b>87 091</b> | <b>30 525 534</b>  |            |                 |                |                   |

**Figure 4.1** shows the mean grease price per NWGA region across all breed and wool categories, with 95 per cent confidence intervals. The red line in the figure below represents the grand mean for all the NWGA regions collectively. Two-tailed Student's t-tests were performed to determine which NWGA regions differ significantly.



**Figure 4.1:** Mean grease price across all breed and wool categories per NWGA region

**Interpretation:** The F-ratio of 1 048.39, with 4 and 87 087 degrees of freedom, is more extreme than the critical value (2.37) and is therefore statistically significant at a p-value of less than 0.001. This means that a statistically significant difference exists in the population means of at least two NWGA regions. **Table 4.2** presents the test statistics, critical values and p-values of the two-sample t-tests carried out on the mean grease price of the various NWGA regions.

**Table 4.2:** T-test scores and p-values comparing mean grease price of the NWGA regions

| <b>Alternative hypothesis</b> | <b>t stat</b> | <b>Critical value<br/>(two-tail)</b> | <b>p-value</b> |
|-------------------------------|---------------|--------------------------------------|----------------|
| Ha: $\mu_{20} = \mu_{21}$     | -47.92        | 1.96                                 | p < 0.001      |
| Ha: $\mu_{20} = \mu_{23}$     | -45.08        | 1.96                                 | p < 0.001      |
| Ha: $\mu_{20} = \mu_{24}$     | -23.10        | 1.96                                 | p < 0.001      |
| Ha: $\mu_{20} = \mu_{25}$     | -40.95        | 1.96                                 | p < 0.001      |
| Ha: $\mu_{21} = \mu_{23}$     | 25.71         | 1.96                                 | p < 0.001      |
| Ha: $\mu_{21} = \mu_{24}$     | 32.36         | 1.96                                 | p < 0.001      |
| Ha: $\mu_{21} = \mu_{25}$     | -3.01         | 1.96                                 | p < 0.01       |
| Ha: $\mu_{23} = \mu_{24}$     | 14.85         | 1.96                                 | p < 0.001      |
| Ha: $\mu_{23} = \mu_{25}$     | -23.46        | 1.96                                 | p < 0.001      |
| Ha: $\mu_{24} = \mu_{25}$     | -29.08        | 1.96                                 | p < 0.001      |

*Bold text indicates that no statistically significant difference exists*

*All t-tests assume unequal variance between groups*

**Interpretation:** The test statistic of 47.92 between Region 20 and 21 is more extreme than the critical value of 1.96 – indicating that, at a significance level of less than 0.001, statistically significant differences exist between the population means of these two regions.

The following conclusions are drawn from the results depicted above:

- The ANOVA shows that statistically significant differences exist in the average price levels achieved by the respective NWGA regions. Hence, the alternative hypothesis is accepted.
- Ranked from the lowest to the highest average grease price, the regions fared as follows: Region 20 (R25.12/kg) returned the lowest average grease price, followed progressively by Region 24 (R29.71/kg), Region 23 (R31.57/kg), Region 21 (R38.58/kg) and Region 25 (R39.87/kg).

### 4.3 Research question 2: What are the contributing factors to the observed differences in price levels among the NWGA regions?

The second research question aims to identify the contributing factors to the observed statistically significant differences in the price levels achieved by the NWGA regions. To achieve this, a logit regression analysis was performed.

**Table 4.3** shows the test results of the regression model based on 63 909 observations in the data set of the fleece and backs wool across all of breed categories. The other wool classing categories, which are bellies and pieces, and locks, were omitted from further testing. Grease price was used as the response variable.

**Table 4.3:** Summary output of logit regression model

| Multiple R = 0.91758169         |        | R square = 0.84195616 |        | Adjusted R square = 0.84192648  |           |         |
|---------------------------------|--------|-----------------------|--------|---------------------------------|-----------|---------|
| F (12, 63896) = 28 366          |        | P-value < 0.0000      |        | Std. Error of estimate: 0.14854 |           |         |
|                                 | b*     | Std. Err.             | b      | Std. Error                      | t (87072) | p-value |
| Intercept                       |        |                       | -0.575 | 0.020                           | -28.268   | 0.000   |
| Mass (kg)                       | -0.120 | 0.002                 | 0.000  | 0.000                           | -71.398   | 0.000   |
| Exchange rate (\$)              | -0.474 | 0.002                 | -0.063 | 0.000                           | -297.903  | 0.000   |
| Mean fibre diameter ( $\mu$ )   | 0.155  | 0.002                 | 0.071  | 0.001                           | 72.194    | 0.000   |
| CV of fibre diameter (%)        | 0.225  | 0.003                 | 0.022  | 0.000                           | 85.300    | 0.000   |
| Clean yield (%)                 | -0.087 | 0.003                 | -0.005 | 0.000                           | -30.867   | 0.000   |
| Vegetable matter base (%)       | 0.056  | 0.002                 | 0.029  | 0.001                           | 32.138    | 0.000   |
| Estimated hauteur (mm)          | -0.153 | 0.003                 | -0.006 | 0.000                           | -59.587   | 0.000   |
| <b><i>White-wool breed</i></b>  | 0.004  | 0.002                 | 0.026  | 0.010                           | 2.486     | 0.013   |
| <b><i>Nondescript breed</i></b> | 0.224  | 0.002                 | 0.217  | 0.002                           | 95.372    | 0.000   |
| <b><i>Crossbreed</i></b>        | 0.311  | 0.002                 | 0.472  | 0.003                           | 135.871   | 0.000   |
| <b><i>Average style</i></b>     | 0.017  | 0.003                 | 0.013  | 0.002                           | 5.526     | 0.000   |
| <b><i>Inferior style</i></b>    | 0.081  | 0.004                 | 0.061  | 0.003                           | 20.784    | 0.000   |

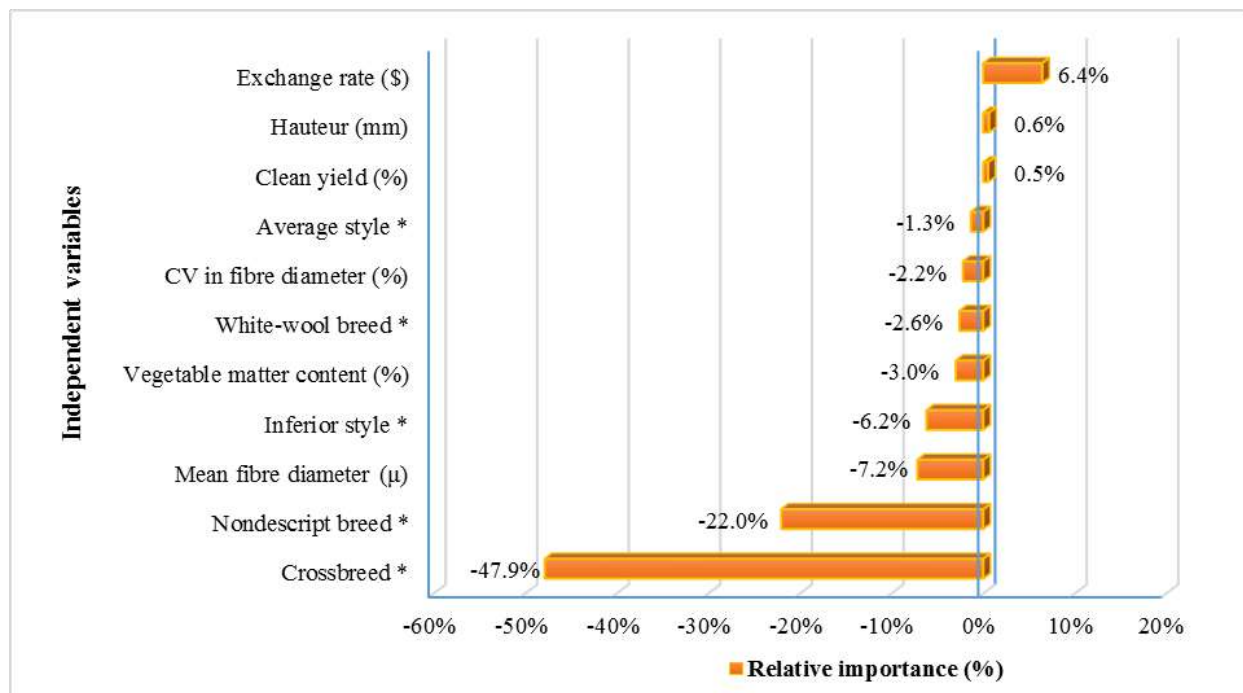
*Categorical variables are indicated bold italic text.*

**Interpretation:** The correlation coefficient (R), coefficient of determination ( $R^2$ ) and F-ratio were examined to determine the goodness-of-fit of the data to the regression line. The regression model achieved satisfactory levels of goodness-of-fit to the data set by explaining the variance of the response variable in relation to the independent variables.

- The correlation coefficient of  $R = 0.9176$  suggests that a strong positive correlation exists among the dependent and independent variables.
- The coefficient of determination of  $R^2 = 0.842$  indicates that 84.2 per cent of the variance of the dependent variable is statistically explained by knowledge of the independent variables.
- The F-ratio with a value of 28 366, with 12, 63896 degrees of freedom, is highly statistically significant with a p-value of less than 0.001.

The regression model investigates two categorical variables, namely: breed and style. The breed category represents four distinct sub-categories, namely: White-wool, Nondescript, Crossbreed and Merino (with Merino as the reference category). Similarly, the style category comprises three distinct sub-categories, namely: inferior style, average style and good style (with good style as the reference category).

**Figure 4.2** shows the relative importance of the independent variables in the regression equation. It is important to mention that the reference categories of the categorical variables are not featured in **Table 4.2** (and **Figure 4.2**) as independent variables because these categories serve as the baseline to which the corresponding categories are compared. The categorical variables in the figure below are indicated by the symbol \*.



**Figure 4.2:** Pareto chart showing the relative importance of the independent explanatory variables in the logit regression model

**Interpretation:** Standardized beta coefficients were used to demonstrate the relative importance of the independent explanatory variables in accounting for variation in the response variable (grease price). Results of the analysis of relative importance indicate the following:

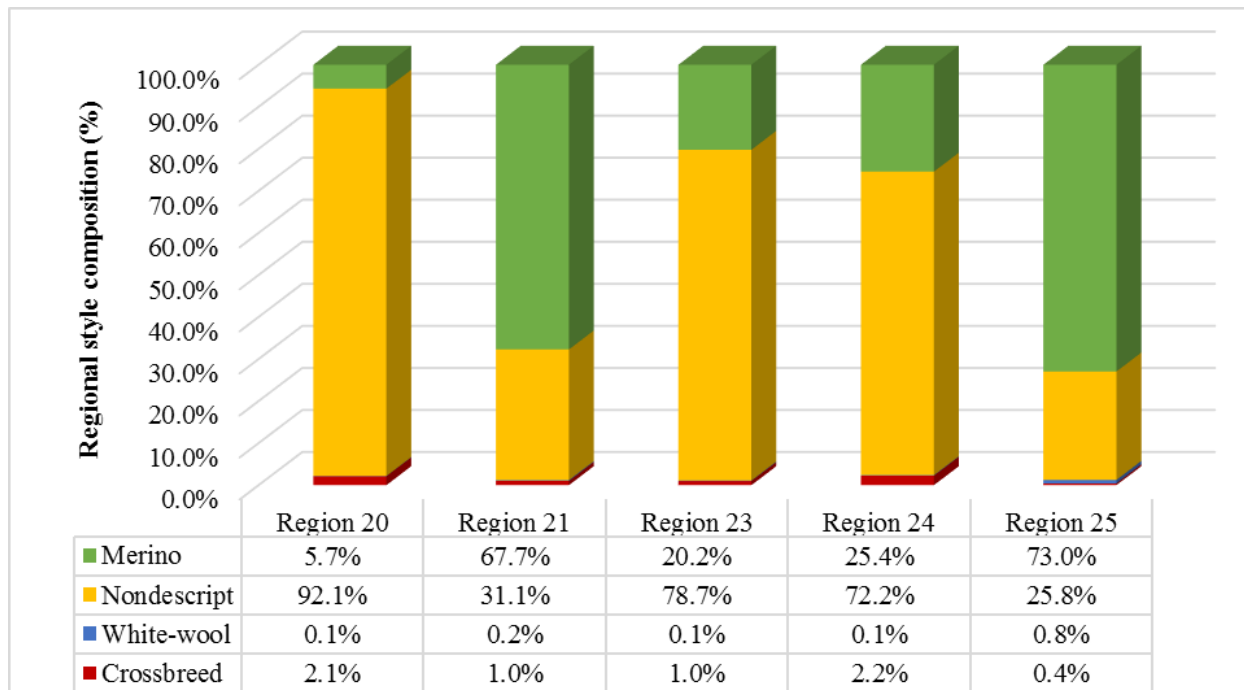
- Breed type proves to be the most influential independent variable in the regression model, explaining 72.5 per cent of the variation in the response variable. White-wool type (-2.6%), Nondescript type (-22.0%) and Crossbreed type (-47.9%) all affect grease price negatively compared to the reference category, which is Merino wool. Thus, it can be concluded that the higher the percentage of Merino wool in a clip, the higher the average grease price will be, while an increase in the percentage of White-wool, Nondescript or Crossbreed wool in a clip will result in a decrease in grease price.
- The model identified style as the second-most important independent variable and this explanatory variable explains 7.5 per cent of the variation in grease price. Average style (-1.3%) and interior style (-6.2%) affect the price of grease wool negatively, when compared to the good-style wool.

- Mean fibre diameter is the third-most important predictor variable in the regression model, explaining 7.2 per cent of the variation in grease price. Fibre diameter is negatively correlated with the response variable, which means that an increase in mean fibre diameter will result in a decrease in price.
- All the other explanatory variables, i.e. coefficient of variation in fibre diameter, hauteur, clean yield and vegetable matter base, each explained less than 4 per cent of the variation in grease price. This does not mean that these variables are not important price-determining factors of grease wool. However, as is evident from the ANOVA and t-tests, the population means for these variables differ statistically significant between the NWGA regions, indicating that the observed differences are not due to chance.
- The exchange rate between the US Dollar and the South African Rand (+6.4) was identified as a significant independent variable in the regression model. It is positively correlated with the response variable – which means that a weakening in the Rand against the US Dollar will result in higher wool prices for South African wool growers. However, because the exchange rate is beyond the control of the wool grower, it was omitted from further tests in the study.

The section below investigates the most important explanatory variables that were identified by the logit regression model. One-way ANOVA analyses were performed on each important independent variable to ascertain whether these variables contribute significantly to the observed differences in price levels achieved by the NWGA regions. The one-way ANOVA analyses and T-tests were delimited to all wool and breed categories delivered during the 2016/2017 wool-selling season.

### 4.3.1 Breed

The logit regression model identified breed as the most important price-determining factor in the regression model. Is breed contributive to the statistically significant differences observed in price levels achieved by the NWGA regions? **Figure 4.3** exhibits the regional breed composition, based on 13 492 observations of all wool types delivered during the 2016/2017 wool-selling season.



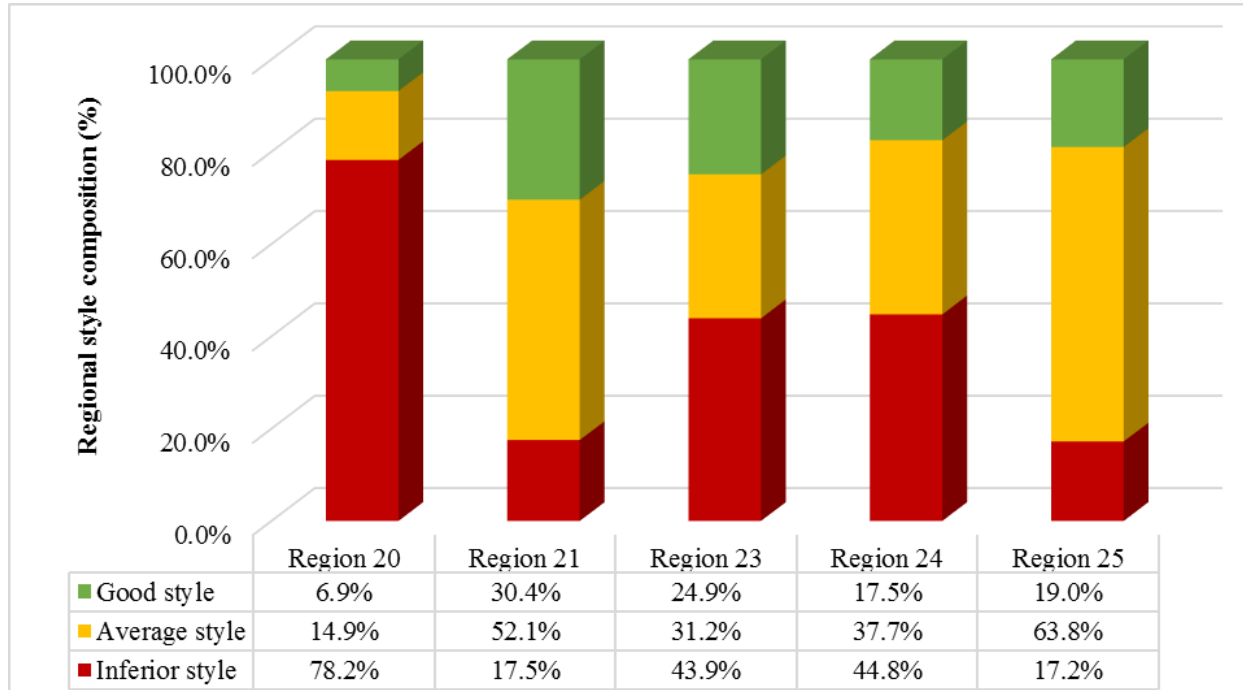
**Figure 4.3:** Regional breed composition of the study area

**Interpretation:** Breed type is a major contributing factor to the observed differences in price levels amongst the NWGA regions. The following conclusions are drawn from **Figure 4.3**:

- Region 20 produces predominantly Nondescript wool (92.1%) and only 5.7 per cent Merino wool. This region also produces significantly less Merino wool compared to any other NWGA region.
- Regions 23 and 24 mostly produce Nondescript wool. However, these regions produce more than four times more Merino wool compared to Region 20.
- Regions 21 and 25 produce predominantly Merino wool and produce significantly lower volumes of Nondescript wool. The latter breed type accounts for approximately a third of the region’s overall wool production.

### 4.3.2 Style

Style was identified as the second-most important explanatory variable in the regression model. Is style attributive to the observed differences in price levels achieved by the NWGA regions? **Figure 4.4** shows the regional style composition, based on 13 492 observations of all wool types delivered during the 2016/2017 wool-selling season.



**Figure 4.4:** Regional style composition of the study area

**Interpretation:** Style is a significant price-determining factor which contributes significantly to the observed differences in price levels achieved by the respective NWGA regions. The following conclusions are drawn from **Figure 4.4:**

- Region 20 produces predominantly wool of inferior style (78.2%) and average style (14.9%). This region manages to produce only 6.9 per cent good-style wool.
- Regions 23 and 24 produces predominantly inferior-style (43.9% and 44.8%, respectively) and average-style (31.2% and 37.7%, respectively) wool. However, these regions produce more than double the volume in good-style wool than NWGA Region 20.

- On the other hand, Regions 21 and 25 produces predominantly good-style (30.4% and 19%, respectively) and average-style (52.1% and 63.8%, respectively) wool. Noticeably lower volumes of inferior-style (17.5% and 17.2%, respectively) wool are produced by these two regions when compared to the other three regions.

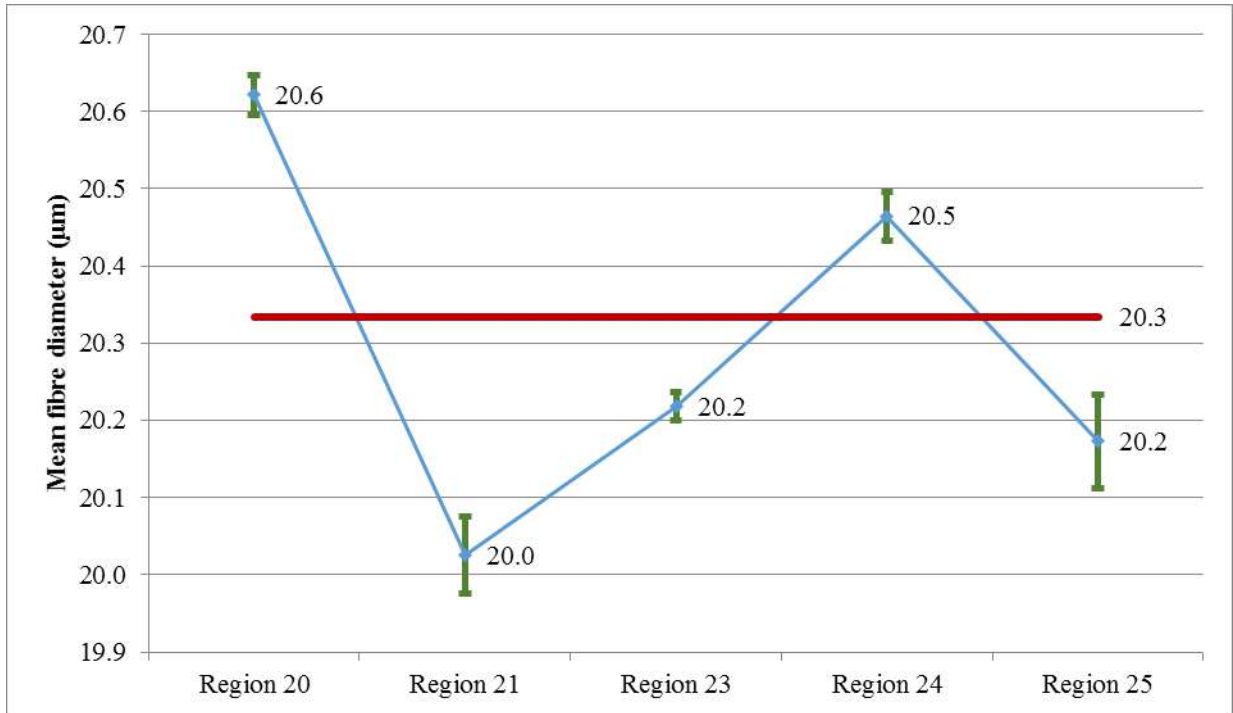
### 4.3.3 Mean fibre diameter

A one-way ANOVA analysis was conducted on mean fibre diameter and the results are presented in **Table 4.4**. **Figure 4.5** shows mean fibre diameter per NWGA region with a 95 per cent confidence intervals. The red line in the figure below represents the grand mean for all the NWGA regions collectively.

**Table 4.4:** ANOVA table showing statistical parameters for mean fibre diameter

| <i>Groups</i>              | <i>Count</i>  | <i>Average (<math>\mu</math>)</i> |           | <i>Variance (<math>\mu</math>)</i> |                |                   |
|----------------------------|---------------|-----------------------------------|-----------|------------------------------------|----------------|-------------------|
| <i>Region 20</i>           | 2 734         | 20.6                              |           | 0.46                               |                |                   |
| <i>Region 21</i>           | 1 107         | 20.0                              |           | 0.72                               |                |                   |
| <i>Region 23</i>           | 6 107         | 20.2                              |           | 0.51                               |                |                   |
| <i>Region 24</i>           | 2 853         | 20.5                              |           | 0.74                               |                |                   |
| <i>Region 25</i>           | 691           | 20.2                              |           | 0.66                               |                |                   |
| <i>Source of Variation</i> | <i>df</i>     | <i>SS</i>                         | <i>MS</i> | <i>F</i>                           | <i>P-value</i> | <i>F critical</i> |
| Between Groups             | 4             | 479.99                            | 120.00    | 210.44                             | 1.94E-175      | 2.37              |
| Within Groups              | 13 487        | 7 690.55                          | 1         |                                    |                |                   |
| <b>Total</b>               | <b>13 491</b> | <b>8 170.55</b>                   |           |                                    |                |                   |

**Interpretation:** The F-ratio of 210.44, with 4 and 13 487 degrees of freedom, is more extreme than the critical value of 2.37, and is therefore highly statistically significant at a p-value of less than 0.001. This substantiates the alternative hypothesis and it is concluded that a significant difference exists between the population means of at least two NWGA regions in terms of mean fibre diameter.



**Figure 4.5:** Population means of mean fibre diameter per NWGA region

A series of post-hoc t-tests was performed to determine whether the population means are statistically significantly different. **Table 4.5** exhibits the t-test scores, critical values and p-values associated with the t-tests performed on the population means of fibre diameter.

**Table 4.5:** T-test scores and p-values comparing mean fibre diameter

| Alternative hypothesis                      | t stat       | Critical value (two-tail) | p-value        |
|---|--------------|---------------------------|----------------|
| Ha: $\mu_{20} = \mu_{21}$                   | 20.862       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{23}$                   | 25.516       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{24}$                   | 7.612        | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{25}$                   | 13.397       | 1.96                      | p < 0.001      |
| Ha: $\mu_{21} = \mu_{23}$                   | -7.129       | 1.96                      | p < 0.001      |
| Ha: $\mu_{21} = \mu_{24}$                   | -14.580      | 1.96                      | p < 0.001      |
| Ha: $\mu_{21} = \mu_{25}$                   | -3.688       | 1.96                      | p < 0.001      |
| Ha: $\mu_{23} = \mu_{24}$                   | -13.342      | 1.96                      | p < 0.001      |
| <b>Ha: <math>\mu_{23} = \mu_{25}</math></b> | <b>1.406</b> | <b>1.96</b>               | <b>0.16004</b> |
| Ha: $\mu_{24} = \mu_{25}$                   | 8.377        | 1.96                      | p < 0.001      |

*Bold text indicates that no statistically significant difference exists  
All t-tests assume unequal variance between groups*

**Interpretation:** Mean fibre diameter is a significant price-determining factor which contributes significantly to the observed differences in price levels achieved by the NWGA regions.

The following conclusions are drawn from the ANOVA and paired t-tests:

- Regions 20 (20.6 $\mu$ ) and 24 (20.5 $\mu$ ) produce on average coarser wool compared to the other NWGA regions.
- Region 21 (20.0 $\mu$ ) produces on average finer wool compared to the other NWGA regions.
- Based on the test statistic from the t-test it is concluded that the population means of Regions 23 and 25 for mean fibre diameter are equal at 20.2 $\mu$  (p-value = 0.16004).
- The practical difference between the lowest and highest value for mean fibre diameter is relatively small. However, results from the statistical analyses indicate that statistically significant differences exist, which suggests that these differences are not due to chance and that this wool attribute contributes significantly to the observed differences in price levels achieved by the respective NWGA regions.

#### **4.3.4 Vegetable matter base**

The regression analysis indicated that the percentage vegetable matter base explains 3 per cent of the variation in grease price. Vegetable matter base is an environmental factor, because it is related to the grazing conditions and subsequent environment in which the sheep exist. The percentage of vegetable matter present in grease wool is not influenced by the genetic composition of the sheep, nor the standard of classing applied by the wool classer.

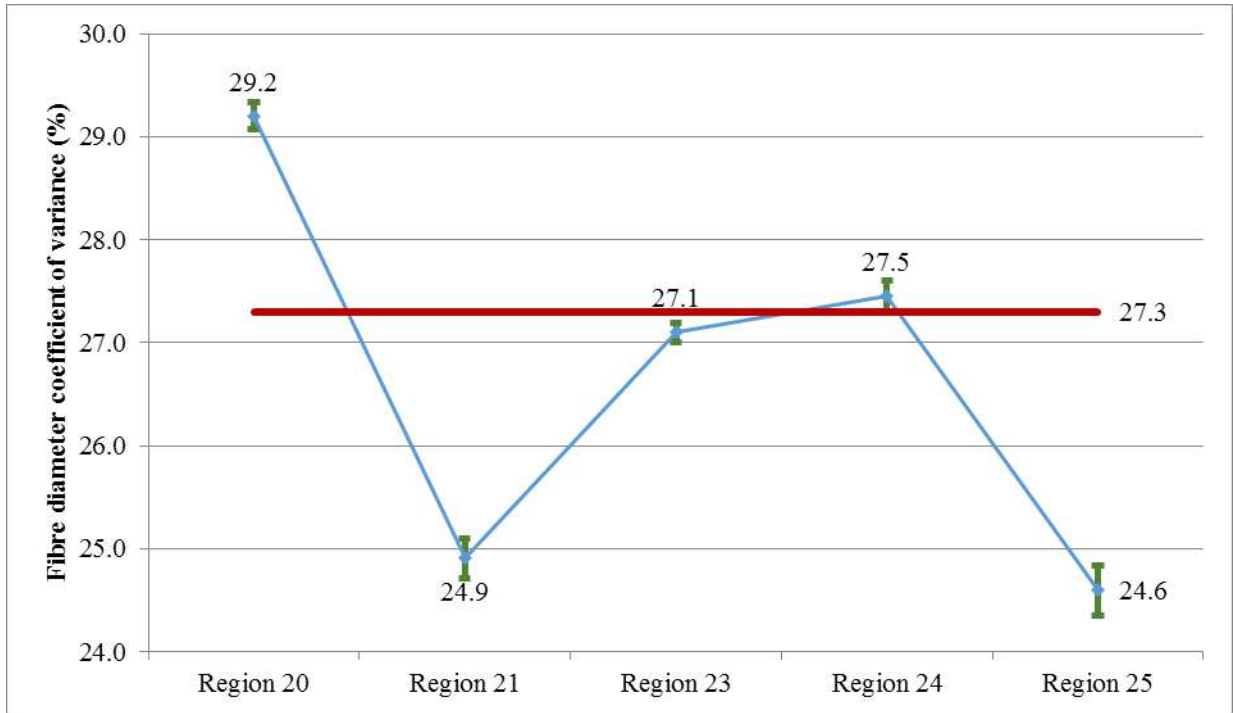
### 4.3.5 Variation in fibre diameter

A one-way ANOVA was performed on the mean coefficient of variation in fibre diameter and the results are presented in **Table 4.6**.

**Table 4.6:** ANOVA table showing statistical parameters for mean coefficient of variation in fibre diameter

| <i>Groups</i>              | <i>Count</i>  |                   |           | <i>Average</i> |                |                   | <i>Variance</i> |
|----------------------------|---------------|-------------------|-----------|----------------|----------------|-------------------|-----------------|
| <i>Region 20</i>           | 2734          |                   |           | 29.2           |                |                   | 13.1            |
| <i>Region 21</i>           | 1107          |                   |           | 24.9           |                |                   | 11.0            |
| <i>Region 23</i>           | 6107          |                   |           | 27.1           |                |                   | 13.2            |
| <i>Region 24</i>           | 2853          |                   |           | 27.5           |                |                   | 16.2            |
| <i>Region 25</i>           | 691           |                   |           | 24.6           |                |                   | 10.7            |
| <i>Source of Variation</i> | <i>df</i>     | <i>SS</i>         | <i>MS</i> | <i>F</i>       | <i>P-value</i> | <i>F critical</i> |                 |
| Between Groups             | 4             | 21 581.86         | 5395.47   | 399.36         | 0.00           | 2.37              |                 |
| Within Groups              | 13 487        | 182 210. 87       | 13.51     |                |                |                   |                 |
| <b>Total</b>               | <b>13 491</b> | <b>203 792.73</b> |           |                |                |                   |                 |

**Interpretation:** The F-ratio of 399.36, with 4 and 13 487 degrees of freedom, is more extreme than the critical value of 2.37, and is therefore highly statistically significant at a p-value of less than 0.001. This substantiates the alternative hypothesis and it is concluded that a statistically significant difference exists between the population means of at least two NWGA regions. **Figure 4.6** depicts the mean coefficient of variation in fibre diameter with 95 per cent confidence intervals. The solid red line depicts the grand mean for all the NWGA regions collectively.



**Figure 4.6:** Population means for coefficient of variation in fibre diameter per NWGA region

A series of post-hoc paired t-tests was performed to determine whether the population means are statistically significantly different. **Table 4.7** exhibits the t-test scores, critical values and p-values associated with the t-tests on the population means for coefficient of variation in fibre diameter.

**Table 4.7:** T-test scores and p-values comparing mean fibre diameter coefficient of variation

| Alternative hypothesis                      | t stat       | Critical value (two-tail) | p-value        |
|---|--------------|---------------------------|----------------|
| Ha: $\mu_{20} = \mu_{21}$                   | 35.403       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{23}$                   | 25.239       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{24}$                   | 17.121       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{25}$                   | 32.348       | 1.96                      | p < 0.001      |
| Ha: $\mu_{21} = \mu_{23}$                   | -19.912      | 1.96                      | p < 0.001      |
| Ha: $\mu_{21} = \mu_{24}$                   | -20.366      | 1.96                      | p < 0.001      |
| <b>Ha: <math>\mu_{21} = \mu_{25}</math></b> | <b>1.951</b> | <b>1.96</b>               | <b>0.05124</b> |
| Ha: $\mu_{23} = \mu_{24}$                   | -3.992       | 1.96                      | p < 0.001      |
| Ha: $\mu_{23} = \mu_{25}$                   | 18.826       | 1.96                      | p < 0.001      |
| Ha: $\mu_{24} = \mu_{25}$                   | 19.628       | 1.96                      | p < 0.001      |

*Bold text indicates that no statistically significant difference exists*

*All t-tests assume unequal variance between groups*

**Interpretation:** It is concluded that coefficient of variation in fibre diameter contributes significantly to the observed differences in price levels achieved by NWGA regions. The following conclusions are drawn from the ANOVA and paired t-tests:

- Wool produced by Region 20 (29.2%) varies significantly more than any other NWGA region in terms of fibre diameter.
- NWGA Regions 21 (24.9%) and 25 (24.6%) produce a much more uniform wool clip in terms of fibre diameter.
- The less extreme test statistics obtained from the paired t-test between NWGA Regions 21 and 25 indicate that the population means of these two regions are equal in terms of variation in fibre diameter.
- The regression model indicates that the relative importance of variation in fibre diameter is small. However, results from the ANOVA analysis and paired t-test indicate that statistically significant differences in the population means exist for this wool attribute – indicating that variation in fibre diameter contributes significantly to the observed differences in price levels achieved by the respective NWGA regions.

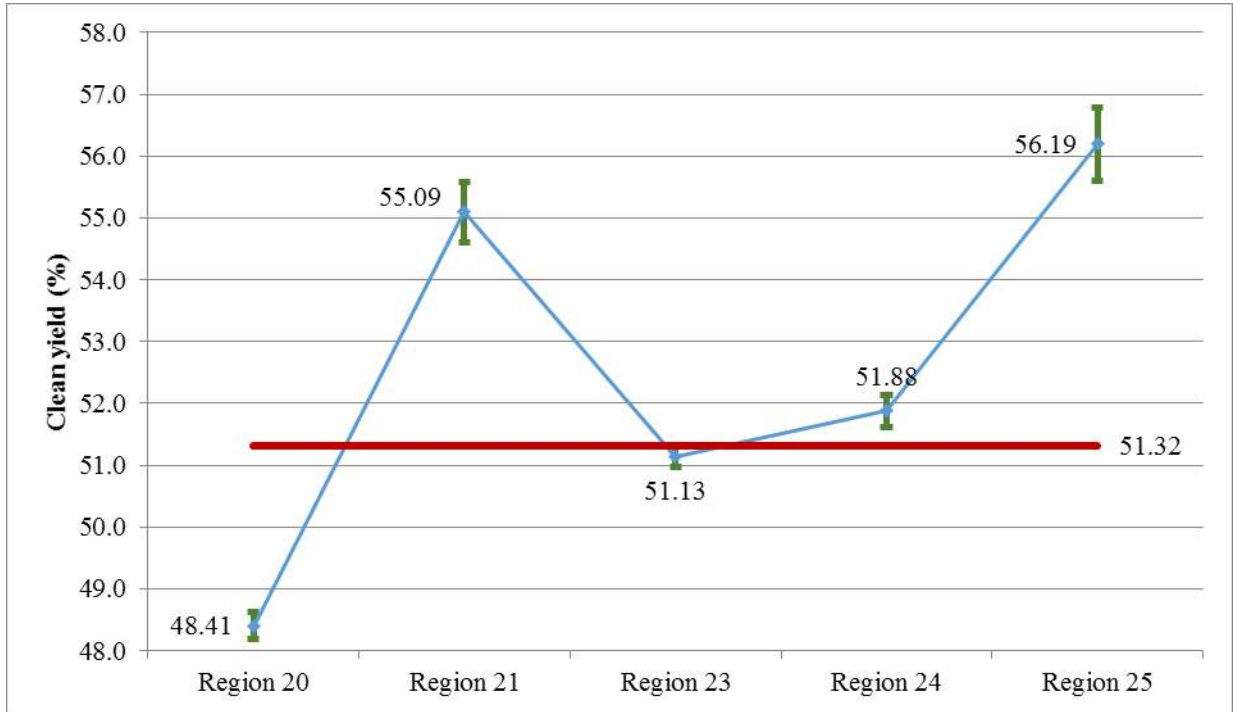
#### 4.3.6 Clean yield percentage

A one-way ANOVA analysis was carried out on the yield percentage and the results are presented in **Table 4.8**. **Figure 4.7** depicts the average yield percentage per NWGA region with 95 per cent confidence intervals.

**Table 4.8:** ANOVA table showing statistical parameters for clean yield

| <i>Groups</i>              | <i>Count</i>  | <i>Average</i>    |           | <i>Variance</i> |                |                   |
|----------------------------|---------------|-------------------|-----------|-----------------|----------------|-------------------|
| <i>Region 20</i>           | 2 734         | 48.41             |           | 33.3            |                |                   |
| <i>Region 21</i>           | 1 107         | 55.09             |           | 67.7            |                |                   |
| <i>Region 23</i>           | 6 107         | 51.13             |           | 47.6            |                |                   |
| <i>Region 24</i>           | 2 853         | 51.88             |           | 51.0            |                |                   |
| <i>Region 25</i>           | 691           | 56.19             |           | 62.2            |                |                   |
| <i>Source of Variation</i> | <i>df</i>     | <i>SS</i>         | <i>MS</i> | <i>F</i>        | <i>P-value</i> | <i>F critical</i> |
| Between Groups             | 4             | 56 504.33         | 14 126.08 | 295.26          | 7.81E-244      | 2.37              |
| Within Groups              | 13 487        | 645 265.23        | 47.84     |                 |                |                   |
| <b>Total</b>               | <b>13 491</b> | <b>701 769.56</b> |           |                 |                |                   |

**Interpretation:** The F-ratio of 295.26, with 4 and 13 487 degrees of freedom, is more extreme than the critical value of 2.37, and is therefore highly statistically significant at a p-value of less than 0.001. The result of the ANOVA indicates that a statistically significant difference exists in the population means of at least two NWGA regions. The solid red line in the figure below depicts the grand mean of all the NWGA regions collectively.



**Figure 4.7:** Population means of clean yield per NWGA region

**Table 4.9** exhibits the t-test scores, critical values and p-values associated with the paired t-tests conducted on the population means for clean yield.

**Table 4.9:** T-test scores and p-values comparing mean clean yield

| Alternative hypothesis    | t stat  | Critical value<br>(two-tail) | p-value     |
|---------------------------|---------|------------------------------|-------------|
| Ha: $\mu_{20} = \mu_{21}$ | -24.697 | 1.96                         | $p < 0.001$ |
| Ha: $\mu_{20} = \mu_{23}$ | -19.296 | 1.96                         | $p < 0.001$ |
| Ha: $\mu_{20} = \mu_{24}$ | -20.022 | 1.96                         | $p < 0.001$ |
| Ha: $\mu_{20} = \mu_{25}$ | -24.369 | 1.96                         | $p < 0.001$ |
| Ha: $\mu_{21} = \mu_{23}$ | 15.080  | 1.96                         | $p < 0.001$ |
| Ha: $\mu_{21} = \mu_{24}$ | 11.439  | 1.96                         | $p < 0.001$ |
| Ha: $\mu_{21} = \mu_{25}$ | -2.831  | 1.96                         | $p < 0.01$  |
| Ha: $\mu_{23} = \mu_{24}$ | -4.641  | 1.96                         | $p < 0.001$ |
| Ha: $\mu_{23} = \mu_{25}$ | -16.184 | 1.96                         | $p < 0.001$ |
| Ha: $\mu_{24} = \mu_{25}$ | -13.144 | 1.96                         | $p < 0.001$ |

**Interpretation:** It is concluded that the clean yield percentage contributes significantly to the observed differences in price levels achieved by NWGA regions.

The following conclusions are drawn from the ANOVA and paired t-tests:

- Region 20 produced the lowest-yielding clip compared to any other NWGA region, averaging 48.4 per cent.
- All the other NWGA regions managed to achieve an average yield of above 50 per cent, except for Region 20.
- Regions 25 and 21 produced the highest and second-highest yielding clips compared to the other regions, averaging 56.2 and 55.1 per cent, respectively.
- The regression model indicate that the relative importance of yield percentage is small. However, results from the ANOVA analysis and paired t-tests indicate that statistically significant differences exist in the population means for this wool characteristic – indicating that clean yield percentage contributes significantly to the observed differences in price levels achieved by the NWGA regions.

Previous research corroborates that the low yield percentages achieved by the NWGA regions are partially due to the dirty kraaling conditions in which the sheep are kept at night (D’Haese *et al.*, 2003a:77).

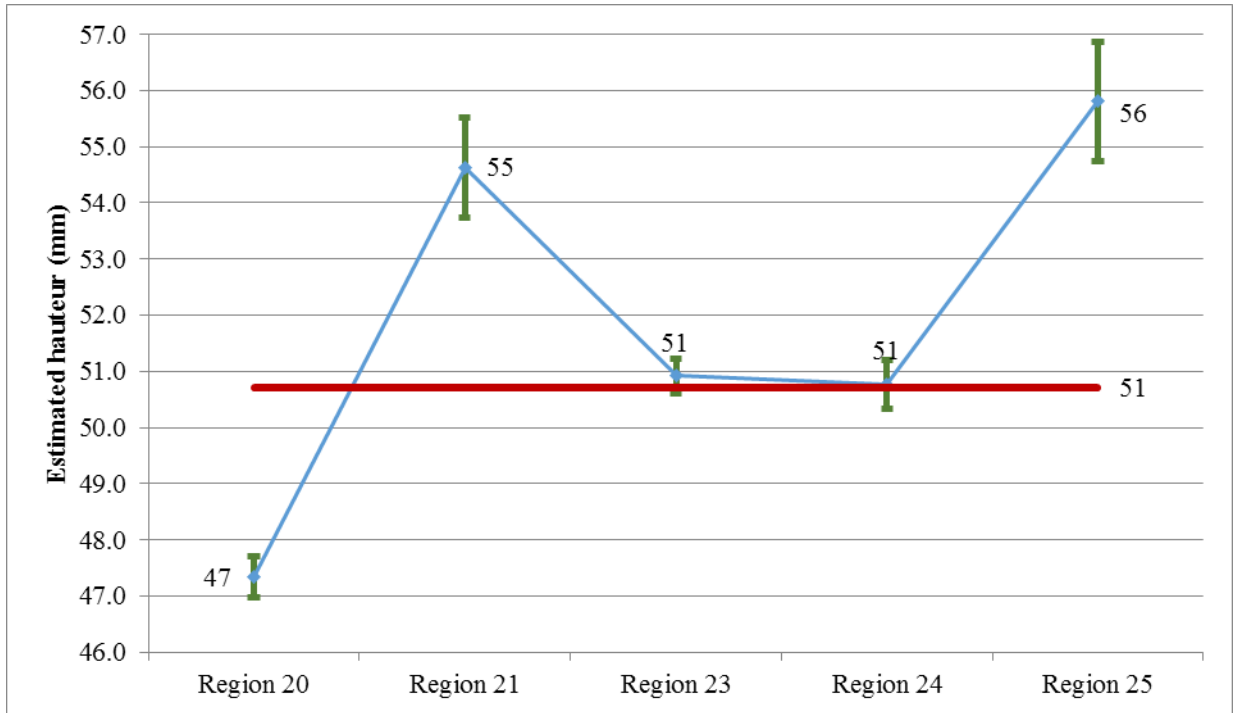
### 4.3.7 Hauteur

A one-way ANOVA analysis was carried out on the estimated hauteur and the results are presented in **Table 4.10**. **Figure 4.8** exhibits mean hauteur per region with 95 per cent confidence intervals. The solid red line in the figure below represents the grand mean of all the NWGA regions collectively.

**Table 4.10:** ANOVA table showing statistical parameters for hauteur

| <i>Groups</i>              | <i>Count</i>  | <i>Average</i>      |           | <i>Variance</i> |                |                   |
|----------------------------|---------------|---------------------|-----------|-----------------|----------------|-------------------|
| <i>Region 20</i>           | 2 734         | 47                  |           | 94.0            |                |                   |
| <i>Region 21</i>           | 1 107         | 55                  |           | 229.0           |                |                   |
| <i>Region 23</i>           | 6 107         | 51                  |           | 153.8           |                |                   |
| <i>Region 24</i>           | 2 853         | 51                  |           | 141.7           |                |                   |
| <i>Region 25</i>           | 691           | 56                  |           | 201.7           |                |                   |
| <i>Source of Variation</i> | <i>df</i>     | <i>SS</i>           | <i>MS</i> | <i>F</i>        | <i>P-value</i> | <i>F critical</i> |
| Between Groups             | 4             | 66 375.39           | 16 593.85 | 112.34          | 2.247E-94      | 2.37              |
| Within Groups              | 13 487        | 1 992 160.08        | 147.71    |                 |                |                   |
| <b>Total</b>               | <b>13 491</b> | <b>2 058 535.48</b> |           |                 |                |                   |

**Interpretation:** The F-ratio of 112.34, with 4 and 13 487 degrees of freedom, is more extreme than the critical value of 2.37, and is therefore highly statistically significant at a p-value of less than 0.001. The result of the ANOVA indicates that a statistically significant difference exists in the population means of at least two NWGA regions.



**Figure 4.8:** Population means associated with estimated hauteur per NWGA region

**Table 4.11** illustrates the t-test scores, critical values and p-values associated with the t-tests on the population means for hauteur.

**Table 4.11:** T-test scores and p-values comparing hauteur

| Alternative hypothesis                      | t stat        | Critical value (two-tail) | p-value        |
|---|---------------|---------------------------|----------------|
| Ha: $\mu_{20} = \mu_{21}$                   | -14.853       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{23}$                   | -14.687       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{24}$                   | -11.848       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{25}$                   | -14.830       | 1.96                      | p < 0.001      |
| Ha: $\mu_{21} = \mu_{23}$                   | 7.705         | 1.96                      | p < 0.001      |
| Ha: $\mu_{21} = \mu_{24}$                   | 7.623         | 1.96                      | p < 0.001      |
| <b>Ha: <math>\mu_{21} = \mu_{25}</math></b> | <b>-1.663</b> | <b>1.96</b>               | <b>0.09651</b> |
| <b>Ha: <math>\mu_{23} = \mu_{24}</math></b> | <b>0.547</b>  | <b>1.96</b>               | <b>0.58457</b> |
| Ha: $\mu_{23} = \mu_{25}$                   | -8.678        | 1.96                      | p < 0.001      |
| Ha: $\mu_{24} = \mu_{25}$                   | -8.617        | 1.96                      | p < 0.001      |

*Bold text indicates that no statistically significant difference exists*

*All t-tests assume unequal variance between groups*

**Interpretation:** It is concluded that hauteur contributes significantly to the observed differences in price levels achieved by NWGA regions. Hauteur is a predetermined estimate of the mean fibre length that a specific wool will achieve in the top after processing.

The following conclusions are drawn from the ANOVA and paired t-tests:

- Wool grown in Region 20 will achieve the shortest mean fibre length in the top compared to the other NWGA region.
- Wool produced by Regions 21 (54.6mm) and Region 25 (55.8mm) will achieve the longest mean fibre in the top compared to the other NWGA regions.
- Apart from Region 20 averaging 47.3 millimetres, all the other NWGA regions managed to achieve a population mean hauteur of above 50 millimetres.
- The logit regression model indicates that the relative importance of hauteur is small. However, results from the ANOVA analysis and paired t-tests indicate that statistically significant differences exist in the population means for this wool attribute – indicating that hauteur contributes significantly to the observed differences in price levels achieved by the NWGA regions.

Previous research corroborates that the mean fibre length in the top (hauteur) depends greatly on the mean staple length and tensile strength of raw wool, while variability of staple length within normal limits has relatively little effect upon processing (Folwer, 1996:46).

#### **4.3.8 Variation in staple length**

A one-way ANOVA analysis was conducted on coefficient of variation in staple length and the results are presented in **Table 4.12**. **Figure 4.9** shows the variability in staple length per NWGA region with 95 per cent confidence intervals. The solid red line in the figure below depicts the grand mean of all the NWGA regions collectively.

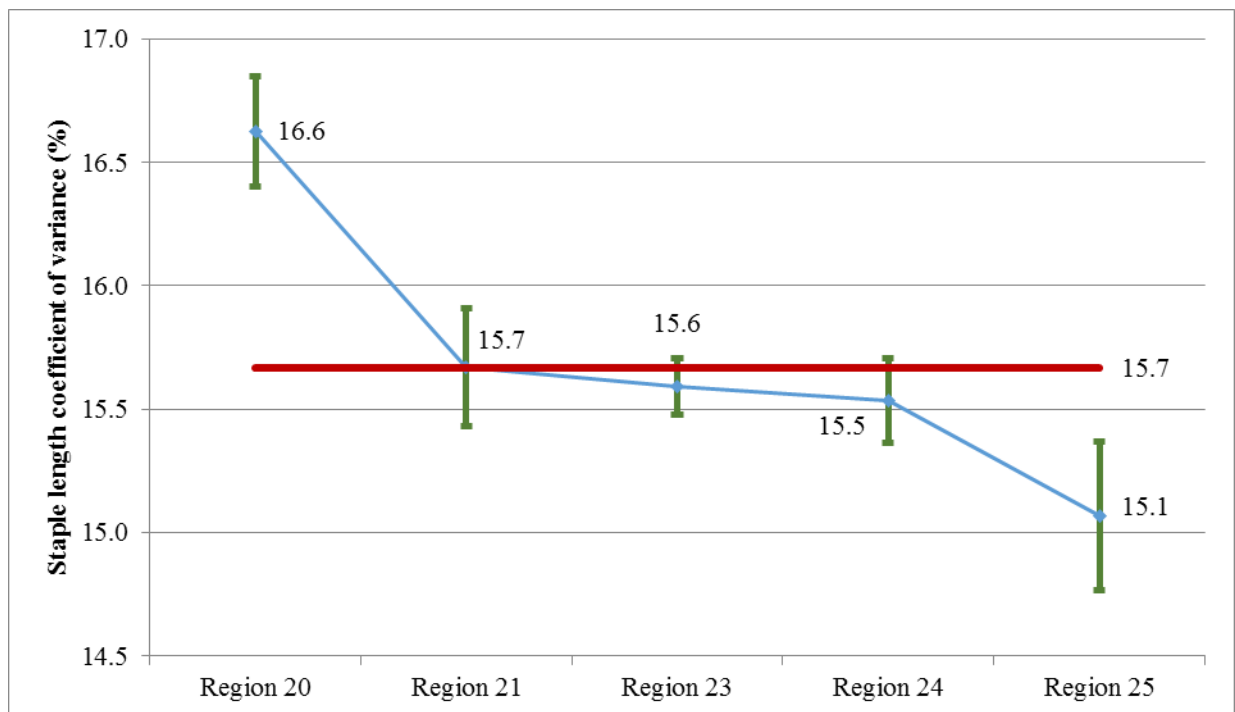
**Table 4.12:** ANOVA table showing statistical parameters for variability in staple length

| <i>Groups</i>    | <i>Count</i> | <i>Average</i> | <i>Variance</i> |
|------------------|--------------|----------------|-----------------|
| <i>Region 20</i> | 567          | 17             | 7.3             |
| <i>Region 21</i> | 598          | 16             | 9.0             |
| <i>Region 23</i> | 2331         | 16             | 7.9             |
| <i>Region 24</i> | 1008         | 16             | 7.8             |
| <i>Region 25</i> | 416          | 15             | 9.7             |

| <i>Source of Variation</i> | <i>df</i> | <i>SS</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F critical</i> |
|----------------------------|-----------|-----------|-----------|----------|----------------|-------------------|
| Between Groups             | 4         | 701.46    | 175.36    | 21.66    | 9.70E-18       | 2.37              |
| Within Groups              | 4 915     | 39 786.53 | 8.09      |          |                |                   |
| <b>Total</b>               | 4 919     | 40 487.99 |           |          |                |                   |

**Interpretation:** The F-ratio of 21.66, with 4 and 4 915 degrees of freedom, is more extreme than the critical value of 2.37, and is therefore highly statistically significant at a p-value of less than 0.001. This suggests that there is a statistical significant difference between the population means of at least two NWGA regions in terms of variability in staple length.



**Figure 4.9:** Population means associated with staple length coefficient of variation

**Table 4.13** exhibits the t-test scores, critical values and p-values associated with the t-tests on the population means for coefficient of variation in staple length.

**Table 4.13:** T-test scores and p-values comparing mean fibre diameter coefficient of variation

| Alternative hypothesis                      | t stat       | Critical value<br>(two-tail) | p-value        |
|---|--------------|------------------------------|----------------|
| Ha: $\mu_{20} = \mu_{21}$                   | 5.735        | 1.96                         | p < 0.001      |
| Ha: $\mu_{20} = \mu_{23}$                   | 8.111        | 1.96                         | p < 0.001      |
| Ha: $\mu_{20} = \mu_{24}$                   | 7.601        | 1.96                         | p < 0.001      |
| Ha: $\mu_{20} = \mu_{25}$                   | 8.186        | 1.96                         | p < 0.001      |
| <b>Ha: <math>\mu_{21} = \mu_{23}</math></b> | <b>0.557</b> | <b>1.96</b>                  | <b>0.57751</b> |
| <b>Ha: <math>\mu_{21} = \mu_{24}</math></b> | <b>0.889</b> | <b>1.96</b>                  | <b>0.37445</b> |
| Ha: $\mu_{21} = \mu_{25}$                   | 3.068        | 1.96                         | p < 0.001      |
| <b>Ha: <math>\mu_{23} = \mu_{24}</math></b> | <b>0.554</b> | <b>1.96</b>                  | <b>0.57932</b> |
| Ha: $\mu_{23} = \mu_{25}$                   | 3.213        | 1.96                         | p < 0.001      |
| Ha: $\mu_{24} = \mu_{25}$                   | 2.646        | 1.96                         | p < 0.001      |

*Bold text indicates that no statistically significant difference exists*

*All t-tests assume unequal variance between groups*

**Interpretation:** It is concluded that variation in staple length did not contribute significantly to the observed differences in price levels achieved by the respective NWGA regions.

#### 4.3.9 Mean staple length

A one-way ANOVA analysis was conducted on mean staple length and the results are presented in **Table 4.14**. **Figure 4.10** shows the population means pertinent to mean staple length with 95 per cent confidence intervals. The solid red line in the figure below represents the grand mean of all the NWGA regions collectively.

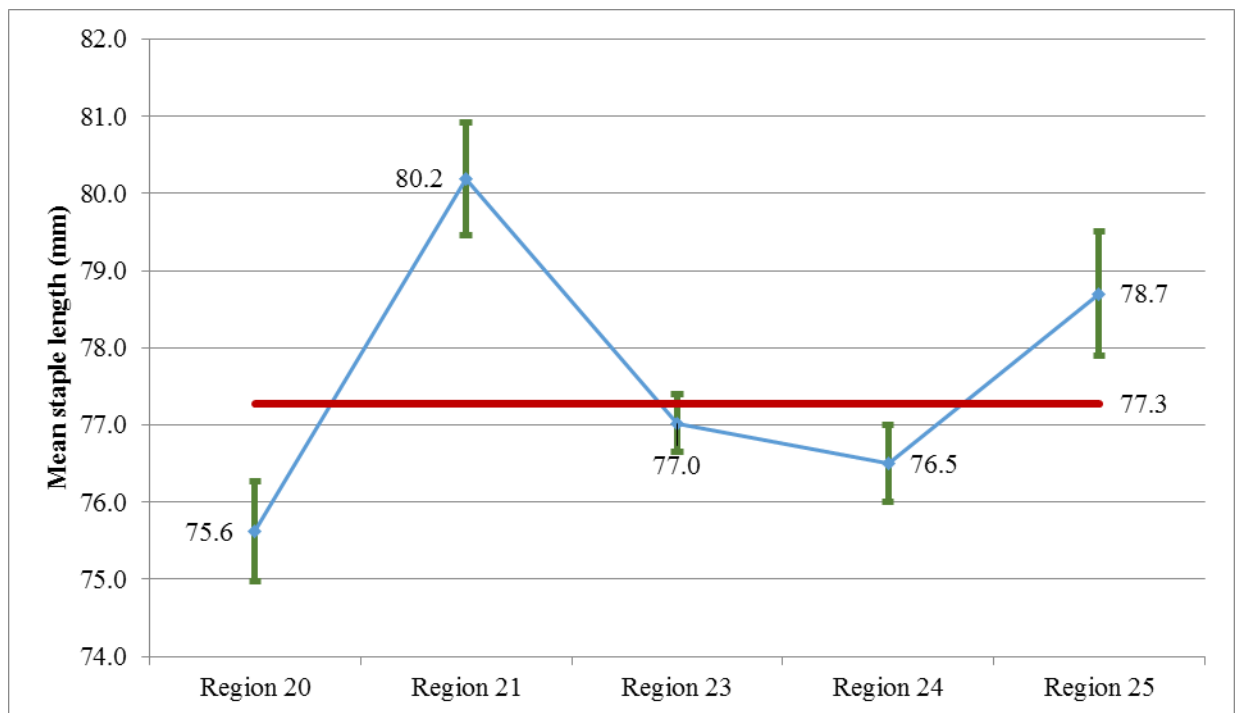
**Table 4.14:** ANOVA table showing statistical parameters for mean staple length

| <i>Groups</i>    | <i>Count</i> | <i>Average</i> | <i>Variance</i> |
|------------------|--------------|----------------|-----------------|
| <i>Region 20</i> | 567          | 76             | 61.6            |
| <i>Region 21</i> | 598          | 80             | 82.3            |
| <i>Region 23</i> | 2 331        | 77             | 82.7            |
| <i>Region 24</i> | 1 008        | 77             | 65.4            |
| <i>Region 25</i> | 416          | 79             | 70.5            |

| <i>Source of Variation</i> | <i>df</i>    | <i>SS</i>         | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F critical</i> |
|----------------------------|--------------|-------------------|-----------|----------|----------------|-------------------|
| Between Groups             | 4            | 8 238.96          | 2 059.74  | 27.23    | 2.197E-22      | 2.37              |
| Within Groups              | 4 915        | 371 792.41        | 75.64     |          |                |                   |
| <b>Total</b>               | <b>4 919</b> | <b>380 031.37</b> |           |          |                |                   |

**Interpretation:** The F-ratio of 27.23, with 4 and 4 915 degrees of freedom, is more extreme than the critical value of 2.37 and is therefore highly statistically significant at a p-value of less than 0.001. The results of the ANOVA analysis substantiate the alternate hypothesis and suggest that there are statistically significant differences in the population means of at least two of the NWGA regions.



**Figure 4.10:** Population means associated with mean staple length per NWGA region

**Table 4.15** exhibits the t-test scores, critical values and p-values associated with the t-tests on the population means pertaining to mean staple length.

**Table 4.15:** T-test scores and p-values comparing mean staple length

| Alternative hypothesis                      | t stat       | Critical value<br>(two-tail) | p-value        |
|---|--------------|------------------------------|----------------|
| Ha: $\mu_{20} = \mu_{21}$                   | -9.217       | 1.96                         | p < 0.001      |
| Ha: $\mu_{20} = \mu_{23}$                   | -3.704       | 1.96                         | p < 0.001      |
| Ha: $\mu_{20} = \mu_{24}$                   | -2.119       | 1.96                         | p < 0.05       |
| Ha: $\mu_{20} = \mu_{25}$                   | -5.845       | 1.96                         | p < 0.001      |
| Ha: $\mu_{21} = \mu_{23}$                   | 7.613        | 1.96                         | p < 0.001      |
| Ha: $\mu_{21} = \mu_{24}$                   | 8.200        | 1.96                         | p < 0.001      |
| Ha: $\mu_{21} = \mu_{25}$                   | 2.691        | 1.96                         | p < 0.01       |
| <b>Ha: <math>\mu_{23} = \mu_{24}</math></b> | <b>1.651</b> | <b>1.96</b>                  | <b>0.09886</b> |
| Ha: $\mu_{23} = \mu_{25}$                   | -3.703       | 1.96                         | p < 0.001      |
| Ha: $\mu_{24} = \mu_{25}$                   | -4.543       | 1.96                         | p < 0.001      |

*Bold text indicates that no statistically significant difference exists*

*All t-tests assume unequal variance between groups*

**Interpretation:** It is concluded that mean staple length contributes significantly to the observed differences in price levels achieved by the respective NWGA regions.

The following conclusions are drawn from the ANOVA and paired t-tests:

- Region 20 (75.6mm) produces on average shorter wool when compared to the other NWGA regions.
- There is no statistically significant difference in the population means of Regions 23 (77.0mm) and 24 (76.5mm) for mean staple length.
- Region 25 (78.7mm) produces on average the second-longest clip compared to the other NWGA regions.
- Region 21 (80.2mm) produces on average the longest clip compared to the other regions.

#### 4.3.10 Tensile strength

A one-way ANOVA analysis was conducted on tensile strength and the results are presented in **Table 4.16**. **Figure 4.11** exhibits the mean tensile strength per NWGA region with 95 per cent confidence intervals.

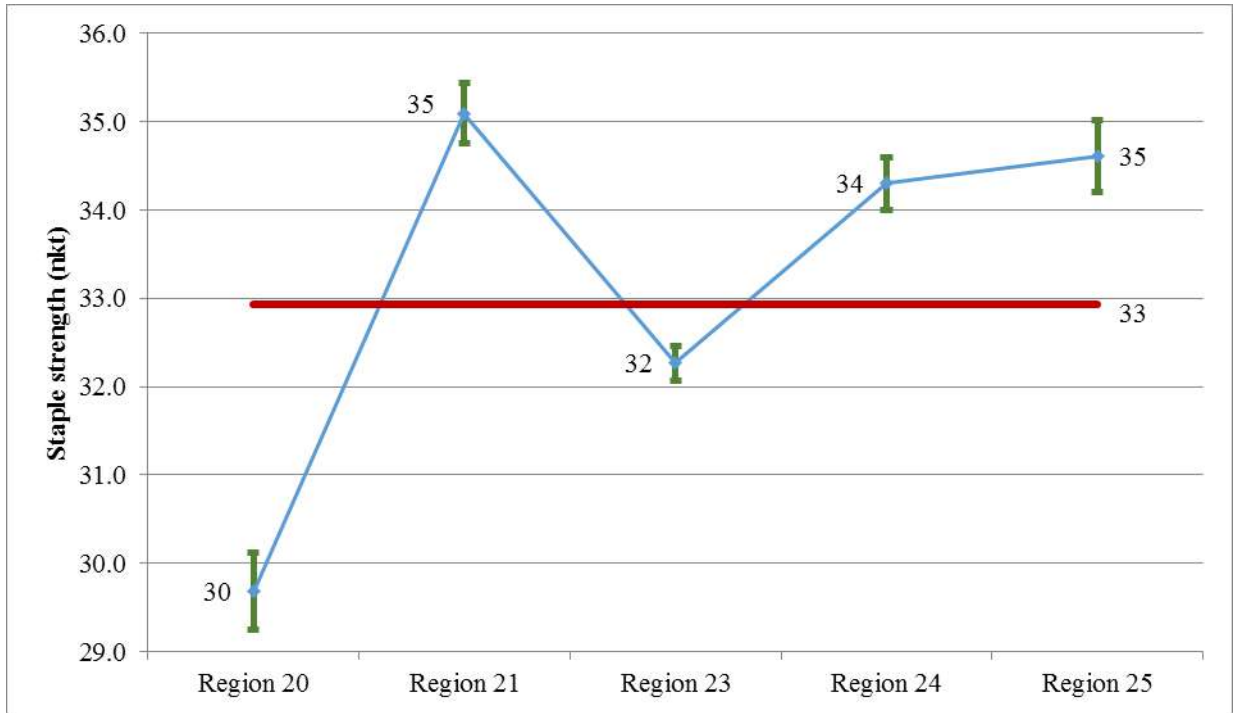
**Table 4.16:** ANOVA table showing statistical parameters for tensile strength

| <i>Groups</i>    | <i>Count</i> | <i>Average</i> | <i>Variance</i> |
|------------------|--------------|----------------|-----------------|
| <i>Region 20</i> | 567          | 30             | 28.3            |
| <i>Region 21</i> | 598          | 35             | 18.1            |
| <i>Region 23</i> | 2 331        | 32             | 22.9            |
| <i>Region 24</i> | 1 008        | 34             | 22.4            |
| <i>Region 25</i> | 416          | 35             | 18.1            |

| <i>Source of Variation</i> | <i>df</i>    | <i>SS</i>         | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F critical</i> |
|----------------------------|--------------|-------------------|-----------|----------|----------------|-------------------|
| Between Groups             | 4            | 12 875.08         | 3 218.77  | 143.62   | 2.73E-116      | 2.37              |
| Within Groups              | 4 915        | 110 156.59        | 22.41     |          |                |                   |
| <b>Total</b>               | <b>4 919</b> | <b>123 031.67</b> |           |          |                |                   |

**Interpretation:** The F-ratio of 143.62, with 4 and 4 915 degrees of freedom, is more extreme than the critical value of 2.37 and is therefore highly statistically significant at a p-value of less than 0.001 – indicating that a statistically significant difference exist in the population means of at least two NWGA regions.



**Figure 4.11:** Population means associated with tensile strength per NWGA region

**Table 4.17** exhibits the t-test scores, critical values and p-values associated with the t-tests on the population means in terms of tensile strength.

**Table 4.17:** T-test scores and p-values comparing tensile strength

| Alternative hypothesis                      | t stat        | Critical value (two-tail) | p-value        |
|---|---------------|---------------------------|----------------|
| Ha: $\mu_{20} = \mu_{21}$                   | -19.133       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{23}$                   | -10.588       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{24}$                   | -17.195       | 1.96                      | p < 0.001      |
| Ha: $\mu_{20} = \mu_{25}$                   | -16.118       | 1.96                      | p < 0.001      |
| Ha: $\mu_{21} = \mu_{23}$                   | 14.138        | 1.96                      | p < 0.001      |
| Ha: $\mu_{21} = \mu_{24}$                   | 3.483         | 1.96                      | p < 0.001      |
| <b>Ha: <math>\mu_{21} = \mu_{25}</math></b> | <b>1.800</b>  | <b>1.96</b>               | <b>0.07214</b> |
| Ha: $\mu_{23} = \mu_{24}$                   | -11.348       | 1.96                      | p < 0.001      |
| Ha: $\mu_{23} = \mu_{25}$                   | -10.129       | 1.96                      | p < 0.001      |
| <b>Ha: <math>\mu_{24} = \mu_{25}</math></b> | <b>-1.204</b> | <b>1.96</b>               | <b>0.22908</b> |

*Bold text indicates that no statistically significant difference exists  
All t-tests assume unequal variance between groups*

**Interpretation:** It is concluded that tensile strength did not contribute significantly to the observed differences in price levels achieved by NWGA regions.

#### **4.4 Research question 3: Can the observed differences be attributed to the genetic composition of the sheep?**

The third research question aims to determine whether the observed differences in price levels achieved can be attributed to the genetic composition of the sheep. The logit regression model identified breed and style as the most influential contributing factors to the observed differences in price levels achieved by the various NWGA regions (see conclusions in **Section 4.3.1** and **Section 4.3.2**). Breed characteristics are inheritable and influenced by the genetic composition of the animal. Style is a summation of the subjectively assessed physical wool attributes, which are genetically predisposed (see **Section 2.9**).

Along with breed and style, the model also identified several objectively measured wool attributes that contribute significantly to the observed differences in price levels achieved by the various NWGA regions (see **Sections 4.3.3** to **4.3.10**). The practical percentage difference between the collective grand mean and the population means was calculated to provide a holistic view of the one-to-one relationship among the NWGA regions for these objectively measured wool attributes. **Table 4.18** depicts the practical percentage differences between the collective grand means and the respective population means for the objectively tested, genetically influenced wool attributes.

Very important to mention is that the objectively measured wool characteristics are either negatively or positively correlated with grease price. **Table 4.18** was designed to quantify whether a region performs below or above average in terms of a specific trait. A negative value indicates below par performance and a positive value the opposite. **Table 4.19** is interpreted similarly.

**Table 4.18:** Regional distribution according to performance levels, based on the practical percentage differences in genetically influenced wool traits

|                            | Collective mean | Region 20 | Region 21 | Region 23 | Region 24 | Region 25 |
|----------------------------|-----------------|-----------|-----------|-----------|-----------|-----------|
| Fibre diameter ( $\mu$ )** | 20.3            | -1.4%     | 1.5%      | 0.6%      | -0.6%     | 0.8%      |
| Yield (%)                  | 51.3            | -5.7%     | 7.3%      | -0.4%     | 1.1%      | 9.5%      |
| Staple length (mm)         | 77              | -2.2%     | 3.8%      | -0.3%     | -1.0%     | 1.8%      |
| Tensile strength (nkt)     | 33              | -9.9%     | 6.6%      | -2.0%     | 4.2%      | 5.1%      |
| Hauteur (mm)               | 51              | -6.7%     | 7.7%      | 0.4%      | 0.1%      | 10.0%     |

Negatively correlated wool traits are indicated by \*\*

The following conclusions are drawn from the table above:

- The table above confirms Region 20 [*column in red*] as the poorest-performing NWGA region in terms of all the genetically influenced wool attributes – indicating an immense genetic handicap in this region.
- Regions 21 and 25 [*column in blue*] were found to be consistently above average in all aspects of the genetically influenced wool attributes – indicating above average genetic quality of the flocks in these regions.
- Performance levels of Regions 23 and 24 are consistently close to average in terms of all the objectively measured wool attributes, except for tensile strength in Region 24.

Findings presented in **Section 4.3** and **4.4** confirm that the observed differences in average price levels achieved by the various NWGA regions, is the result of significant differences in the genetic make-up of the respective sheep flocks

#### 4.5 Research question 4: Can the observed differences be attributed to the standard of wool classing practices applied by the shearing communities?

The fourth research question aims to discover whether the observed differences can be attributed to the degree of classing applied by the shearing communities. This study focused on variation in fibre diameter and staple length to ascertain the standard of classing applied by the wool classer. As referred to before, the variation in fibre diameter across the body of the sheep accounts for only 6 to 12 per cent of the total variation – indicating that this attribute is dependent on the standard of classing applied by the wool classer (see **Section 2.9.3**). Although no corroborating evidence could be found in published literature, the researcher believes variation in staple length is a credible indication of the standard of classing applied by the wool classer. **Table 4.19** illustrates the practical percentage difference between the collective means and the regional population means in terms of variation in staple length and fibre diameter.

**Table 4.19:** Regional distribution according to performance levels, based on the practical percentage differences in the variation in fibre diameter and staple length

|                                   | Collective mean | Region 20 | Region 21 | Region 23 | Region 24 | Region 25 |
|-----------------------------------|-----------------|-----------|-----------|-----------|-----------|-----------|
| Variation in fibre diameter (%)** | 27.3            | -7.0%     | 8.7%      | 0.7%      | -0.6%     | 9.9%      |
| Variation in staple length (%)**  | 15.7            | -6.1%     | 0.0%      | 0.5%      | 0.8%      | 3.8%      |

*Negatively correlated wool traits are indicated by \*\**

The table above substantiates the differing standards of classing applied by the various NWGA regions. For interpretation of table above, see note on interpretation of **Table 4.18**.

The following conclusions are drawn from the table above:

- Region 20 [*column in red*] produces the clip with the most variability in both staple length and fibre diameter – indicating that the shearing communities in this region consistently apply the lowest standard of classing compared to any other NWGA region.
- In Region 20, mean variability in fibre diameter and staple length is 7.0 and 6.1 percentage points below average compared to the collective mean of all the regions, respectively.

- Region 25 [*column in blue*] produces the most uniform clip, with mean variability in fibre diameter and staple length, 9.9 and 3.8 percentage points above average compared to the collective mean of all the NWGA regions, respectively.
- Based on the afore-going observation, it is concluded that the shearing communities in Region 25 consistently apply a higher standard of classing when compared to the other NWGA regions.
- In Region 21, uniformity in staple length was equal to the collective average calculated from all of the NWGA regions. However, Region 21 achieved 8.7 percentage points above average in terms of variation in fibre diameter. This observation suggests that the standard of classing in terms of fibre diameter is more than satisfactory; however, more attention should be given to ensure length uniformity.
- The degree of classing applied by shearing communities in Regions 23 and 24 is consistently close to the collective average in terms of variability in fibre diameter and staple length.

## 4.6 Summary

This chapter presents the empirical data obtained from this study and consists of comprehensive analyses of the quantitative data set. This study reveals conclusively that statistically significant differences exist in price levels achieved by the respective NWGA regions. The relative importance of the independent variables was determined based on the beta coefficients generated by the logit regression model. Factors contributing to the observed differences were identified and discussed in further detail. Finally, the contributing factors to observed differences in price levels were attributed to either the standard of wool classing applied by the shearing sheds or to the genetic composition of the sheep.

## **CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS**

### **5.1 Introduction**

This chapter provides a discussion of the findings that emerged from this study. The chapter concludes with suggestions for further research and recommendations for enhancing wool production, specifically in the NWGA regions with below par performance levels..

### **5.2 Discussion**

The research findings of this study confirm that statistically significant differences exist in the price levels achieved by the respective NWGA regions. Results of the study indicate that NWGA Region 20 is the poorest-performing region, fetching an average grease price of R25.12 per kilogram. Region 24 (R29.17/kg) is the second poorest-performing region, followed closely by Region 23 (R31.57/kg). The best-performing NWGA regions are Region 25 (R39.87/kg) and Region 21 (R38.58/kg). Development efforts should therefore focus primarily on Regions 20, 23 and 24, which were identified as the poorest-performing NWGA regions. This recommendation does not mean that the best-performing regions should be ignored. In fact, these regions should be closely monitored since they already possess genetically enhanced breeding flocks from which replacement rams and ewes could be selected to improve the flocks of the poorly-performing regions.

The study found that the very low price levels achieved by Region 20 are the combined result of genetically inferior-quality sheep producing correspondingly poor-quality wool, along with extremely poor classing practices applied by the shearing communities in this region. Results also indicate that the low price levels achieved by NWGA Regions 23 and 24 are associated with the genetic quality of the sheep in these regions. The poorest-performing regions (Regions 20, 23 and 24) produce predominantly Nondescript wool, while the best-performing regions (Regions 21 and 25) produce mainly Merino wool. Furthermore, the poorest-performing regions produce predominantly inferior and average-style wool, while the best-performing regions produce predominantly average- and good-style wool.

This study provides substantive evidence that the observed differences are predominantly the result of the genetic composition of the sheep. Proper classing of poor-quality wool does improve the average price of a clip; however, quality is the overriding factor when the price of wool is determined. Thus, well-classed poor-quality wool can never fetch higher price levels than poorly-classed good-quality wool.

### **5.3 Future studies**

The quality of wool, resulting from the genetic composition of the sheep, largely overshadowed the effect of classing applied to the observed differences in price levels achieved. Future analyses of the influence of classing applied by the wool classer should aim to eliminate the overwhelming effect of genetic quality observed in this study. The researcher suggests that future research should focus on the standard of classing applied to specifically the same type of wool. The standard of classing applied can be evaluated in more detail also examining the qualifiers recorded in the AWEX-ID system.

### **5.4 Recommendations**

James *et al.* (1990:586) stress that the heritability estimates of wool characteristics associated with quality is intermediate to high – indicating that genetic improvement in these characteristics is possible with selective breeding. Genetic improvement is needed to reduce or eliminate the observed statistically significant differences in price levels achieved by the various NWGA regions – with specific focus on breed type and style. However, genetic change is a slow process and swift remedial intervention would require drastic measures.

The study therefore makes the following recommendations:

- Replacing all inferior-quality rams in an area with superior-quality rams producing Merino-type wool. All Nondescript rams must be removed from an area. Earlier studies indicate that there are no fences to separate the inferior rams from the breeding stock (King, 2013b:41; Makapela, 2008:84; Perret, 2002:6). If the inferior rams are not completely removed from the area, their influence will dilute the genetic effect of the superior rams.

- Accelerated genetic change by also replacing the Nondescript ewes with superior-quality ewes producing Merino-type wool. This drastic approach should especially be considered in the poorest-performing regions – namely Region 20, followed by Regions 23 and 24. By replacing the low-producing Nondescript ewes with high-producing ewes producing Merino-type wool, income levels can be maintained with fewer animals, which in turn will also reduce pressure on the communal rangelands.
- Earlier studies indicate that the mortality rate of lambs on communal rangelands is extremely high due to poor veld conditions and excessive stocking rates (Makapela, 2008). Lamb survival can be improved by establishing a breeding program which ensures that lambs are born and raised during times of good veld conditions. Improvement in the lamb survival rate will accelerate the rate of genetic improvement of the breeding flocks due to better ewe replacement rates.
- Planting cultivated pastures will intensify production and increase lamb survival rates on degraded marginal rangelands.
- A holistic approach is required to achieve and maintain optimum production levels in the communal areas. Development efforts should invest in the establishment of general flock management and healthcare programmes to increased reproduction and lamb survival.

The recommendations above do not necessarily mean that the standard of classing practices applied by the shearing communities should be ignored. Low prices levels achieved due to high levels of variation in fibre diameter and staple length are counter-productive and can be avoided.

**APPENDIX: Descriptive statistics of the objectively measured wool attributes as indicated in the original BKB data set with 87 087 observations**

| <b>Region 20</b>                            | <b>25th</b> | <b>75th</b> | <b>Max</b> | <b>Min</b> | <b>Median</b> | <b>Mean</b> | <b>Stdev.</b> |
|---|-------------|-------------|------------|------------|---------------|-------------|---------------|
| Mean fibre diameter ( $\mu$ )               | 20.3        | 21.1        | 22.9       | 17.7       | 20.6          | 20.7        | 0.61          |
| Fibre diameter coefficient of variation (%) | 26.4        | 32.0        | 42.0       | 20.8       | 28.4          | 29.2        | 3.54          |
| Clean yield (%)                             | 44.65       | 51.10       | 69.19      | 30.44      | 47.70         | 48.36       | 5.66          |
| Staple length coefficient of variation (%)  | 15          | 19          | 35         | 9          | 17            | 18          | 3.57          |
| Mean staple length (mm)                     | 69          | 80          | 112        | 53         | 75            | 72          | 7.99          |
| Staple strength (nkt)                       | 25          | 34          | 47         | 14         | 30            | 28          | 6.09          |
| Vegetable matter base (%)                   | 1.17        | 2.02        | 6.40       | 0.05       | 1.48          | 1.48        | 0.74          |
| Hauteur (mm)                                | 40          | 50          | 80         | 20         | 46            | 48          | 9.51          |
| <b>Region 21</b>                            | <b>25th</b> | <b>75th</b> | <b>Max</b> | <b>Min</b> | <b>Median</b> | <b>Mean</b> | <b>Stdev.</b> |
| Mean fibre diameter ( $\mu$ )               | 19.9        | 20.6        | 25.0       | 16.1       | 20.2          | 20.0        | 0.71          |
| Fibre diameter coefficient of variation (%) | 23.4        | 26.7        | 39.00      | 19.0       | 24.8          | 24.3        | 2.76          |
| Clean yield (%)                             | 48.57       | 60.80       | 74.1       | 30.44      | 56.79         | 58.48       | 8.15          |
| Staple length coefficient of variation (%)  | 13          | 18          | 29         | 7          | 15            | 15          | 3.58          |
| Mean staple length (mm)                     | 74          | 86          | 115        | 54         | 79            | 82          | 8.96          |
| Staple strength (nkt)                       | 30          | 38          | 58         | 15         | 34            | 35          | 5.43          |
| Vegetable matter base (%)                   | 0.91        | 1.90        | 7.77       | 0.05       | 1.29          | 1.32        | 0.79          |
| Hauteur (mm)                                | 46          | 66          | 80         | 20         | 56            | 61          | 13.53         |

| <b>Region 23</b>                            | <b>25th</b> | <b>75th</b> | <b>Max</b> | <b>Min</b> | <b>Median</b> | <b>Mean</b> | <b>Stdev.</b> |
|---|-------------|-------------|------------|------------|---------------|-------------|---------------|
| Mean fibre diameter ( $\mu$ )               | 20.0        | 20.8        | 25.1       | 16.4       | 20.4          | 20.2        | 0.68          |
| Fibre diameter coefficient of variation (%) | 24.9        | 29.5        | 41.4       | 19.1       | 26.8          | 27.3        | 3.36          |
| Clean yield (%)                             | 45.69       | 56.81       | 73.07      | 29.75      | 49.97         | 51.42       | 6.87          |
| Staple length coefficient of variation (%)  | 14          | 19          | 35         | 7          | 16            | 16          | 3.52          |
| Mean staple length (mm)                     | 69          | 84          | 115        | 50         | 75            | 75          | 9.05          |
| Staple strength (nkt)                       | 28          | 35          | 59         | 12         | 31            | 30          | 6.05          |
| Vegetable matter base (%)                   | 0.98        | 1.90        | 8.32       | 0.04       | 1.34          | 1.38        | 0.71          |
| Hauteur (mm)                                | 44          | 56          | 80         | 20         | 48            | 52          | 11.34         |
| <b>Region 24</b>                            | <b>25th</b> | <b>75th</b> | <b>Max</b> | <b>Min</b> | <b>Median</b> | <b>Mean</b> | <b>Stdev.</b> |
| Mean fibre diameter ( $\mu$ )               | 20.2        | 21.0        | 25.1       | 16.9       | 20.5          | 20.5        | 0.69          |
| Fibre diameter coefficient of variation (%) | 25.2        | 29.8        | 39.3       | 19.9       | 26.9          | 27.3        | 3.59          |
| Clean yield (%)                             | 47.47       | 56.65       | 70.70      | 30.44      | 49.98         | 54.10       | 6.60          |
| Staple length coefficient of variation (%)  | 13          | 18          | 31         | 7          | 15            | 16          | 3.40          |
| Mean staple length (mm)                     | 69          | 83          | 112        | 53         | 75            | 74          | 7.94          |
| Staple strength (nkt)                       | 30          | 37          | 57         | 14         | 33            | 34          | 5.41          |
| Vegetable matter base (%)                   | 1.17        | 2.03        | 8.95       | 0.21       | 1.45          | 1.67        | 0.76          |
| Hauteur (mm)                                | 44          | 56          | 80         | 20         | 48            | 53          | 10.52         |

| <b>Region 25</b>                            | <b>25th</b> | <b>75th</b> | <b>Max</b> | <b>Min</b> | <b>Median</b> | <b>Mean</b> | <b>Stdev.</b> |
|---|-------------|-------------|------------|------------|---------------|-------------|---------------|
| Mean fibre diameter ( $\mu$ )               | 19.9        | 20.7        | 25.0       | 16.1       | 20.3          | 20.2        | 0.74          |
| Fibre diameter coefficient of variation (%) | 23.5        | 26.7        | 37.5       | 19.0       | 24.8          | 24.5        | 2.87          |
| Clean yield (%)                             | 49.94       | 61.93       | 72.69      | 29.75      | 57.12         | 59.08       | 7.89          |
| Staple length coefficient of variation (%)  | 13          | 17          | 30         | 9          | 15            | 15          | 3.57          |
| Mean staple length (mm)                     | 71          | 84          | 113        | 52         | 76            | 77          | 8.12          |
| Staple strength (nkt)                       | 31          | 39          | 54         | 19         | 35            | 36          | 5.16          |
| Vegetable matter base (%)                   | 1.06        | 1.92        | 9.42       | 0.23       | 1.43          | 1.51        | 0.80          |
| Hauteur (mm)                                | 46          | 64          | 80         | 20         | 56            | 60          | 12.53         |

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