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Impact of a Multi-Stakeholder Approach on Rural Livelihood and Socioeconomic Status of the Farming Community at Zanyokwe Irrigation Scheme, Amahlathi Local Municipality, Eastern Cape

Dumani, A.[1], Mbangcolo, M.M.[2], Mpambani, B.[3], Mpengesi, X.[4] and Titimani, M.[5]

Corresponding Author: A. Dumani. Correspondence Email: aziledumani@gmail.com

ABSTRACT

Access to finance and production inputs are some of the challenges that dominate the small-scale farming sector in South Africa. Public Private Partnerships (PPP) are among some of the alternatives that could be utilised to assist small-scale farmers. An informal partnership was initiated between the Department of Rural Development and Agrarian Reform (DRDAR), Rance Rural Development (RRD), and the farmers of Sidalukukhanya Agriculture Co-op (SAC) for pepper production at the Zanyokwe Irrigation Scheme. A study was conducted to evaluate the socioeconomic impact of this partnership. A questionnaire was administered to the members of SAC for data collection. Results showed that this PPP significantly improved the livelihood and socioeconomic Status of SAC members farming at the Zanyokwe Irrigations Scheme. Through this partnership, approximately 13% of jobs are created in the field for the co-op members, while 6% are permanently employed in the processing factory. Similarly, 56% of seasonal employment intake occurred during planting and harvesting s in the cropping fields at Zanyokwe Irrigation Scheme in Keiskammahoek. A further 25% of seasonal jobs were created through the processing of produce at the agro-processing factory in Stutterheim. Most

[1] Agricultural Advisor; Department of Rural Development and Agrarian Reform, Amahlathi Agricultural Office, PO Box 166, Stutterheim, 4930. aziledumani@gmail.com

[2] Deputy Director: Food Security, Department of Rural Development and Agrarian Reform, Independence Avenue, Private Bag X0040 Bhisho, Mongezi.mbangcolo@drdar.gov.za, ORCID: http://orcid.org/0000-0002-7378-6839

[3] Scientific Manager: Horticulture Research, Department of Rural Development and Agrarian Reform, Döhne Agricultural Development Institute, Private Bag X 15, Stutterheim 4930, Eastern Cape, South Africa.

[4] Agricultural Advisor; Department of Rural Development and Agrarian Reform, Döhne Agricultural Development Institute, Stutterheim, Eastern Cape, South Africa

[5] Agricultural Advisor; Department of Rural Development and Agrarian Reform, Döhne Agricultural Development Institute, Stutterheim, Eastern Cape, South Africa

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farmers increased their business by 20% and production skills by 80%. Therefore, this partnership has shown the potential to improve the livelihood and socioeconomic Status of Zanyokwe farmers.

Keywords: Multi-stakeholder approach, Socioeconomic, Farming community, Irrigation scheme

1. INTRODUCTION

In South Africa, smallholder irrigation schemes were developed to improve rural livelihoods through sustainable food production for food security and poverty alleviation; yet these development objectives remain unfulfilled (Fanadzo *et al.*, 2018). Irrigation schemes are among the vital tools that can be used to meet the world's fast-rising food demands (Salah *et al.*, 2007). FAO *et al.* (2017) indicated that global hunger increased in 2016, and the world's undernourished population increased to an estimated 815 million people from 777 million in 2015. Hence, poverty eradication is highlighted as part of the 2030 Agenda for Sustainable Development of the United Nations. However, the high cost of running an irrigation scheme results in low productivity. These costs include the cost of infrastructure development, human capacity development, production inputs, as well as mechanisation. As a result, the objectives of irrigation schemes, such as food production, poverty eradication, and job creation for the betterment and development of rural livelihoods, are often not met. Melvyn (2003) pointed to government bodies and their lack of financial support for the failure of irrigation schemes. Fanadzo *et al.* (2018) further stated that there is a contradiction between the national agenda and its high interest in smallholder farmer development, but it needs more financial support from the government to the sector. Rankin *et al.* (2016) support this by saying that while massive investments are required to unleash the potential of agriculture in irrigation schemes for sustainable development and poverty reduction, low public budgetary allocations to the sector result in low productivity growth.

According to Raidimi *et al.* (2017), the involvement of the public sector alone is insufficient to address the multi-faceted problems confronted by South African producers. This is mainly due to limited government resources. As such, the partnerships that bring together public, private, and civil society actors (PPPs) are highly encouraged as growth drivers for improving agricultural productivity and rural livelihood (Salah, 2007). Zagst (2012) defined PPPs as a

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formal partnership between public and private institutions to address sustainable agricultural development objectives, where the public benefits from the partnership are clearly defined, investment contributions and risks are shared, and active roles exist for all partners. Hence, various stakeholders' involvement and the strengthening of existing PPPs are crucial for the future of agricultural development. Raidimi *et al.* (2017) emphatically stated that a multi-stakeholder system's combined strength and synergies would naturally benefit farmers by applying and transferring new technologies to maximise their profit, which would address food security challenges and improve rural livelihoods. According to Mitchell (2008), partnerships between the public and private sectors are a promising approach to meeting various sustainable development goals within the country and should be explored to ensure food security. In his State of the Nation Address (2020), the president of the Republic of South Africa mentioned that the "government cannot solve the South African economic challenges alone" and noted that the economy had not grown at any meaningful rate for over a decade. This necessitates an inclusive economic growth approach to conquer the fight against poverty. Hence, Rance Rural Development (RRD), EC-DRDAR, and Sidalukukhanya Agric Co-op farmers (SAC), farming at Zanyokwe irrigation scheme, joined hands to reduce poverty, create jobs, and ensure food security in the rural communities through pepper production. This study seeks to evaluate the impact of this partnership on the rural livelihood and socioeconomic status of the farming community at ZIS.

1.1. Objectives of the Study

This study:

- Evaluated the impact of a multi-stakeholder partnership on rural livelihoods;
- Assessed the socioeconomic status of the farming community of Zanyokwe; and
- Demonstrated the impact of PPPs on agricultural productivity.

2. METHODOLOGY

2.1. Study Location

The study was conducted at the Zanyokwe Irrigation Scheme (Figure 1) (S32°40’55.032”, E27°9’9.681”) in Keiskammahoek, Eastern Cape, South Africa. The scheme is owned by the community members, with each member owning portions of land ranging from one to two hectares (Ha) per household. The land is under traditional authority. The total land size is about 420 Ha, and the whole area is under irrigation. Farming is a significant economic activity

practised in Keiskammahoek. The irrigation scheme plays a pivotal role in sustaining crop production within the area. Hence, farmers produce various crops for economic purposes and to sustain their livelihoods.

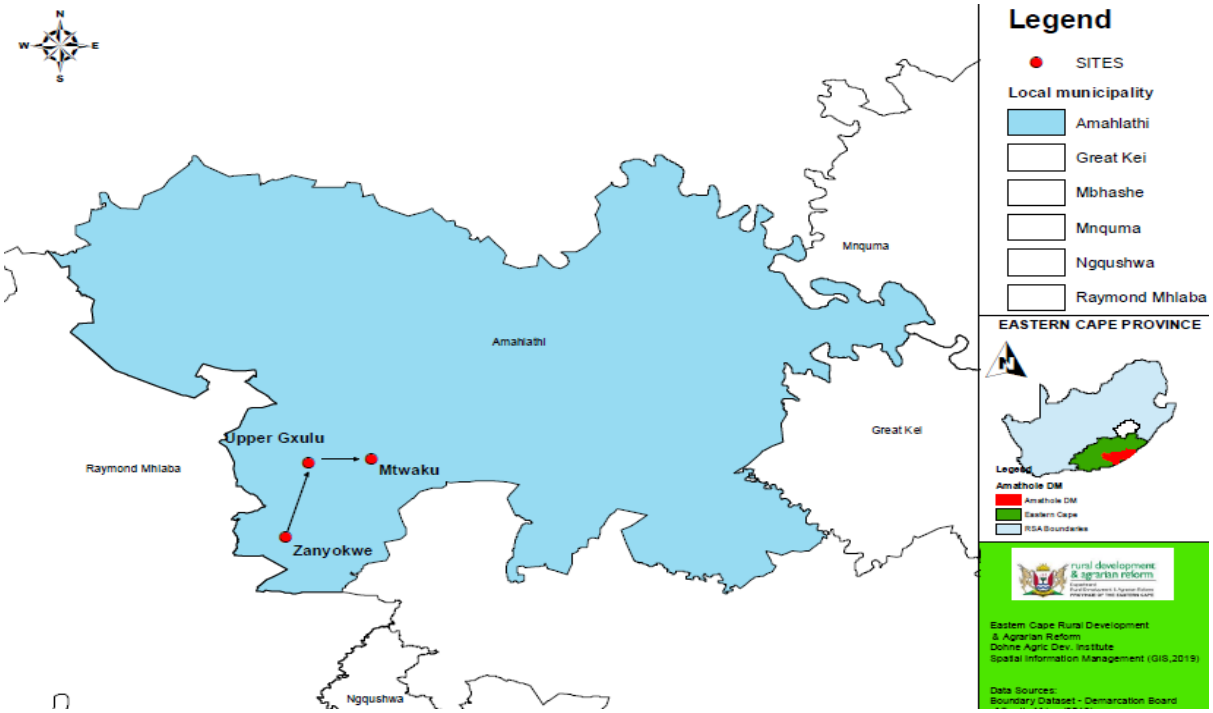

FIGURE 1: Map of Amahlathi Local Municipality showing Zanyokwe Irrigation Scheme in Keiskammahoek

2.2. Data Collection

Although Zanyokwe Irrigation Scheme is a vast area with multiple crop production activities within the scheme, this study focused on the Sidalukukhanya Co-operative (Co-op) (SAC), which comprised of eighteen members, and each member contributed a portion of land towards the formation of the Co-op. SAC is currently in partnership with DRDAR and RRD for peppers' production; their beneficiation model is 50:50 profit share. Hence, the study was conducted to evaluate the impact of this partnership on rural livelihood and the socioeconomic Status of Co-op members and their households. Primary data was collected through a survey (Mdiya *et al.*, 2021) using a structured questionnaire as the primary data collection tool. The questionnaire was divided into sections to answer the main research questions. It covered the demographic characteristics, such as age, gender, marital status, education, employment, and skills of the Co-op members (Chimonyo *et al.*, 2020). The questionnaire was administered during face-to-

face interviews to 12 project participants randomly sampled and carried out in IsiXhosa (the native vernacular of the people) to reduce misinterpretations and ensure confidence (Mdiya *et al.*, 2021).

2.3. Data Analysis

Gathered data was entered, verified, coded, and cleaned using the Microsoft Excel package to ease the handling of both string and coded variables. The coded data were then exported into the Statistical Package for Social Sciences (SPSS 20.0) for descriptive analysis.

3. RESULTS AND DISCUSSION

3.1. Demographics of Sidalukukhanya Co-op

The survey revealed that the Co-op's land is 100% owned by the farmers, who inherited it from past generations. However, this is communal land under the traditional authority regarding land tenure. Concerning the demographics of the Co-op, Figure 2 shows that most of the members are women. It is important that women lead the executive committee. Thus, women are directly involved in the decision-making aspects of the project. Interestingly, Koppen *et al.* (2017) note that research shows that women are the pioneers of small-scale farming and have been the land's dominant cultivators throughout history. Dube (2012) also reported that about 60% of women farm in the irrigation schemes, and those women hold high positions in the committee.

The average age of respondents and most Co-op members are middle-aged (67%), with the elderly holding around 33%. Regarding age, there is potential sustainability of the project; however, Co-op members also need to introduce their children to farming for succession and long-term sustainability of the project. Hofferth (2003) argued that older people have rich experiences in social and physical environmental aspects that influence farming. It was observed that most of the respondents were married, followed by single and widowed members, while a few were divorced.

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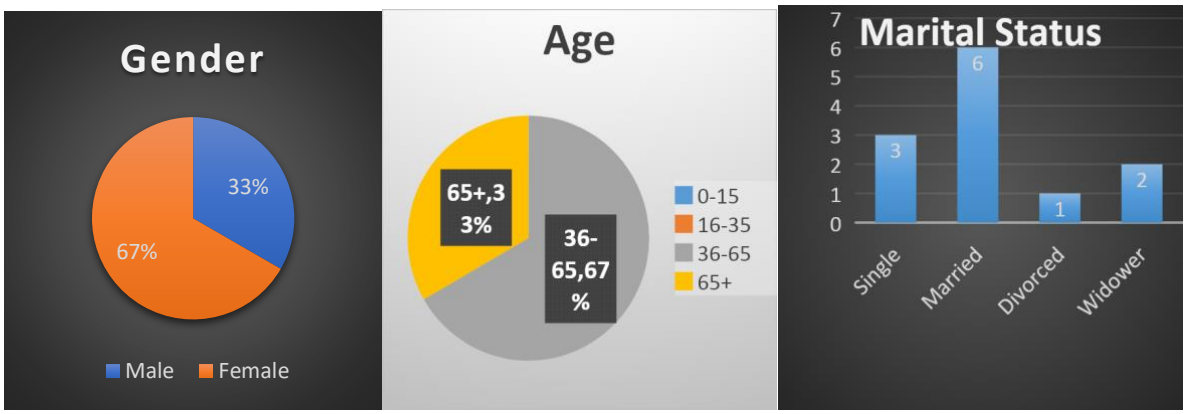

FIGURE 2: Demographics of the Co-op Members

The education level of the members in this PPP is presented in Figure 3 below. The results showed that all the members attended school, although 83% ended their education at Grade 9, with only 8% reaching the secondary education level (Grade 10-12). While none of the members held a post-matric qualification, they are literate, able to read and write and most importantly, read the terms and conditions written in the partnership contract. According to Dube (2012), education is important in farming as it enables the farmer to process information easily and use it to make informed decisions. Furthermore, education allows farmers to perform tasks more efficiently, enhance productivity and quality, and rapidly adapt to an ever-changing environment and improved technologies. Paddy (2003) also stated that education is crucial in farming as it influences the awareness of possible advantages of modernised agriculture through technological inputs, reading of agricultural literature, such as input instructions, and overall improved decision-making.

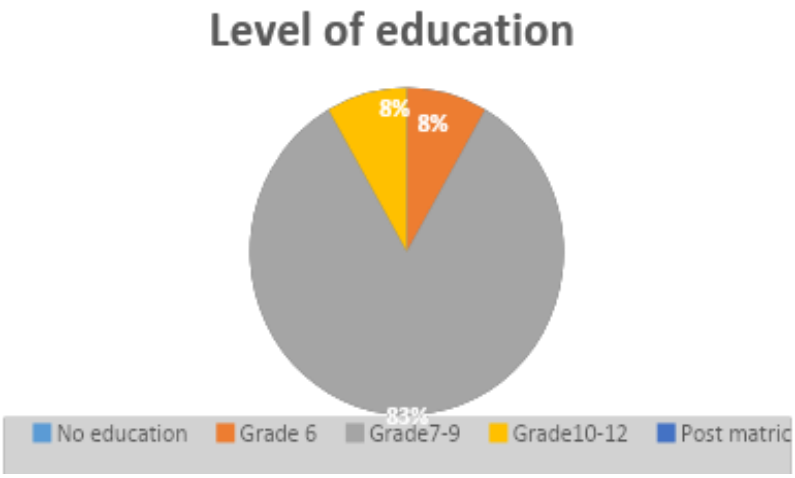

FIGURE 3: Education Status of Sidalukukhanya Farmers Co-op

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3.2. Impact of the Partnership on Socioeconomic Status and Rural Livelihood

3.2.1. Jobs Created Through Partnership

The results in Figure 4 indicated that the partnership played a pivotal role in creating both permanent and seasonal jobs. Through this partnership, employment opportunities for unskilled, semi-skilled, and skilled labour in the rural communities of Amahlathi Local Municipality have been realised. As shown in Figure 4, approximately 13% of jobs were created in the field for the Co-op members, while 6% were permanently employed in the processing factory. Similarly, 56% of seasonal employment intake was required during the planting and harvesting periods in the cropping fields at Zanyokwe Irrigation Scheme in Keiskammahoek. At the same time, a further 25% of seasonal jobs were created through the processing of produce at the agro-processing factory in Stutterheim. Dube (2012) reported that PPPs in agriculture had encouraged the economically active population, which led to improved rural livelihoods in rural communities. Warnars *et al.* (2008) stated that agricultural-based PPPs have economic multiplier effects, including employment opportunities for farm workers, produce transporters, and retailers selling farm inputs to meet the production surge. Similarly, Mhalila (2007) reported that agriculture PPPs contributed immensely to livelihood improvement, improved socio-economy, and food security in rural areas, creating a situation where people no longer depended on government food relief parcels.

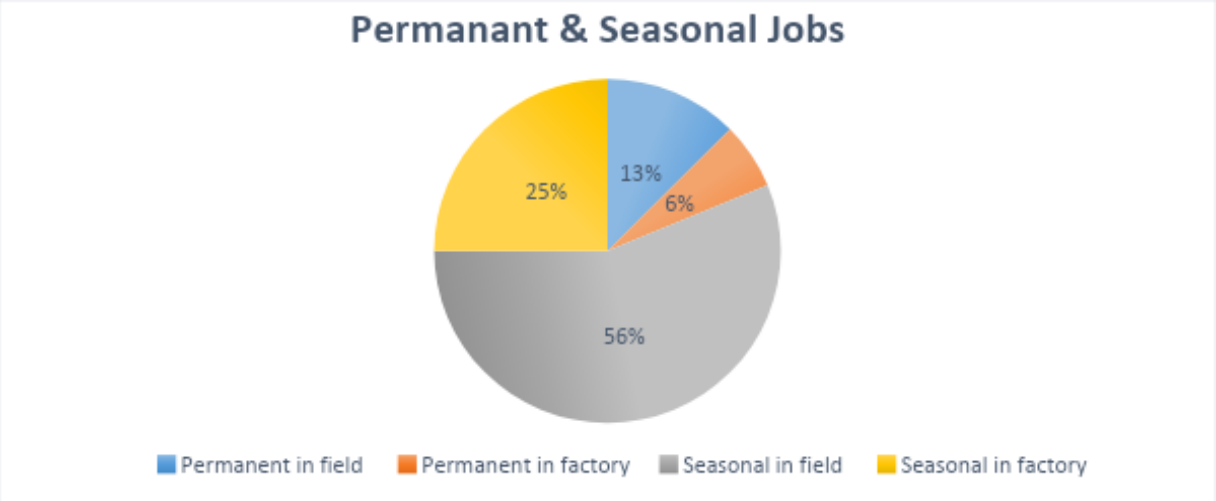

FIGURE 4: Permanent and Seasonal Employment Jobs Created Through the PPP

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3.2.2. Skills Attained Through the Partnership

The results of this study (Figure 5) showed that farmers participating in the partnership were capacitated with various skills such as management, record keeping, financial, and technical skills to improve their socioeconomic status. As indicated, the study focused on growing peppers, and most farmers were trained in chilli pepper production to ensure high-quality produce. Additionally, some farmers were trained in managerial and financial skills to improve the supervision in the Co-op. This, in turn, enabled them to supervise workers during the peak period of the season (planting and harvesting). Dube's (2012) study focused on Gweru Irrigation Scheme and reported a significant impact on improving lives in communities participating in the partnership.

FIGURE 5: Skills Obtained by Farmers Through the PPP

3.2.3. Impact of Partnership on the Livelihoods of Sidalukukhanya Co-Op Farmers

The results (Figure 6) showed that the farmers of the Co-op benefited in various ways from the partnership. These include financial stability from the produce profit share, jobs created in the value chain of chilli pepper, and benefitting the local community. The Co-op members indicated that they could buy household assets, pay children's school fees, extend their houses and purchase livestock. Rankin *et al.* (2016) reported that the income earned by smallholder farmers participating in PPPs enables them to live a better quality of life. Dube (2012) stated that farmers in irrigation schemes could build better houses and furnish their homes. Warnars *et al.* (2009) also reported that among the benefits of PPPs in irrigation schemes is the substantial contribution to the food security and economic progress of African rural

communities. This, in turn, gives rural households greater purchasing power for essential commodities, including improved access to healthcare services and education.

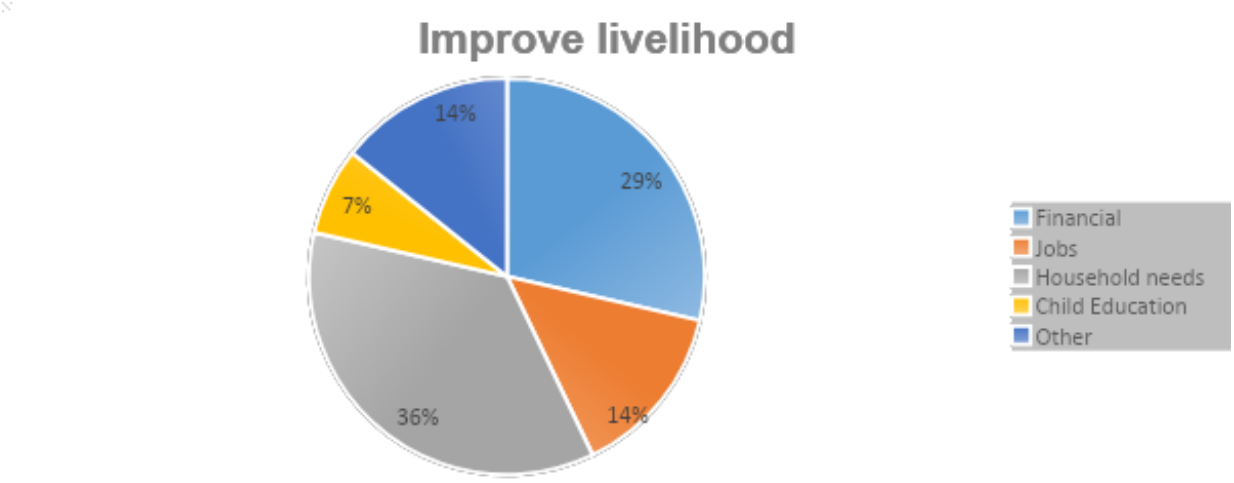

FIGURE 6: Impact of Partnership on Farmer's Livelihoods

4. SWEET CHILLI PEPPER CROP AS THE PPP "ECONOMIC BACKBONE"

4.1. Growing Practices

The economic backbone of the PPP is horticulture, predominantly sweet chilli pepper cropping. The crop is a member of the S*olanaceae* plant family, scientifically known as *Capsicum annuum L*, and is commonly known as sweet chilli or bell pepper by locals. Sweet peppers originate from Central and South America, where numerous species have been used for centuries (Manrique, 1993). The crop grows well under warm summer conditions and is sensitive to cold and frost (DAFF, 2013). The optimum temperature requirements for the growth and development of sweet chilli peppers range from 20 - 27°C. The crop drops flowers in high temperatures above 32°C (Sajan *et al.*, 2001).

Sweet peppers grow well when planted in deep, fertile, and well-drained soils (DAFF, 2013), making it necessary to do a soil test to determine the soil's nutrient content. Peppers grow best in a soil pH between 6.0 and 7.0. The soil pH should be adjusted to near neutral (7.0) for maximum yields (Anon, 2000). The demands of pepper vary with the stage of development; however, transplants must be watered to root level to ensure good establishment. Before planting, thorough soil preparation is done with the aid of a tractor, and ridges are established to create rows. The black landscape fabric plastic is laid on ridges for weed suppression and

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moisture conservation. At planting, transplants are dipped in fungicide for fungal control. One transplant is placed per station, planted at 350 mm spacing between plants in double rows and a spacing of 800 mm allocated between rows for pathways to accommodate 80 000 plants/ha. To maximise crop yields, agronomic activities, such as watering, hand weeding, and insecticide applications, are administered until the crop is ready for harvest. At harvest, the fruit is hand-picked, and 25 tons/ha is regarded as the average yield. The harvested crop is then stored in a cold room to maintain quality.

5. CHALLENGES ENCOUNTERED BY FARMERS:

- The increased frequency of droughts is a major challenge highlighted by the farmers. As a result, the area allocated to chilli peppers was reduced from 18 Ha to 12 Ha in this season due to water shortages from the water source (Sandile Dam);
- Farmers have no direct market access with the end user of the produce; and
- Inadequate access roads within the scheme to accommodate the easy transportation of produce.

6. FUTURE PLANS

The private partner (RRD) plans to exit the primary production stage of the project and allow the farmers to produce the peppers on their own. However, RRD aims to be the potential market for the farmers by buying their produce for processing.

7. CONCLUSION AND RECOMMENDATIONS

The respondents mentioned many success stories associated with the partnership. Moreover, respondents indicated that the training acquired from this partnership was vital and would enable them to continue producing even if the partner exits in the future. The partnership significantly contributed to the livelihoods and socioeconomic status through job creation for the farmers and the local community around Zanyokwe Irrigation Scheme and other areas of Amahlathi Local Municipality. Hence, partnerships of this nature are recommended to expand to other irrigation schemes in the province to ensure food security and improve rural livelihoods throughout the Eastern Cape province.

8. ACKNOWLEDGEMENTS

The authors would like to thank the farmers of Sidalukukhanya Agric Co-op for their participation in the study. We extend our deepest gratitude to Rance Rural Development for allowing us to conduct the research and for their contribution to the study's success.

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Impact of Climate Change on Sustainable Pastoral Livelihoods in Loima Sub-County, Turkana County, Kenya

Imana, C.A.[1] and Zenda, B.[2]

Corresponding Author: C. Imana. Correspondence Email: chrisimana@gmail.com

ABSTRACT

Climate change and variability have adversely affected communities' pastoral livelihoods in Kenya. The study aimed to investigate sustaining pastoral livelihoods in a changing climate in Loima Sub-County, Turkana County, Kenya. A total of 59 pastoralists were interviewed using a questionnaire. The data was analysed using the Statistical Package for Social Sciences (SPSS) software Version 22. SPSS employed descriptive statistical techniques like frequencies, percentages, cross-tabulations and proportions, means, and standard deviation. Pie charts, graphs, figures, and tables were used to present the data analysis output. Climate has been observed to vary continuously by pastoralists. Climate hazards mostly reported were livestock diseases and the frequency of droughts. The findings also indicated that livestock keepers preferred to graze their livestock on mountains/hills. Pasture and water availability and security determine the pattern of livestock movement. Pastoralists adopted various strategies to cope with climatic changes. Some of these strategies included diverse utilisation of livestock products, controlled grazing, herd diversification, and labour distribution among household members. In conclusion, climatic change and variability effects on the livelihoods of the pastoralists are evident. However, they have diversified ways of adapting and coping with these catastrophes to sustain themselves. To avert the effects of climate change, Turkana agriculture extension officers should focus on value addition to livestock products, provision of livestock insurance schemes, veterinary services, and livestock disease surveillance. Furthermore, agriculture extension needs to develop and enforce livestock policies and develop appropriate contingency plans. Among the policies recommended are- the management of grazing areas, regulations on migratory routes, and rules governing the use of water sources.

[1] Department for Sustainable Food Systems and Development, Faculty of Natural and Agricultural sciences, University of the Free State, Republic of South Africa, chrisimana@gmail.com

[2] Department for Sustainable Food Systems and Development, Faculty of Natural and Agricultural sciences, University of the Free State, Republic of South Africa, mashyit@yahoo.co.uk

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Keywords: Sustainability, Pastoralists, Livelihoods, Climate Change, Turkana

1. INTRODUCTION

Pastoralists are livestock keepers who live mainly in Africa's remote parts, often with variable rainfall patterns. Sub-Saharan Africa hosts approximately 50% of the pastoralists living in the world (Scoones, 2021; Food & Agriculture Organisation[FAO], 2018). Pastoralists lived in Arid and Semi-Arid Lands (ASALs) and maintained their livelihoods by keeping livestock. These livestock provide them with milk, meat, blood, transport, and trade (Watson, 2016). At least half of their income is obtained from livestock and/or their products. Djido *et al.* (2021) and Opiyo *et al.* (2016) inform that there is an increasing concern that poor communities, mostly ASALs, will suffer more from climatic changes due to heavy reliance on natural resources and vulnerability to droughts, flood occurrences and low adaptation capacities (Afful, 2016). For decades, the Turkana pastoralists' resilience has been strong, but due to the frequent climatic change effects, their perseverance seems to have waned. Watson (2016) and Cuni-Sanchez *et al.* (2018) have documented why Turkana pastoralists have remained vulnerable due to climate change: the reliance on natural resources, such as firewood and herbal medicine, occupancy of less productive lands and severe environmental degradation, including nomadic ways of life.

Even though pastoralism plays a critical role in the sustenance of the livelihoods of Turkana pastoralists, climate change has emerged as the main challenge threatening their survival. In such areas, climatic changes have led to high poverty rates, reduced access to water and grazing land leading to adverse competition over scarce resources, long-drawn-out conflicts, and in most cases, livestock raids. There is also a loss of livestock from diseases and reduced pasture lands (Schilling, 2018). Climatic changes and variability have increased water scarcity for domestic use and forage regeneration. Drought frequency and competition from agriculture and oil industrial uses threaten water availability (Schilling, 2018). In some other localities, climatic variability and changes have led to increased floods and droughts (Maka *et al.*, 2019). These unfavourable climatic changes have reduced the capacity of the pastoralists to cope or maintain their livelihoods. Climate change has been attributed indirectly or directly to human activity that modifies the composition of the global atmosphere and results in the natural variability observed over a comparable time (Adebisi-Adelani & Akeredolu, 2020).

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Turkana pastoralists have few options for effective adaptation and coping measures to avert these catastrophes. The area has continuously experienced frequent droughts, flash floods, and the washing away of livestock herds (Ng'anga *et al.*, 2016). There is, therefore, an urgent need to determine the effects of climate change on Turkana pastoralists' livelihoods. Further, viable coping and adaptation mechanisms of Turkana pastoralists have to be studied and recommended to the national government, county government, and other development partners. The study will hopefully also help design agriculture extension frameworks that would enable pastoralists to adjust to a rapidly changing development context and enhance our conception of their livelihoods. Moreso, the study will enhance our understanding of the diverse ways pastoralists make their living and improve their lives in ASAL areas. Although much has been written about agriculture extension workers towards their work and agronomic skills worldwide. Studies on the coping and adaptation mechanisms needed by extension workers in Kenya, to support pastoralists have not received the attention it deserves. This study aims to contribute to closing this gap by assessing the extent to which pastoral livelihoods can be sustainable in a changing and variable climate.

1.1. Objectives of the Study

The broad objective of the study was to assess the extent to which pastoral livelihoods can be sustainable in a changing and variable climate in Turkana County, North West Kenya. The specific objectives were to:

- Investigate sustainable livelihood options pursued by pastoralists within the study area.
- Identify the climatic changes experienced by local Turkana pastoralists.
- Determine the adaptation and coping strategies of Turkana pastoralists to climate change and its variability.
- Propose policy or legal frameworks necessary to sustain pastoralists' livelihoods to remain viable under variable climatic changes using the above analysis outcomes.

2. METHODOLOGY

The study was conducted in Loima Sub-County, Turkana County, which is located in North-West Kenya (Appendix 1). Loima is one of the seven sub-counties constituting Turkana County. The sub-county is considered a marginalised area and classified as ASAL, and it covers a land mass of 2,119.10-kilometre square, with a population of 107.795 people (KNBS,

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2019). Loima sub-county lies in agroecological zones (AEZ) IV (semi-humid to semi-arid) and V (semi-arid) and is hot and dry throughout most of the year (Jaetzold & Schmidt, 1983). The temperatures continuously range between 24°C to 38°C. The rainfall of Loima is bimodal and highly variable, with a long-term mean of 216 mm and a maximum of 500mm per year (Rutoh, 2019). This study chose pastoralists' households as the basic unit of analysis, with members living and sharing income. A multistage sampling procedure was used to select the households to be interviewed. Multistage sampling was considered because it allows random selection after determining the sample to be considered in the study. It does not need a sampling frame or can be applied where there is no sampling frame, reducing sample preparation costs (Muzah, 2018).

In the first stage, Turkana County and Loima sub-county were purposively sampled because they are mostly affected by climatic changes and variability. All the sub-county wards were considered for the study in the second stage. The third stage involved sampling 60 households comprising 15 from each of the four wards in the sub-county. A sample of 59 households was obtained through a simple random sampling procedure in which, except in one ward where nine respondents were considered due to non-response of one household, ten respondents from five wards responded to the questionnaire. In each ward, households were stratified to livelihood zones, such as formally employed, fisheries, pastoral and agro-pastoralists.

Data were collected from 59 pastoralists using a semi-structured questionnaire. A pre-test of the data collection tool was undertaken by piloting the questionnaire with six pastoral householders (one in each ward) to ascertain the authenticity of the questionnaire and ensure it yielded the required data. The respondents were requested to provide comments on the clarity of the parameters used in the questionnaire.

The data under analysis are quantified and, therefore, numerical, leading to the use of statistical formulas. Information collected included: the household head's primary occupation, utilisation of various livestock products, income obtained from multiple occupations, and livestock keeping as a livelihood strategy. Regarding climate, information was collected on weather and climate change, climate hazards affecting livestock, the degree of exposure to risk factors, adaptation strategies, controlled grazing zones, diversification, destocking, livestock grazing patterns, the determinants of the climate movement, and the grazing pattern of livestock throughout the year.

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3. RESULTS AND DISCUSSION

3.1. Demographic Information

According to the results in Table 1, there exists a gender gap between males and females. These results indicate that any strategy that may be used to develop farming systems in the area will not equally benefit men and women. The results agree with similar studies by Setshedi and Modirwa (2020) and Zenda and Malan (2021) that the gender gap exists between men and women in agriculture. Of the 59 respondents, 64% were males, and 36% were females (TABLE 1). The distribution of the ages was 33% distributed across three age categories, as depicted in Table 2.

TABLE 1: Sex of the Respondents

Age – Sex Distribution		Frequency	Females
Total		59	100%
Male		38	64%
Female		21	36%

TABLE 2: Age-Sex Distribution

Age – Sex Distribution	Total	Males	Females
Total	59	38	21
18 to 35	31%	29%	33%
35 to 40	34%	34%	33%
Above 40	36%	37%	33%

3.2. Level of Education

The results in Table 3 indicate a low attendance of pastoral children in formal schools compared to children from families with formal employment. The findings agree with the research conducted by Dyer (2021), who studied the relationship between formal education and pastoralists in Western India. As indicated, most of the respondents who participated in the survey did not have formal education. More men lacked formal education compared to women. The younger age group (18 to 35 years) had more formal education than older respondents (TABLE 3).

TABLE 3: Education Level of the Respondents

	Total	Gender		Age Category		
	Total	Male	Female	18 to 35	35 to 40	Above 40

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Never been to school	66%	71%	57%	50%	65%	81%
Grade R to grade 8	29%	24%	38%	39%	35%	14%
Grade 9 to grade 12	3%	3%	5%	11%	0%	0%
Tertiary qualification	2.%	3%	0%	0%	0%	5%

3.3. Number of Years in Livestock Farming

The results in Table 4 indicate that most respondents have been practising livestock keeping for between 5-10 years, with age being a leading factor, where older people reported to have practised livestock keeping longer than their younger counterparts. The finding disagrees with the study by Opiyo (2016), who states that the Turkana pastoralists have kept livestock as their livelihood for hundreds of years. Opiyo further informed that the Turkana community raised livestock for subsistence and socio-economic reasons. On the other hand, Schilling *et al.* (2018) confirmed that reliance on livestock has been changing as pastoral households resort to a market economy, taking more livestock to sale.

TABLE 4: Summary Statistics of a Survey Carried Out in Turkana (n=59)

Farming experience	**Percentage**
Less than 5 years	10
5 to 10 years	39
10 to 20 years	31
More than 20 years	20

3.4. Dependencies

The results in Figure 1 indicate that all respondents reported having dependents living with them. Households had an average of eight dependents and a median value of six. The sample's average household-dependant size closely mirrored the 2019 Census data report that put the average household size for Turkana County at 5.6. A comparative analysis of dependent size across various age categories revealed that the older the respondents, the higher the number of dependents, as depicted in Figure 1. Yoda (2020) supports the findings on the number of dependents. He found that increased droughts among the Turkana increased the dependency ratio.

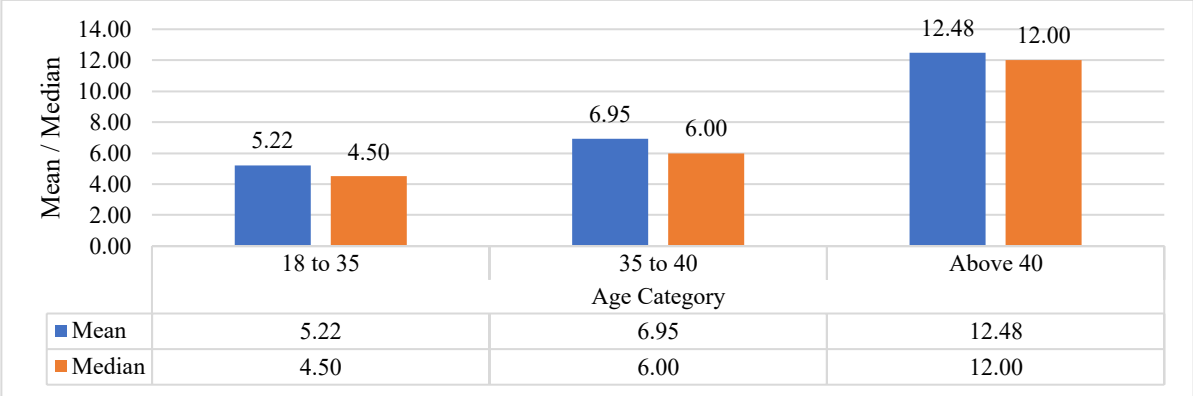

FIGURE 1: Percentage of Respondents With Dependencies in their Farming System

3.5. Pastoral Livelihood Options and Other Livelihood Strategies

3.5.1. Main occupation

The results of Figure 2 indicate that most respondents reported practising livestock farming as their primary occupation, while a few reported practising crop production. Other occupations reported included salaried employment and business ventures (Figure 2).

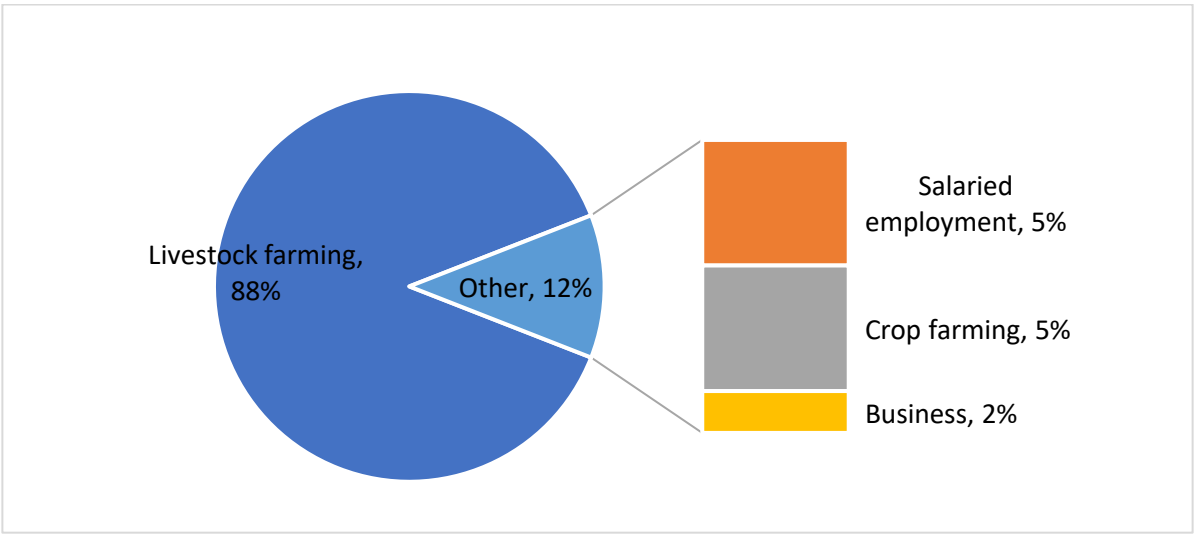

FIGURE 2: Displays the Respondents' Primary Occupation Percentages

Pastoralists mostly keep livestock, most of which do well in the dry areas of Kenya. This finding agrees with the study by The Food Economy Group (2016), which stated that 60% of Kenya's livestock are found in ASALs. It shows that 88% of the respondents practised livestock farming as their primary occupation. Only 5% of the respondents reported practising crop production; 5% said their primary occupation was salaried employment, and for 2%, the main occupation was business (Figure 2). This indicates that livestock farming plays an important role in pastoral communities.

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3.5.2. Type of Livestock Kept

The results in Table 5 depict that goats were the most common animals. The popularity of goats can be attributed to the fact that they are browsers and can withstand adverse climatic conditions. They are also versatile because the owners can quickly sell them for immediate needs. The findings also agree with the study by Opiyo (2016), which stated that the Turkana Pastoralists preferred to keep goats in their farming system since the species is perceived to be more resistant to drought than other livestock.

TABLE 5: Summary Statistics of a Survey Carried Out in Turkana (n=59)

Types of livestock reared by farmers in the Turkana County	**Percentage**
Cattle	20
Sheep	63
Goats	98
Camel	41
Donkey	24
Poultry	19
The main reasons for rearing livestock in Turkana County	
To provide money to maintain their families	76
Providing money for school fees	54
Cultural reasons	51
Reasons for selling livestock	
Drought	36
To buy food	95
Education	59
Medical care	51

3.5.3. Reasons For Keeping Livestock

Table 5 also indicates that Livestock rearing is the preferred primary occupation for various reasons but mainly as a significant source of income to provide for their families. The primary reasons cited included historical/cultural reasons, ease of management, drought-resistant, and they breed quickly. The main reason for preferring to rear livestock was to provide money to maintain their families (76%), followed by providing money for school fees (54%), and, lastly,

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for cultural reasons (51%). The finding also agrees with the study by Imana (2016), who stated the main reason for keeping livestock (mainly goats) was to provide household food.

3.5.4. Reasons For Selling Livestock

As indicated in Table 5, most respondents reported that their primary motivation for selling animals is to buy food, with education and health care tying in second place. Some respondents said that their primary motivation to sell animals was drought (36%) (Table 5). The ASAL region is prone to adverse climatic conditions which have threatened pastoralists' and communities' way of life in this region, concluding the findings by Opiyo (2016). This finding disagrees with the study by Opiyo (2016), who researched the Turkana pastoralists and found that they use this option to cover regular adaptation costs. Nevertheless, they sell their livestock to cope with short-term shocks. Every few years, thousands of livestock die due to drought and flooding. The government sometimes comes in to rescue these farmers by buying their animals, slaughtering them, and distributing the meat to disaster-stricken families.

3.5.5. Income Obtained From Various Occupations

The results in Figure 3 indicate that most households relied on livestock keeping as their livelihood strategy. Households that received high income (above R20000) relied on business. The finding further explains that pastoralists relied on diversified sources of revenue. This finding agrees with Opiyo (2016), who stated various reasons the pastoralists have to diversify their livelihood and income sources, one of which is to cope with climate changes and variability. The households obtained income from various occupations. Most respondents obtained it from livestock (44%), business (8%), and crop farming (7%) (Figure 3). The households which received income between R1000-R5000 received their income mainly from livestock (25%), business (7%), and crop farming (5%) (Figure 3). Further, the household which received income between R5000-10000 reported mainly relying on livestock (8%) (Figure 3). Those receiving income between R10000 to R20000 relied only on livestock (2%). Finally, households that received income above R20000 reported obtaining their income mainly from business (2%) (Figure 3).

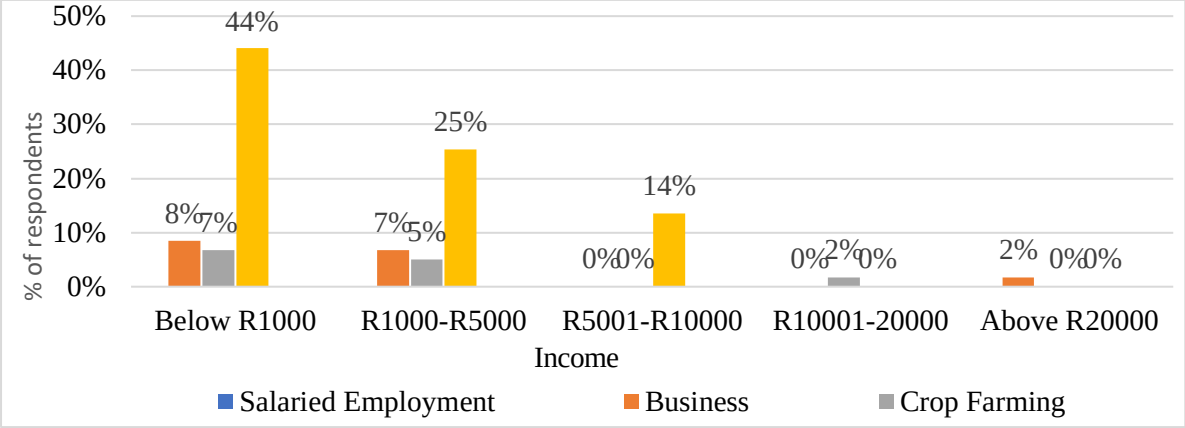

FIGURE 3: Sources of Income for Turkana County Livestock Farmers

3.5.6. Livestock Keeping as a Livelihood Strategy

From Figure 4 below, most pastoralists preferred to keep livestock for the future as a livelihood strategy, and 39% of all respondents reported they did not intend to continue with the venture as a livelihood strategy (Figure 4). These sentiments were mostly echoed by the males (45%) compared to the females (29%).

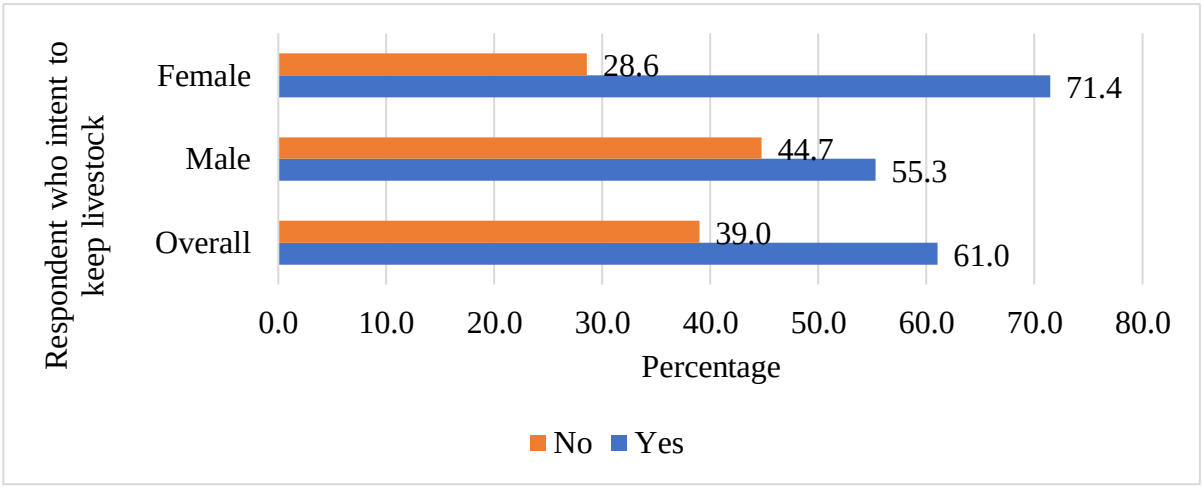

FIGURE 4: Displays the Percentage of Respondents Who Intend to Continue Keeping Livestock

The results in Figure 5 below indicate that livestock farmers would opt for a more sustainable venture like crop farming, business, and beekeeping. In contrast, most women who would abandon livestock keeping reported they would venture into business, and most men would venture into crop production. The younger farmers are more likely to start a business compared to older folk who venture into crop farming (Figure 5). Pastoralism as a livelihood strategy is

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threatened by climate change and other natural disasters like the recent locust infestation in ASAL regions. The sustainability of pastoralism as a livelihood strategy is reduced further by low government policies on ASAL and a lack of alternative livelihood ventures. The communities in this region already realise that pastoralism may not be sustainable in the long run.

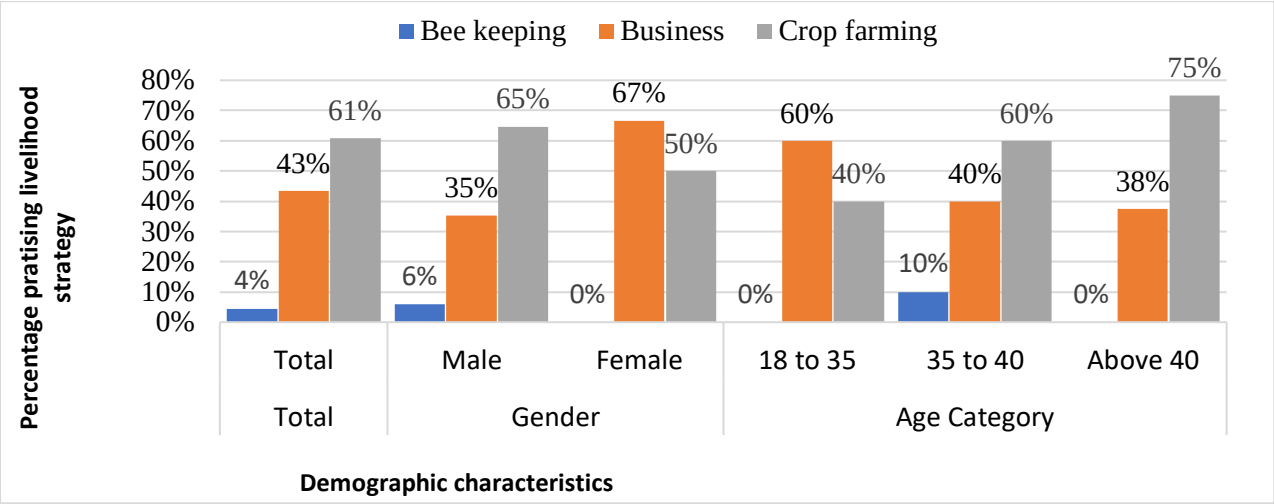

FIGURE 5: Livelihood Strategy of the Respondents

3.6. Effects of Climate Change and its Variability on Pastoral Livelihoods

3.6.1. Weather and Climatic Changes

Table 6 shows that all respondents who participated in this study agreed that the area had temperature, weather, and climatic changes. The majority opined that the changes or patterns have been varying continuously (Table 6). This finding is factual since pastoralists live in ASAL areas prone to changing and variable climates.

These findings agree with Djido (2021) studies, which postulated that pastoral livelihoods are threatened by the adverse impacts of a variable and changing climate. They were further concerned that the climatic changes adversely reduced the capacity of the pastoralists to promote their livelihoods. The study also concurs with Nga'nga *et al.* (2016), who alluded that continued extreme weather changes were likely to continue with severe impacts on livestock, human and natural resources.

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TABLE 6: Summary Statistics of a Survey Carried out in Turkana (n=59)

Perception of the respondents regarding temperature, weather, and climatic changes in an area.	**Percentage**
Varies continuously	86
Increasing	8
Don't know	2
No change	2
Decreasing	2
Main causes of livestock deaths	
Diseases	95
Drought	53
Predation	8
Slaughter	3
Floods	3
Other	0
The respondent's level of satisfaction with the condition of their livestock	
Yes	8
No	92
Reasons for dissatisfaction with livestock conditions	
Diseases	66
Drought	90
The grazing field is poor	12
Other	2

The fears of pastoralists identified in this study were also confirmed by Ramanan (2020), who stated that climate change could mean changing situations, such as weather or temperature patterns, for an extended period. All the respondents reported that they had noticed changes in the rainfall amount, drought, floods, and wind. Climate change was a significant threat to pastoralism, and diseases were singled out as the primary cause of animal deaths, followed by drought. Other factors reported causing death included: predation at 8%, slaughter at 3%, and floods (3%). Climatic changes and variability lead to drought, water shortages, and pasture

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depletion, explaining why it has become a significant threat to pastoralism. This finding agrees with Lenaiyasa (2020) study, which researched a similar environment (Samburu-Kenya). Lenaiyasa's study associated climate change and livestock mortality. The study reported that adverse climatic changes resulted in animals' deaths, ultimately bringing hunger to pastoralists and their dependents. Climatic changes are further related to wasting livestock conditions, leading to rampant disease outbreaks and market reduction.

Livestock condition is a critical variable for pastoralists because it indicates the average market price of the livestock. The pastoralists observe the body condition and the behaviour of the animals. Up to 92% of the respondents reported that they were not satisfied with the condition of their livestock (Table 6). The majority singled out drought (90%), livestock diseases (66%), and poor pasture (12%) as the leading causes of poor animal conditions due to climate change (Table 6). This finding agrees with Mushy's (2018) and Ng'anga *et al.* (2016) studies. The two studies pointed out adverse climatic changes as the culprit threatening water resources and poor pastures. These result from frequent drought, which is a consequence of climate change. The two studies added flash floods, which washed away herds of livestock.

Disease outbreaks, which can also be attributed to climate change, were reported as the most recurring phenomenon. About 80% of the respondents rated it the highest, while 20% rated drought as high in occurrence (Figure 6). About one in nine of the respondents reported the occurrence of drought as either the highest (49%) or high (39%) (Figure 6). Flood occurrence was ranked as average or low by the majority of the respondents, with hailstorms seldom happening in the region. The occurrence of hailstorms was not rated, as this only happens in areas with high precipitation. This finding can be explained by the fact that pastoralists have always been risk-averse. The pastoralists have devised ways of spreading the risk. For example, Alex (2018) states that pastoralists have had to divide their livestock relatives and may resort to raiding to increase or maintain stock after drought or disease outbreaks.

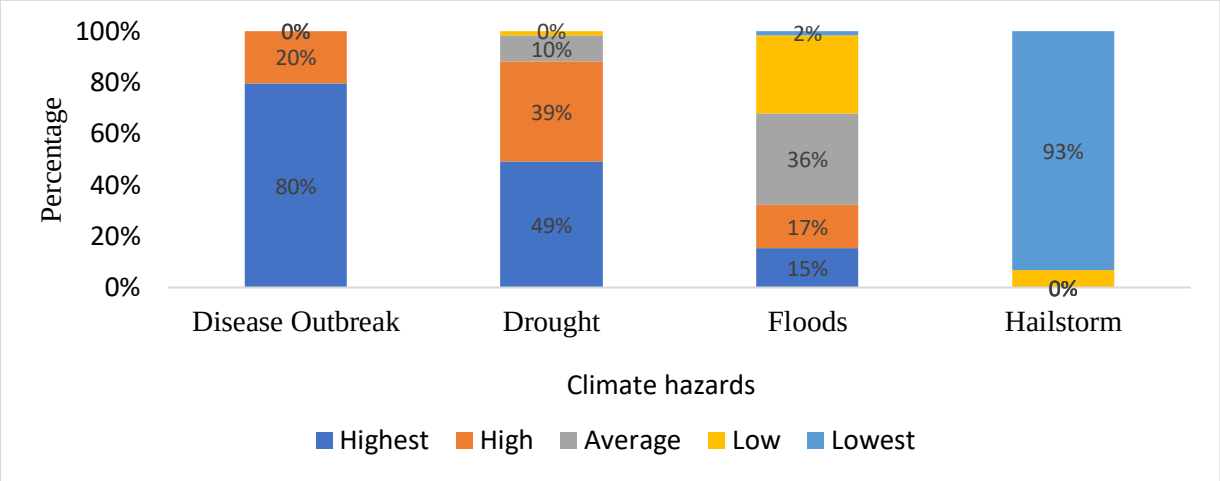

FIGURE 6: The Occurrence of Climate Hazards According to the Respondents

3.6.2. Other Climatic Hazards Reported

The results in Table 7 indicate that the climatic hazards reported include locust infestation by 45% of the respondents, worms attacking plants by 69%, and animal parasites infestation at 79% (Table 7). The respondents were also asked if they were conversant with other climatic hazards which affected their livestock. Most respondents pointed out parasite infestation, while locust infestation and work attacks were least mentioned. Due to locust invasions in the East Africa region during the year of the study, the respondents were worried these could have some adverse effect on their livestock. The literature reviewed did not provide enough information regarding the effects of these hazards on the livelihoods of pastoralists.

TABLE 7: Percentage of the Respondents Facing Other Climate Hazards

	Frequency	Percent
Total	29	100%
Locusts infestation	13	45%
Worms attacking plants	20	69%
Animal parasites infestation (ticks etc)	23	79%

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3.7. How Pastoralists Adapt and Cope With Adverse Effects of Climate Change and its Vulnerability

3.7.1. Diversification

The results in Figure 2 showed that the main occupation of the pastoralists was livestock. However, pastoralists still pursued alternative livelihoods (employment, crop farming, and business) to cushion against livestock failure deaths or raids. The research supports the finding by Ng'asike (2020), who asserts that pastoralists may also seek to diversify herds to survive ravages of droughts, diseases, or disasters.

3.7.2. Destocking

As shown in Table 8 below, most pastoralists sold their livestock. Further, most sold the products simply to earn money that can efficiently be utilised for other uses. This is a form of destocking. This research supports the finding performed by Nkuba (2019), who states that pastoralists resorted to destocking to acquire income for alternative livelihoods. Similar studies by Popoola *et al.* (2019) in the Eastern Cape, South Africa, reported that 55% of respondents use destocking as an adaptation measure. Popoola *et al.* (2019) further noted that some pastoral communities cushion against drought through destocking. Pastoralists who face huge losses due to drought opt for other livelihoods.

TABLE 8: Utilisation of Livestock and Their Products by the Respondents

	Animal (whole)	Milk	Meat	Skin	Blood
Sold	73%	32%	41%	29%	2%
Family use	80%	97%	98%	88%	98%
Dowry	56%	2%	5%	0%	0%
Kinship	4%	0%	0%	0%	0%
Other	5%	0%	0%	7%	5%

3.7.3. Determinants of Livestock Movement

The results of Figure 7 reveal that pasture and water availability were the main determinants of their movement. This finding is supported by Cocimano (2021), who proposes the creation of grazing zones to enable pastoralists to control their livestock mobility through fencing. The writer stated that creating grazing zones further minimises potential conflict between the warring groups. The writer further confirms that conflicts have also restricted pastoralists from grazing their livestock, reducing pastures' availability. From the findings, most farmers

reported that they move their animals more than twice throughout the year, and these movements are informed by seeking new pastures. Others moved livestock in search of water, while others moved for insecurity. The movement can be explained by the fact that pastoralists are mobile and graze on communal rangelands in search of pasture and water.

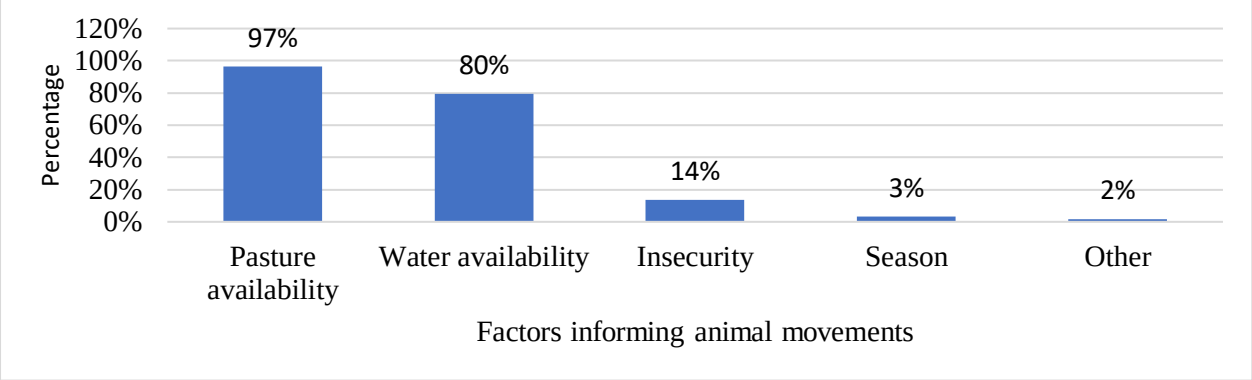

FIGURE 7: The Determinants of Livestock Movement

3.7.4. The Grazing Pattern of Livestock Throughout the Year

Figure 8 shows that increased movement for grazing can be associated with the fact that land in Loima is communal and pastoralists are nomadic and can move anywhere. The finding contradicts the idea of controlled grazing, where Olimba (2018) describes a system where producers control the grazing arrangements of livestock, which is not practised in pastoral lands. This method would have worked in privately owned lands, allowing other areas to be set aside as reserves for dry-season grazing (Olufemi, 2019).

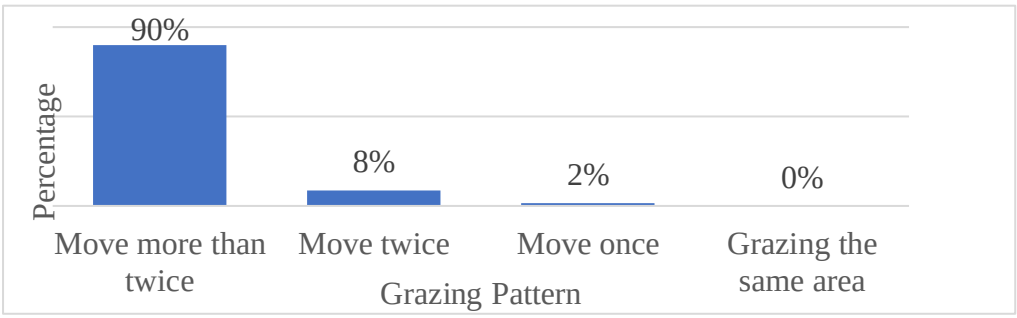

FIGURE 8: The Percentage of Respondents and Associated Livestock Grazing Pattern

Mgugi (2020) suggests adopting plans to guarantee drought-time access to specific grazing reserves, which must be developed in the context of general policy on pastoral land tenure. The practice involves dividing the livestock into small herds grazed separately and prioritising milk

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animals or other categories. Regarding livestock grazing, most respondents reported moving more than twice throughout the year. Two categories were reported to have moved twice and once. None of the respondents grazed the same area throughout the year.

4. CONCLUSION AND RECOMMENDATIONS

The study has contributed to the existing literature by informing that all pastoralists have witnessed the effects of climate change in the form of weather changes. The pastoralists experienced the effects of climatic changes and variability through drought, water scarcity, pasture depletion, and increased livestock diseases. Further, as much as pastoralists have practised various livelihood options, livestock keeping remains the primary livelihood option, and they wish to pursue them even when climate effects worsen. Pastoralists have devised other adaptation and coping mechanisms, such as diversifying into other livelihoods such as crop farming, herd splitting, controlled grazing, and destocking. Pastoralists have also devised other strategies, rules, and regulations for grazing management, migration or use of resources, and conflict resolution when it arises. The research has also come up with some recommendations:

- The department of agriculture extension and development partners should support pastoralists through programs that assist with water for both human and livestock fodder production. These will ultimately strengthen pastoralists' capacity to cope and recover from climatic change effects.
- The department of agriculture extension and development partners should invest in veterinary services and disease surveillance programs in livestock grazing areas. These will readily contribute to disease control/treatment and cushion against disease outbreaks.
- There is a need for comprehensive and proactive communication and coordination of government weather predictions through extension agents to act as an early warning system for livestock keepers.
- The government can develop policies and strategies for managing pasture land, water resources, and migratory routes with the pastoral communities.
- It is also crucial to investigate further ventures into commonly owned grazing areas and practice zoning and controlled grazing management.

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Is There a Case for Supporting Animal Traction Research, Policy, and Practice in Rural South Africa? - A Review

Zantsi, S.[1], and Christian, M.[2]

Correspondence Author: S. Zantsi. Correspondence Email: siphezantsi@yahoo.com

ABSTRACT

Appropriate and efficient technology contributes a great deal to smallholder farmer development. This study uses a systematic literature review to debate whether animal traction research and practice should receive support. Firstly, the smallholder farming system is reviewed to contextualise the discussion and present a state-of-the-art review of animal traction in South Africa. After finding the diminishing use of animal traction among smallholder farming systems, the inquiry probes the causes of the rural development policies, basic education curriculum, and higher learning institutions. The results reveal that the technological needs of smallholder farmers can be met with animal traction. However, a lack of support from policies and learning institutions has contributed to the negative attitude toward animal traction. We further note that new animal traction technology is unlikely to be known to smallholders because of poor information dissemination caused by a weak agricultural extension. After realising the benefits of animal traction, it seems worthwhile to revamp animal traction research and practice for subsistence farmers.

Keywords: Small-scale; Bottom-up approach; Extension; Government; Rural development

1. INTRODUCTION

Animal traction uses animals (cattle, donkeys, horses, mules, buffaloes, camels) to carry out soil tillage and transport goods and humans. For years, animal traction has been a significant component of agricultural production, especially on smallholder farms. However, its utility and

[1] Postdoctoral Research Fellow, Centre for Sociological Research and Practice, Department of Sociology, Faculty of Humanities, University of Johannesburg, siphezantsi@yahoo.com, Orcid 0000-0001-9787-3913

[2] Senior Lecturer, Department of Agricultural Economics and Extension, North West University, Private Bag X2046, Mmabatho 2046, mzuyanda1990@gmail.com, Orcid 0000-0003-4446-0298

value have diminished over the years, and attention is given to other forms of mechanical power, such as tractors. Some localised studies provide evidence of this assertion. For example, Stroebel, Swanepoel and Pell (2011) reported that smallholder farmers ranked animal traction in Limpopo as the least important benefit of farming with cattle. Zamchiya (2019) found that in one village in the Eastern Cape, animal traction was only used by 20% of the smallholder households. In the Wild Coast, Hajdu, Neves and Granlund (2020) reported that a few households only used animal traction with larger gardens. This trend is similar in developed countries (Wilson, 2003). However, there is scepticism about why South Africa, a developing country, is following this trend from the developed countries. Evidencing this is the country's approach to rural development projects. A case in point is the government support programme, focusing on commercialising subsistence farmers through massive food production and mechanisation in the Eastern Cape (Jacobson, 2013). However, evidence shows that the limited success of the programme above has been caused by inappropriate approaches and unsuitable technology suggested to farmers, among other factors (Fischer & Hajdu, 2015).

Animal traction values and benefits to the subsistence smallholder farming systems have been documented in numerous studies (Starkey Jaiyesimi-Njobe & Hanekom, 1995; O'Neill Sneyd, Mzileni, Mapeyi, Njekwa & Israel, 1999; Simalenga, Belete, Mzeleni & Jongisa, 2000; Hart, 2011; Sheckleton & Hebinck, 2018; Zantsi & Bester, 2019). Subsistence and semi-subsistence agriculture are the dominant forms of agriculture in South Africa, and many smallholder farmers are poor, with obsolete to non-existing infrastructure (StatsSA, 2016). This makes animal traction more appropriate for such households and conditions (Makaota & Motiang, 2000). There is also evidence that even commercially-oriented irrigating smallholders with small plots make more profits from using affordable technology, such as donkey-pulled ploughs, than those who do not use animal traction (Tapela & Alcock, 2011). Furthermore, there have been new developments in animal traction with more suitable drawn machinery, such as no-till planters, mowers, and animal-drawn discs, to mention just a few.

However, these developments remain unknown to the South African smallholders partly due to poor dissemination of such information and little support from educational institutions and rural development policies (Starkey, 2000). For example, a recent systematic review of literature on smallholder technology adoption has shown that useful technologies remain unknown to smallholders in sub-Saharan Africa because of poor diffusion caused by a weak agricultural extension (Takahashi *et al.*, 2020). Joubert (2016) attributed the death of animal

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traction research in South Africa to a lack of priority from educational institutions and government policies.

In light of this background, this study seeks to first present state-of-the-art animal traction research in South Africa. Secondly, it discusses the policy and practice of animal traction concerning low adoption. Lastly, it argues whether there is a case for greater support of animal traction research and education in South Africa. We follow a systematic review approach to address the first and second research objectives.

In the next section, we contextualise our discussion by presenting the nature of South African smallholder farming, after which we describe the study methodology in section 3. In section 4, a synthesis of the reviewed literature will be presented thematically and extensively discussed. Lastly, we conclude with the scope for future research in section 5.

2. SOUTH AFRICAN SMALLHOLDER FARMING SYSTEMS IN BRIEF

According to Statistics South Africa's Agricultural Household Survey, there are 2.3 million households practising farming on a smallholding base (StatsSA, 2016). Most of these smallholder households are in Eastern Cape (27,9%), followed by Limpopo 24,1% and KwaZulu-Natal (18,6%). Mpumalanga, Free State and the Northern Cape follow with 18,2%, 16,6% and 13,8%, respectively. Western Cape and Gauteng recorded the lowest participation rates, with 3,6% and 4,9%, respectively. These smallholder households have farms with either animal or crop only, and some with a mix of the two. The provincial distribution of smallholders by type of farming is shown in Figure 1. Of the total agricultural households in South Africa, a vast majority (42%) of agricultural households in South Africa farms mostly with animals (see Figure 1 below). This somehow resembles the land distribution of South Africa, where over 60% of the land is extensive grazing land (DAFF, 2017). The herd size is smaller in large stock (cattle), with 70%owning only between one and ten animals and 27% owning between eleven and a hundred animals, and the remaining owning more than a hundred animals (StatsSA, 2016). Regarding sheep, 47% of households own between eleven and a hundred animals, and those who own more than a hundred animals are 9,2% (StatsSA, 2016).

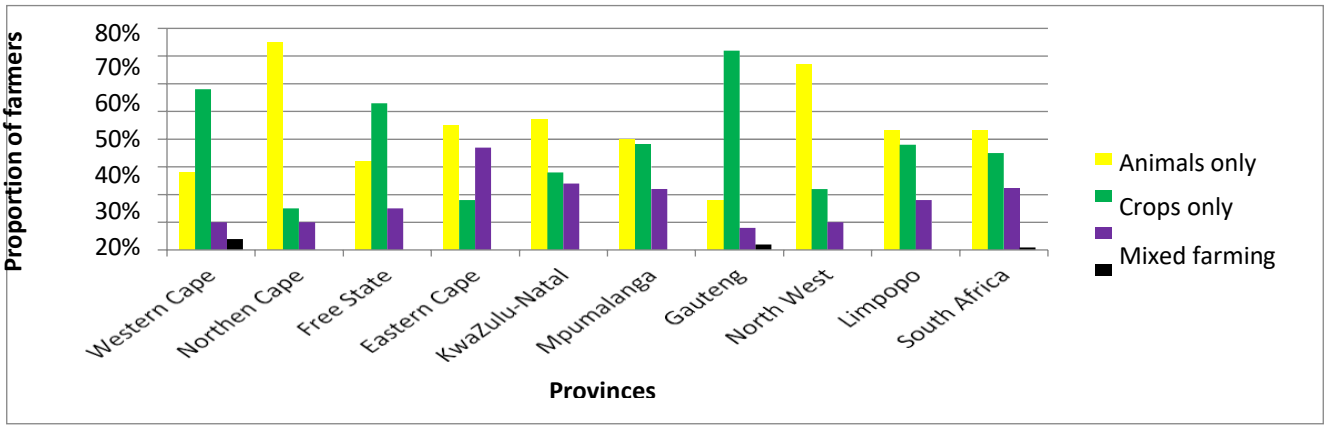

FIGURE 1: Types of Farming Activities Practiced by Agricultural Households (Source: StatsSA, 2016)

Smallholder households who practice crop farming cultivate in their backyards relatively small plots ranging between 0-20 hectares (StatsSA, 2016). Although smallholders generally share similar features, they are not homogeneous, as sub-groups that share similar features that are more specific can be found. A general typology of subsistence, semi-subsistence, and commercially-oriented smallholders are used to distinguish smallholders (Olofsson, 2020). This implies that animal traction might be suitable for specific groups, such as subsistence and semi-subsistence, who cultivate very small plots and own fewer animals than commercially-oriented smallholders (Zantsi & Bester, 2019).

3. METHODOLOGY

3.1. Approach

Review studies have gained popularity in scientific literature as one way of collecting facts from published scientific literature about a specific research inquiry. Review studies have emerged as one method of addressing research questions accepted in many disciplines, including rural development studies (Okoli, 2015). While there is more than one type of review study (e.g. traditional, snowball, systematic), systematic literature reviews (SLR) are the most preferred type for their rigorousness and replicability over other forms (Okoli, 2015). SLR has emerged as one scholarly work valuable for informing policy and practice (Petticrew & Roberts, 2006). For the reasons above, review studies have been widely adopted and used in numerous scientific and quality literature (Santeramo & Lamonaca, 2019; Fielke, Taylor & Jakku, 2020).

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In this study, as in the studies above, we also follow an SLR ensuing the guideline outlined in Okoli (2015). In the previous study, the following steps are recommended: formulating a purpose or research question, conducting a literature search, determining criteria for inclusion, screening studies for inclusion, synthesis of information from the literature, and writing. We supplement the SLR with a snowball literature review to ensure we capture a broader literature, as some journals are not indexed in large databases for scientific literature. We adapt this from Fielke *et al.* (2020).

3.2. Literature Search and Inclusion

There are numerous ways of conducting a literature search. In this study, we wanted to capture as much literature as possible by looking at various databases for scientific literature and other platforms. We first explored the three largest scientific literature databases, Scopus, Web of Science, and Science Direct, as used in similar studies (Zhang, Xu, Zhang, Wang, He & Zhou, 2020). These were accessed from the University of Stellenbosch's library databases. As was used in the study by Blakeman (2013), the largest and often free-access search engines, Google and Google Scholar, were used. Sabinet-African journals, the most extensive database for African journals, were utilised as some African journals are not indexed in Scopus, Web of Science, and Science Direct. In reading some of the first studies obtained and from our background, we delved into the ATNESA and SANAT as they have a compilation of literature on animal traction in Africa and South Africa. Most of these were directly accessible from google. The following keyword search combinations"animal+traction+research+and+practice+in+south+africa& animal+draft+power" was used for studies published between 1995-2020.

Sabinet yielded 59 studies from different sources, presented in Figure 2. However, only seven studies were relevant and retained for depth review. In Scopus, only one article appeared by O'Neill *et al.* (1999), while in Web of Science, we found no studies in South Africa. While several studies were in our various search outputs, not all were relevant to our study question. As such, a decision had to be made about which studies to read in depth and which ones to be left out. This screening criterion was based on reading the title and abstract and where we found information related to animal traction, policy and practice, particularly in South Africa and Southern Africa. Such studies were downloaded and retained for full-text in-depth review.

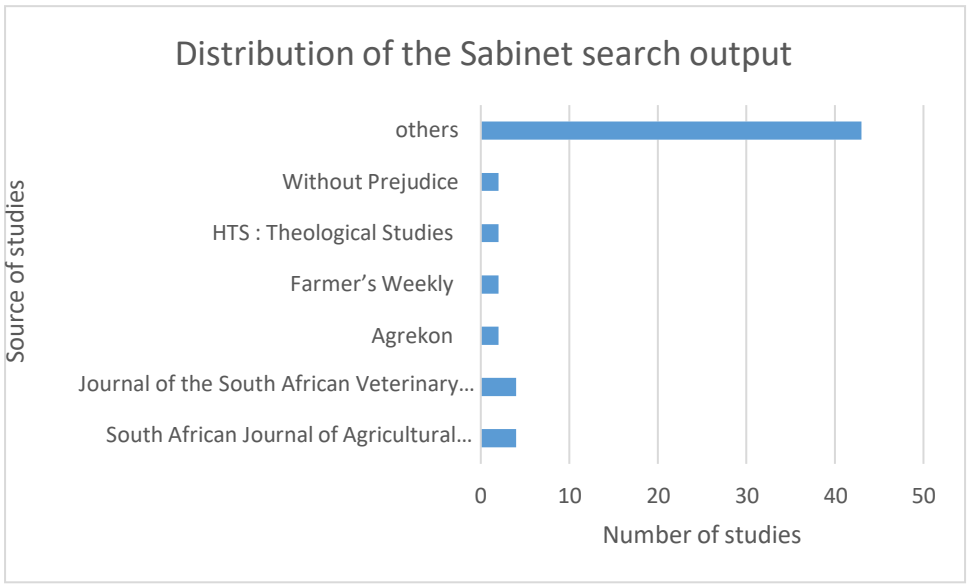

FIGURE 2: **Results of Search Output From Sabinet Indexed Journals**

3.3. Synthesis of Literature

This study followed a qualitative synthesis of the literature to assimilate the retained studies for full-text review. Following similar review studies (Machete & Shale, 2015), we employed a thematic analysis where we developed themes from the literature reviewed to quantify and qualify facts relating to our study question.

4. RESULTS: SYNTHESIS OF THE REVIEWED LITERATURE ON ANIMAL TRACTION RESEARCH IN SOUTH AFRICA

We identified five themes from reviewed literature to present a state-of-the-art review of animal traction in South Africa. The first theme speaks to the significant research outlets publishing animal traction research in South Africa. This is important, especially since animal traction research has seen a decline in journal outlets because of low-interest novelty and readership (based on authors' observations and literature search). By virtue, much of the research work on animal traction has been done by the South African Network for Animal Traction and Animal Traction Network for East and Southern Africa. These are well-established organisations for animal traction research in East Africa and South Africa. In terms of open publishing outlets, the *South African Journal of Agricultural Extension* and *Agricultural Systems* and *Development Southern Africa* is one of the few publishers of animal traction work.

The second theme that we have identified relates to how prevalent animal traction is among

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smallholders, which animals are used, and the ups and downs of using animal traction. Since Starkey *et al.* (1995) book, there has not been national work on animal traction in South Africa. Starkey *et al.* (1995) found that animal traction was used by 40-60% -of about 400 000 smallholders across South Africa. Within the smallholder farming system, cattle were mainly used for traction. The cattle are primarily used for ploughing, planting, seeding, weeding, and transporting goods (Makaota & Motiang, 2000). Six-spans are preferred in these animals (O'Neill *et al.*, 1999). There are also some cases of donkey use within the smallholder farming systems in Limpopo and KwaZulu Natal (van Averbeke & Khosa, 2011; Hart, 2011; Tapela & Alcock, 2011).

The following are the most pronounced benefits of animal traction: reduction of drudgery from humans (Wellsa & Kreceka, 2001), facilitating rural development (Wellsa & Kreceka, 2001), and encouraging sustainability and convenience for farmers with small plots such as avoiding waiting in queues for tractors, which may result in missing good rainfall (Makaota & Motiang, 2000). Evidence suggests that fewer smallholders own tractors, and many cannot afford to use expensive technologies (Hart, 2011; van Averbeke & Khosa, 2011; Zamchiya, 2019). Prevailing arguments supporting animal traction among smallholder farming systems are usually based on their advantages and appropriateness compared to tractors. Table 1 summarises the strengths and weaknesses of using animal power instead of tractors. It was compiled by the then National Department of Agriculture, now known as the Department of Agriculture, Forestry and Fisheries.

TABLE 1: **Different Draught Animals Commonly Used in South Africa Compared With Tractors**

Consideration	**Donkeys**	**Oxen**	**Horses**	**Mules**	**Tractors**
Purchase price (R)	R2 000 - 3 500	R9 000 – 15 000	R2 500 - 15 000	R10 000 - 25 000	Starts from R165 000
Working life (years)	12 - 25	6 - 9	15 - 20	20 - 30	7 - 15
Feed/fuel	Poor grass and working supplement	Good grass and working supplement	Good grass and quality working supplement	Poor grass and working supplement	Diesel or petrol and oil for lubrication

Management	Hardy, disease resistant, low management	Hardy, disease-prone, low management	Disease-prone, high management	Hardy, disease-resistant, low management	Service maintenance, high management
Operator's skill	All animals respond well to patient, friendly handling, and good management. Become confused and difficult when handled roughly. Horses and mules need one operator; donkeys and oxen 2 to 3 operators.				One highly trained operator withservice backup team
Advantage	Easy to manage, willing, produce manure, reproduce, very low operating cost	Easy to manage, strong, produce manure, low operating cost	Willing, fast, reproduce, produce manure, below average operating cost	Willing, easy to manage, hardy, long life, low operating cost	Powerful, last, effective, much work in a short time
Disadvantage	Can only work for short periods, small	Slow, cannot reproduce	Need high management	Difficult to acquire, cannot reproduce	Very high operating cost, difficult to repair
Daily workoutput: ploughing	4 hours	6 hours	5 hours	6 hours	Up to 22 h (change operator)
Type of activities	Animals can be used to plough, harrow, plant, cultivate, transport, carry loads, pump water, thrash grain, and for riding slowly				Can power all farm activities quickly

(Source: Adapted from NDA, undated)

In the preceding paragraphs, one sees the impression that cattle and donkeys seem to be the most preferred work animals. However, the facts presented in Table 1 point in a different direction. In terms of power and costs, donkeys and horses seem to be the best option for

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subsistence farmers (Zantsi & Bester, 2019). Reasons supporting the previous statement include subsistence smallholders who own small herds of cattle and small plots of arable land. Further, labour for subsistence farming is problematic to mobilise (Hull, 2014; de La Hey & Beinart, 2016); therefore, it is important to choose animals that require few labourers and can be handled by women, which account for the majority of smallholder households (StatsSA, 2016).

4.1. Animal Traction Education in Schools and Institutions of Higher Learning

Any successful technology adoption and understanding rely on research and development (R&D). The foundation of such R&D is an early curriculum on such technology. Swiegers (2000:104) argued how primary schools can be a nursery for the incubation of love for farming and improve technology appreciation:

"As more complex and productive new technologies and institutions that require a high level of verbal and numerical literacy become available to an agricultural area, primary schooling will become a worthwhile private and social investment for farm operations. Results will show that as technology increases, education of agricultural participants will become more profitable". Starkey, Njaiyesimi-Njobe, and Hanekom (1995) extensively discussed animal traction's history and crucial aspects in South Africa. In their analysis, it was clear that the rise and fall of animal traction in the 1960s and the 1970s led to numerous negative attitudes and neglect of animal traction research. They reckon that officials, including agricultural extensionists, probably knew little about animal traction. This has bred a generation with little knowledge of animal traction because even in schools, agricultural colleges, and universities, there was very little inclusion of animal traction (Starkey *et al.* 1995). A report from Food and Agriculture Organization (2010) echoed the same sentiments about the neglect of animal traction in education curricula and the vicious cycle of agricultural officials with no background in animal traction. To date, it is likely only the University of Fort Hare, where the South African Network of Animal Traction office is, that still has animal traction research practical in their curricula.

4.2. Animal Traction Policy and Practice

The imperative of rural development and agricultural development has been heavily debated, and its contribution to rural economic growth and employment has been emphasised. It is from such lines of thinking that even the National Development Plan in chapter six has focused on

building vibrant and inclusive rural communities (NPC, 2011).

However, what seems to be of conflict between research and policy practice is the mechanism of achieving rural and agricultural development to achieve vibrant and inclusive rural development (for a nuanced discussion, see Stoop & Hart, 2005). One example is suitable and appropriate technology for rural agricultural households. This is partly caused by a poor knowledge triangle – the linkages between research, teaching, and extension (ASSAF, 2017). Hazell (2005) emphasised the need for developing appropriate technologies for smallholders to improve the viability of small farms in today's highly competitive agricultural industry. Such technology includes high-yielding varieties, both seeds and animal breeds, and mechanisation.

Numerous researchers have blamed the use of inappropriate technologies for the failure of rural and agricultural development projects to promote the use of tractors instead of animal traction, which is a well-known mechanisation in rural areas (Fowler, 1999; Fischer & Hajdu, 2015). This is embedded in the ignorance of animal traction in rural and agricultural development policies. For example, two decades ago, Shetto *et al.* (2000:197) argued that "there is a lack of effective policies and support in promoting animal traction". Their context was focused on sub-Saharan Africa. This is certainly evident in South Africa, where there are very little or non-existence of animal traction policies. Swiegers (2000:103) expressed the same sentiments: "*it is with regret that I today have to report that, on the question of; "Are supporting policies for information to develop animal traction in South Africa in place?" My answer will be no… None of the Provincial or National Departments of Agriculture has an active programme on promoting animal traction.* This occurs despite the prominent role of publicly funded research and extension in meeting the technology needs of small farms (Hazell, 2005).

Although more than two and half decades ago, Starkey *et al.* (1995) expressed some positive attitude towards considering animal traction from the Reconstruction and Development policies to date, policies are silent on this issue, even in cases where there is a clear need for them. For example, the one household-one hectare policy intended for subsistence households (DRDLR, 2016) could be accompanied by one household and one horse for carrying the subsistence tillage. Fowler (1999:269) conveyed this as the "use of developed world approach in a developing world". The other common narrative defining the negligence of following a top-down policy approach in rural development is what is referred to by its proponents as "continuities catch rural development policies" (Hebinck, Fay & Kondlo, 2011).

This reality occurs despite the changing focus in rural development policies towards sustainable development (see Ellis & Biggs, 2001 for a detailed discussion). In this line of thinking which takes a bottom-up approach, development is seen to arise from the best use of household assets in a manner that promotes sustainability. In light of climate change and global warming, animal traction has been viewed as one contribution in cases where this is applicable, such as working small plots. Again, animal traction contributes by promoting crop-livestock farming systems that encourage organic fertilisation.

Lastly, this theme reveals the low adoption of animal traction technology is more pronounced in literature. Many studies attribute this to psychological and economic factors (Mbata, 2001; Starkey 2011; Kepe & Tessaro, 2014). These results stem from the stigma and low social status associated with animal traction users (Starkey, 2011). In one village in the Eastern Cape, Kepe and Tessaro (2014) reported how elderly community members reasoned for fallow arable land. They criticised young people for buying cars instead of cattle that can be used in arable production. The negative attitude around animal traction, diminishing use, and lack of policy support also affects the demand for animal-drawn implements. For example, disc-drawn implements and boom sprays are available in other countries. Still, in the ordinary former homeland, animal traction implements retailers, where most smallholder farmers could not be found. One of the author's visits in 2018 and 2019 to Agrotechnorama – Swiss Federal Agricultural Museum and German Agricultural Museum saw many different animal tractions implements than those found in the former Transkei's Umtiza™ farmers' coop. The latter is one of the growing retails for agricultural inputs, both plant and animal, and farm implements in most rural parts of the Eastern Cape province.

5. CONCLUDING REMARKS AND AREAS FOR FUTURE RESEARCH

This research note had three objectives. The first one was presenting the state-of-the-art review of animal traction research and practice in South Africa; the second objective was to discuss policy and practice of animal traction concerning low adoption. The third objective was to build an argument or debate on whether a case for greater support of animal traction research and education in South Africa exists. Through a systematic literature review approach, we noted that the small-scale farming system in South Africa is broad and can be categorised into subsistence, semi-subsistence, and commercial smallholding. The diminishing adoption and use of animal traction while subsistence and semi-subsistence smallholder households raise

questions. The first question is why the use and adoption of animal traction declined while evidence shows that subsistence and semi-subsistence can benefit from using animal traction.

It seems animal traction receives little support from rural development policies, and there are thriving negative attitudes regarding the use of animal power among rural communities. The institutions of basic and higher education offer few courses on animal power, which might be one factor behind the diminishing use of animal traction. It seems highly unlikely that new developments in animal traction technology will reach poor farmers, highlighting the ineffective role of agricultural extension. If animal traction offers benefits that can meet the power needs of subsistence and semi-subsistence smallholders, why should it not be supported? This question warrants further research that is grounded on empirical data.

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APPENDIX: LITERATURE SEARCH LINK

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search?value1=animal+traction+research+and+practice+in+south+africa&option1=fulltext&operator2=AND&value2=animal+draft+power&option2=fulltext&operator3=AND&value3=&option3=fulltext&operator4=AND&value4=&option4=fulltext&operator5=AND&value5=&option5=fulltext&operator6=AND&value6=&option6=fulltext&operator7=AND&value7=&option7=fulltext&operator8=AND&value8=&option8=fulltext&operator11=AND&option11=date_from&value11=1994-05-01&operator10=AND&option10=date_to&value10=2020-05-01&sortField=default&sortDescending=true&operator12=AND&option12=pub_collection&operator13=AND&option13=accessTypeId&operator14=AND&option14=sabinet_accreditation&option912=resultCategory&value912=ResearchPublicationContent&pageSize=59

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Baseline Study of Soil Nutrient Status in Smallholder Farms in Limpopo Province of South Africa

Mokgolo M.J.[1] and Mzezewa J.[2]

Corresponding Author: M.J. Mokgolo. Correspondence E-mail: matomej.josphistos19@gmail.com

ABSTRACT

An assessment of soil nutrient status based on farmers' samples was carried out in the Capricorn, Sekhukhune, and Waterberg Districts of the Limpopo Province of South Africa. A total of 336 soil samples were collected and analysed for pH, phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). The results showed that the pH of more than 80% of the submitted soil samples was suitable for the production of most field crops ,while less than 20% required liming to make them productive. Phosphorus levels were very low (<8 mg kg^{-1}), with most soils (≥95%) needing P fertilisation to improve crop yields. Potassium was adequate (>250 mg kg^{-1}) for most districts' crops. Between 70% and 74% of soils from Sekhukhune and Waterberg Districts were deficient in Ca (<200 mg kg^{-1}). Magnesium was adequate (>300 mg kg^{-1}) in more than 60% of the analysed samples. Apart from soil pH, all soil properties showed a high degree of variability across all districts. Further studies are needed to investigate the role of field management, crop rotation, field position in the landscape, lithology, and socioeconomic conditions of the farmer on the observed trends of soil nutrients.

Keywords: P Deficiency, Smallholder, Soil analysis, Soil fertility.

1. INTRODUCTION

Food production in sub-Saharan Africa (SSA) depends on the soil's capacity to provide nutrients to the growing plants (Smaling *et al.*, 1997). However, research has shown that the soil in the region is increasingly showing signs of physical and chemical degradation and

[1] Lecturer, Department of Plant Production, Tompi Seleka College of Agriculture, Private Bag X9619, Marble Hall, 0450, South Africa. matomej.josphistos19@gmail.com, ORCHID: https://orcid.org/0000-0001-9528-2263

[2] Senior Lecturer, Department of Soil Science, University of Venda, Private Bag X5050, Thohoyandou, 0950, South Africa. Jestinos.Mzezewa@univen.ac.za

cannot support crop production (Smaling *et al.*, 1997; Sanchez *et al.*, 1997). Therefore, low soil fertility in SSA is a major contributor to low food production (Sanchez *et al.*, 1997). This is against the ever-increasing human population in SSA that largely depends on agriculture for livelihood (Chikowo *et al.*, 2014). Despite contributing 90% of food production in the region, smallholder farmers, also called small-scale farmers, occupy the least productive lands (Wiggins, 2009). This is due to the historical patterns of racial land dispossession and impoverishment, which systematically eroded successful land-based production systems and livelihoods in South Africa (Neves & Du Toit, 2013). Therefore, food sufficiency remains a pipe dream if farmers continue to depend on soils with low nutrient status for crop production. Like the rest of SSA region, the productivity of cropping systems in the smallholder agricultural sector in southern Africa is curtailed by low soil nutrient status (Snapp, 1998).

In their review of soil fertility status in South Africa, Barnard and du Preez (2004) stated that soil fertility was generally low. Soil acidification was identified as the most important cause of declining soil fertility, especially in high-rainfall regions. Nitrogen levels are low and often associated with low (<1%) soil organic carbon content typical of South African soils (Du Preez *et al.*, 2011). Previous studies indicated that phosphorus (P) was deficient in most South African soils (Van Niekerk, 1989). Van Biljon (2010) reported that the potassium (K) levels in maise-producing areas were above the K threshold values. This is because very little K is removed by grain annually due to low grain yields. However, there is inadequate information about the smallholder farming sector.

The smallholder farmers are based in the former homeland areas (Kirsten and Van Zyl, 1998). In the Limpopo Province, smallholder farming occupies approximately 30% of the provincial land surface area (Oni *et al.*, 2003). Smallholder farmers utilise low-level production technology and mainly produce for subsistence (Whitbread *et al.*, 2011; Oni *et al.*, 2003). The low productivity of smallholder agriculture is attributed to poor access to production resources. Lack of money for soil analysis and recommendations results in incorrect fertiliser inputs and, consequently, low crop yields (Baiphethi & Jacobs, 2009). For instance, maise yields of less than 0.5 t ha^{-1} are common (FAO, 2019).

However, the Limpopo Department of Agriculture and Rural Development (LDARD) introduced advisory support services to develop and strengthen the capacity of smallholder farmers. The department offers subsidised soil analysis and smallholder farmer training

(LDARD, 2017). They regularly train extension advisors on the appropriate soil fertility and management strategies that smallholder farmers could adopt to improve crop yields and enhance income. Through this project, hundreds of farmers have submitted their soil samples for nutrient analysis, resulting in a large database in the province. This article provides an overview assessment of the soil nutrient status of smallholder farms based on analysed soil samples from the Capricorn, Sekhukhune, and Waterberg districts of the Limpopo Province. A better understanding of soil nutrient status will help design correct fertiliser programmes. This article will also be foundational for further soil fertility studies in the province.

1.1. Study Approach and Assumptions

The study was based on soil samples analysed by the Tompi Seleka Agricultural College covering the districts of Capricorn, Sekhukhune, and Waterberg (Figure 1). In evaluating soil fertility, general guidelines for soil pH and nutrients in South Africa were followed (FERTASA, 2016). The assumption was that the submitted soil samples would represent the general soil fertility conditions from the three districts in the Limpopo Province. The soil samples were collected from the farm fields on request. The study also considered the data set of pH, K, Ca, Mg and P. Except for N and organic carbon, which were not determined in this study, these are the most critical soil properties influencing crop yield.

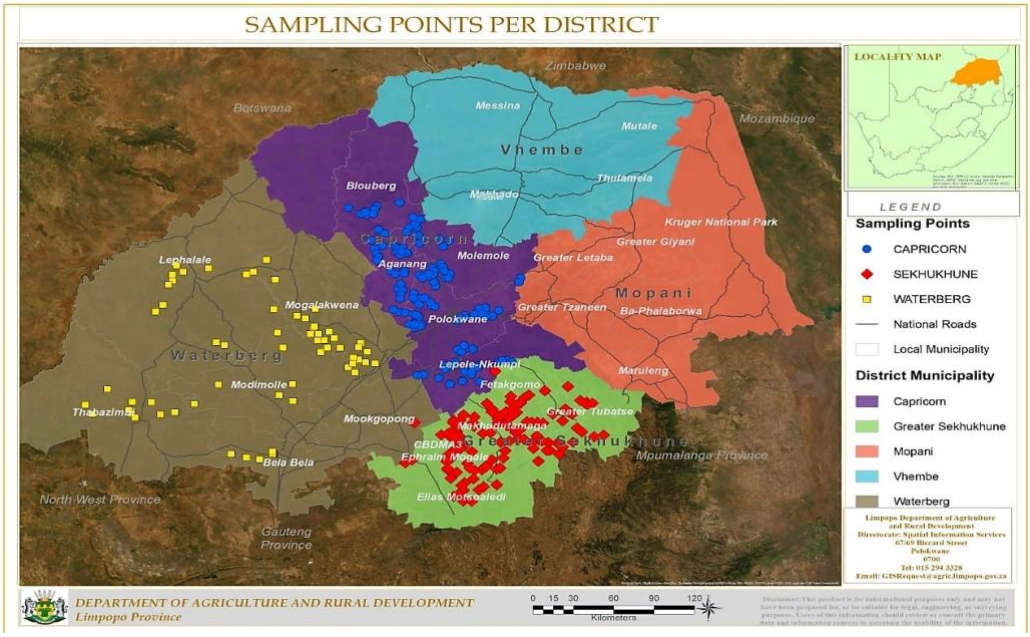

FIGURE 1: Map Depicting Study Location and Sampling Sites (Capricorn, Sekhukhune, and Waterberg)

2. METHODOLOGY

2.1. General Description of the Study Area

The study was carried out in the years 2015, 2016, and 2017 in the Capricorn, Sekhukhune, and Waterberg districts of the Limpopo Province, located in the northern-most part of South Africa (Figure 1). The three districts occupy a total surface area of 80 146 km^2 of 125 755 km^2 or 64% of the Limpopo Province. Most of the population resides in the rural areas where maise crop is mainly cultivated, followed by sunflower, sorghum, millet, watermelon, cowpeas, and groundnut under dryland conditions. Some smallholder farmers cultivate vegetables such as beetroot, butternut, tomato, onion, spinach, and cabbage in addition to the field crops (Oni *et al.*, 2003; Manicus, 2009; Rankoana, 2016). In 2016, there were nearly 232,000 smallholder farmers in the Limpopo Province (Statistics SA, 2016). The Capricorn District has 104 116, Sekhukhune has 86 046, and Waterberg has 41 810 (DRDLR, 2016a; DRDLR, 2016; DRDLR, 2016c).

Topography, soil, and climate are the major determinants of the area's agricultural potential. The underlying geology of the Capricorn District is medium-grained, yellowish, laminated sandstone. It is also characterised by granite, biotite granite-gneiss, pegmatite, lava, and pyroclasts. The soils are characterised by grey iron-containing lateritic soil types formed over the granite. These are sandy or gravel in texture and usually contain a hard -containing the hardpan's bottom layer. In certain areas, the region also has non-leached, black clay soil, while to the west, light brown sandy soil of the Waterberg Sandstone and Lime deposits occur. The escarpments are also characterised by the round granite mounds formed by the intrusion of younger granites. The Capricorn district lies in the summer rainfall region and has a warm climate. The district's mean maximum (36.5oC) and minimum (0.8oC) temperatures occur during December and June, respectively. The mean annual precipitation for the district ranges from 400 – 500 mm, where the most rain falls between October and March, and the peak period is in December/January. Rainfall between May and September is generally low, and the average precipitation rate for June to August is 4.6 mm (DRDLR, 2016a).

The geology of the Sekhukhune District consists of the Eastern Bushveld and Springbok flats region. The overall geology of the area is classified as Gabbro, Anorte band, Clinopyroxenite, and Arenite. The district has heavy metal soils derived from predominantly pyroxenite, norite, and anorthosite formations. The Sekhukhune District Municipality is typical of the Savanna Biome: warm, moist summers and cool, dry winters. The average maximum temperature in

summer is 23˚C, and the minimum is 18˚C. In winter, the average temperature is 13.5˚C, and the minimum is 7˚C. The mean annual precipitation for the district ranges from 500 – 700 mm (DRDLR, 2016b).

The major geological formations in the Waterberg District include the arenite in the southern portion of the municipality, gneiss and sedimentary formations, which affect the rural area, and shale, which affects the eastern part of the district. Diverse soil types characterise the Waterberg region. These include weakly developed soils on mountainous catchments, uplands, and rocky areas, dystrophic, red and yellow, freely draining sandy soils, and plinthic upland duplex and para-duplex soils. Rainfall in the district averages between 400mm and 650mm per year, with most rainfall occurring mainly during mid-summer. The northern and western regions of the Waterberg District experience a hot and semi-arid climate. The southern and eastern regions are more humid and slightly cooler. The district's temperature varies from a maximum of 33^{o}C in summer months to around 2^{o}C in winter (DRDLR, 2016).

2.2. Soil Sampling and Analyses

Where soils were not homogeneous, random and judgmental samplings were used to collect soil samples to obtain a composite representative sample. A total of 115, 164, and 57 soil samples were collected from Capricorn, Sekhukhune, and Waterberg districts, respectively. Farmer's request for sample collection determined the sample size for each district. The soil samples were collected using a soil auger from the farms and homestead gardens of the three districts and were geo-referenced. The soil surface was cleared to remove debris or obstacles before collecting each sample. About eight subsamples per hectare were collected from 0-20 cm on each site. Subsamples from this depth were bulked to approximately 1.5 kg in a polyethylene laboratory sampling bag and taken to the Tompi Seleka Soil and Water Analytical Laboratory. The collected samples were air-dried at room temperature, disaggregated, and sieved through a 2-mm sieve. Physicochemical analyses included particle size distribution, soil pH (water and KCl), exchangeable cations (K^{+}, Ca^{2+}, Mg^{2+}), and available P. The percentage fractions of sand, silt and clay in the soil samples were determined using hydrometer after dispersing with sodium hexametaphosphate (calgon) as described by Van Reeuwijk (2002).

Soil pH was measured in the supernatant suspension of a 1:2.5 (soil: liquid mixture) using a digital electronic pH meter (Multiple-Parameter pH/TDS/EC/Temp. Bench meter). Two

portions of 10 g of dried soil (≤ 2 mm) were mixed with 25 ml deionised water for pH in water or pH_w and potassium chloride solution for pH in KCL or pH_{KCl}, each in a separate bottle and stirred for 5 seconds with a glass rod and allowed to stand for 50 minutes before stirring again and taking pH readings of the samples with a calibrated pH meter. Results were recorded as pH_w and pH_{KCl}. Available phosphorus (P) was determined by Bray 1 method (Bray & Kurtz, 1945). Potassium (K), Calcium (Ca), and Magnesium (Mg) were extracted in 1M ammonium acetate (NH_4OAc) at pH 7, and the exchangeable cations were determined using the Atomic Absorption Spectrophotometer (AAS) (Agilent Technologies 200 Series AA). Descriptive statistics were analysed using MS Excel 2016 version.

3. RESULTS AND DISCUSSION

3.1. Soil Physical Properties

Tables 1, 2, and 3 show descriptive statistics and variation in measured soil properties across the Capricorn, Sekhukhune and Waterberg districts. All the soils had low average clay content (15% - 19%) and high sand content (71% - 75%). Means of silt content were also low and ranged from 7% to 12%. However, some variations in soil fractions were noted. Sand fraction had a low coefficient of variation (CV) (15% - 19%) across the three districts. In contrast, clay and silt fractions in the Capricorn and Sekhukhune districts had high values of CV (59% - 86%). However, the Waterberg District had a low clay fraction (6%) (Table 1, 2, 3). Sand fraction had the highest standard deviation across all districts compared to clay and silt fractions. Therefore, on average, the studied soils were classified as sandy loam textures, confirming the dominance of acidic rock parent materials in the study area (Chinoda *et al.*, 2009). Sandy textured soils tend to be excessively drained and low in nutrient content level (Snapp, 1998) due to their low base adsorption (Manicus, 2009). Organic manure and other organic amendments can be applied to improve the soil's physical properties and supplement plant nutrients (Nyamangara *et al.*, 2000; Manicus, 2009).

TABLE 1: Descriptive Statistics for pH, Nutrients (P, K, Ca, Mg), and Soil Particle Sizes (Clay, Silt, Sand) for Capricorn District (n=115)

Soil characteristics								
pH (H_2O)	pH (KCl)	P	K	Ca	Mg	Clay%	Silt%	Sand%

Statistic			mg kg^{-1}						
Min	4.85	3.79	0.1	0.08	24.90	0.05	1	2	33.4
Max	9.01	7.91	24.2	619.10	3044	798.21	46	74	97
Mean	6.89	5.73	2.75	140.92	509.02	154.45	17.21	12.09	71.21
SD	0.96	1.10	3.37	115.57	610.39	151.46	10.11	10.41	13.48
CV	14	2	123	82	120	98	59	86	19

SD = Standard Deviation; CV = Coefficient of variation

TABLE 2: Descriptive Statistics for pH, Nutrients (P, K, Ca, Mg), and Soil Particle Sizes (Clay, Silt, Sand) for Sekhukhune District (n=164)

	Soil characteristics								
	pH (H_2O)	pH (KCl)	P	K	Ca	Mg	Clay%	Silt%	Sand%
Statistic			mg kg^{-1}						
Min	4.71	3.86	0.1	0.07	13.8	0.43	2	0.2	11.52
Max	9.38	8.43	47	725.18	955.3	916.8	66.80	46	97.2
Mean	6.83	5.80	2.32	95.18	210.47	177.61	15.27	10.45	74.61
SD	0.96	1.07	4.32	83.71	197.50	211.16	10.35	8.00	14.40
CV	14	18	186	88	94	119	68	77	19

SD = Standard Deviation; CV = Coefficient of variation

TABLE 3: Descriptive Statistics for pH, Nutrients (P, K, Ca, Mg), and Soil Particle Sizes (Clay, Silt, Sand) for Waterberg District (n=57)

	Soil characteristics								
	pH (H_2O)	pH (KCl)	P	K	Ca	Mg	Clay%	Silt%	Sand%
Statistic			mg kg^{-1}						
Min	4.71	4.02	0.1	0.07	43.89	0.43	4.48	0.2	39.52
Max	8.5	7.79	9.8	290.04	1069.6	1021.63	44.48	20	92.2
Mean	6.33	5.25	1.87	79.58	188.86	150.15	18.99	7.14	73.82

SD	0.82	0.93	2.36	7.87	159.66	190.13	1.11	4.40	11.11
CV	13	18	81	10	85	127	6	62	15

SD = Standard Deviation; CV = Coefficient of variation

3.2. Soil pH

Table 4 shows the standard guidelines for assessing pH and nutrients in South African soils. The means soil pH_w (6.33-6.89) and pH_{KCl} (5.25-5.80) for all districts were in the slightly acidic to slightly alkaline range (FERTASA, 2016). In all cases, pH variation was low (CV<20%). Soil pH analyses revealed that most of the soil samples (>90%) from the Capricorn District were in the pH range of slightly acidic to slightly alkaline (Table 5). Few soil samples (>85%) in this pH range were recorded in Sekhukhune and Waterberg Districts (Table 5). This is the pH range suitable for most crops in South Africa (FERTASA, 2016). Between 5 and 10% of samples from Capricorn and Sekhukhune Districts were too acidic (pH_w <5.5; pH_{KCl} <4.5) and unsuitable for normal crop production (FERTASA, 2016). Meanwhile, soil samples in this pH range were slightly higher in the Waterberg District at nearly 15% (Table 5). Less than 5%, 10%, and 0% samples from Capricorn, Sekhukhune, and Waterberg Districts, respectively, were too alkaline (pH>8.0) and unsuitable for crop production.

The results suggest that soil pH had no major limitation to crop production in most arable soils of smallholder farms in the three districts. This could be attributed to low rainfall in the area and limited use of reduced nitrogen fertilisers. High rainfall and N fertiliser are two major causes of soil acidification (Banard & Du Preez, 2004). In KwaZulu-Natal Province, soil acidity was found to limit crop production in high rainfall community farming areas of Obonjaneni (mean pH_{KCl} of 4.04) (Roberts *et al.*, 2003) and at Cedara (pH_{KCL} in 0-0.15 m layer of 4.49) (Farina *et al.*, 1983). In Zimbabwe, Nyamangara *et al.* (2000) reported that 77% of analysed granitic soils from smallholder farmers were unsuitable for crop production due to acidity induced by N fertiliser use and the leaching of bases.

3.3. P Status

Available P was low in all three districts, with P means between 2.32 and 2.75 mg kg^{-1}. The coefficient of variation of P was high for all districts (81% to 186%). Most soils (>90%) from the three districts were acutely deficient in P (<8 mg kg^{-1}) (Table 5) and required P fertilisation to improve crop yields, and a few samples (3% to 5%) from the three districts had low-medium

to high (8-30 mg kg^{-1}). These results confirmed previous reports that P limits crop production among smallholder farmers in SSA (Snapp, 1998; Roberts *et al.*, 2003; Kihara *et al.*, 2016). Similar results were obtained in smallholder farms of Lusikisiki in the Eastern Cape Province, South Africa by Buhmann *et al.* (2006). Nyamangara *et al.* (2000) reported that 84% of the soil samples from smallholder farmers in Zimbabwe were deficient in resin extractable P (<15 mg kg^{-1} P_2O_5), and only 16% had adequate P levels.

3.4. K, Ca, and Mg Status

The coefficient of variation values for all exchangeable bases was high (85%-120%) except K in Waterberg, which had low variation (CV=10%). The high degree of variation could be attributed to differences in inherent soil properties and farmer management practices as observed elsewhere (Zingore *et al.*, 2007). More than 80% of samples from the Capricorn District and three-quarters of samples from the Sekhukhune and Waterberg Districts had adequate K (>250 mg kg^{-1}). This agrees with van Biljon (2010), who reported that K was adequate in most of the South African maise-producing soils, especially under low yields typical of smallholder farms where small amounts of K are removed from the soil. Moreover, the high availability of K could be a result of limited leaching due to low rainfall in the study area (Farina *et al.*, 1983). More than two-thirds of the samples in Sekhukhune and Waterberg Districts were deficient in Ca (<200 mg kg^{-1}) (FERTASA, 2016) compared to about one-third of the analysed samples from the Capricorn District. More than two-thirds of samples from the three districts had adequate exchangeable Mg (>300 mg kg^{-1}) (FERTASA, 2016). However, a low proportion of about one-third of analysed samples from the districts was classified as having low Mg content (<50 mg kg^{-1}). The proportion of samples with low Mg content was almost similar at 34% and 35% for Sekhukhune and Waterberg, respectively. However, that proportion was slightly less than 30% for Capricorn District.

The levels of Ca and Mg are related to soil pH under normal conditions, and their deficiency could be corrected by lime application (Banard & Du Preez, 2004). However, further studies are needed to develop correct recommendations to avoid nutrient imbalances (Van Biljon, 2010). In other studies, Buhmann *et al.* (2006) reported that 73% of the soils in the high rainfall area of Lusikisiki in the Eastern Cape had adequate Ca levels despite the leaching environment in the study area. This was attributed to the strong association between organic carbon and Ca that could have prevented Ca from leaching away.

TABLE 4: General Guidelines for Assessing pH and Nutrients in South African Soils (adapted from FSSA, 2016)

Soil characteristics	Nutrient status
Soil pH_w	
Below 5.5	Very acidic
5.5-8.0	Slightly acidic to slightly alkaline
Above 8.0	Very alkaline
Soil pH_{KCl}	
Below 4.5	Very acidic
4.5-8.0	Slightly acidic to slightly alkaline
Above 8.0	Very alkaline
Available P (Bray 1) (mg kg^{-1}*)*	
<8	Low
8-30	Low-medium to high
>35	Very high
Exchangeable K (mg kg^{-1}*)*	
<40	Low
>250	High
Exchangeable Ca (mg $kg^{-1)}$	
<200	Low
>3000	High
Exchangeable Mg (mg kg^{-1}*)*	
<50	Low
>300	High

TABLE 5: Soil pH and Nutrient Status for Soil Samples Submitted to Tompi Seleka Laboratory by Smallholder Farmers from Capricorn, Sekhukhune, and Waterberg Districts

Soil parameter	Number of submitted samples and percentages (brackets)		
	Capricorn	Sekhukhune	Waterberg
Soil pH_w			

Below 5.5	6(5)	11(7)	8(14)
5.5-8.0	105(91)	142(86)	49(86)
Above 8.0	4(4)	11(7)	0(0)
Soil pH_{KCl}			
Below 4.5	13(11)	17(10)	12(21)
4.5-8.0	102(89)	147(90)	45(79)
Above 8.0	0(0)	0(0)	0(0)
Available P (Bray 1) (mg kg^{-1})			
<8	111(96)	158(96)	54(95)
8-30	4(4)	5(3)	3(5)
>35	0(0)	1(1)	0
Exchangeable K (mg kg^{-1})			
<40	19(17)	39(24)	14(25)
>250	96(83)	125(76)	43(75)
Exchangeable Ca (mg kg$^{-1)}$			
<200	37(32)	115(70)	42(74)
>3000	78(68)	49(30)	15(26)
Exchangeable Mg (mg kg-1)			
<50	31(27)	56(34)	20(35)
>300	84(73)	108(66)	37(65)

4. CONCLUSION

The study evaluated soil fertility status in the Capricorn, Sekhukhune, and Waterberg Districts of the Limpopo Province of South Africa. The study analysed 336 soil samples from small-scale farmers in the three districts. Soil fertility indicators included soil pH (pH_w and pH_{KCl}), available P, and exchangeable base cations (K, Ca and Mg). All soil properties except soil pH showed large variability across the three districts. This was attributed to individual farmers' diverse geology and soil management practices that could have contributed to a wide range of available nutrients. A large proportion (>80%) of the studied soils had pH suitable for most

crops in South Africa. Less than 10% of samples from Capricorn and Sekhukhune Districts, and less than 15% from Waterberg District were too acidic [(pH_w<5.5] and required liming to make them productive. When considering the pH_{KCl} scale, less than 15% of samples from Capricorn and Sekhukhune, and about 20% from Waterberg Districts required liming (pH_{KCl}<4.5). Soils that were too alkaline [pH_w>8.5 pH] to make crop production impossible were less than 10% in Capricorn and Sekhukhune Districts, while Waterberg District had none. Most soil analysed (>90%) was acutely deficient in P, confirming the results of previous studies. Between 4% and 5% of samples from the three districts had low-medium to high available P, meaning that normal P- fertilisation is needed in the studied soils. More than three-quarters of the analysed samples recorded high K levels (>250 mg kg^{-1}). More than two-thirds of samples from Sekhukhune and Waterberg Districts were deficient in Ca, suggesting that the application of Ca was required to improve crop yields. In contrast, only one-third of samples from the Capricorn District were poor in Ca. Generally, more than two-thirds of the soils had adequate Mg contents, while less than a third were deficient in Mg from all three districts, suggesting that applying Mg could be beneficial. The causes of nutrient deficiency and their variability are numerous. To explain the observed trends, further studies are needed to investigate the role of field management, crop rotation, the position of the field in the landscape, lithology, and socioeconomic conditions of the farmer. Such studies may take the form of case studies and field surveys. Therefore, this study forms the foundation for future studies.

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Institutional Arrangements and Support Systems for Independent Smallholder Irrigators in the Msinga Local Municipality, South Africa

Dube, S.V.[1]

Corresponding Author: SV. Dube. Correspondence Email: dubesnethemba@gmail.com

ABSTRACT

This article describes the present institutional arrangements for irrigators' resource access, agricultural support systems accessible to irrigators, and the various constraints irrigators experience. The survey acquired data from 101 snowballed respondents for the quantitative phase of the study. The qualitative phase gathered information from four purposively selected focus group discussions. According to the findings, irrigators commonly gained access to production land through traditional authority (81.2%). Gender was a barrier to land access, where male-headed families had larger land sizes than female-headed ones (t=4.993, p=0.028). Concerning irrigation water, irrigators abstract it wherever they find access, without any institutional arrangement or restriction. The main limitations to irrigators' water availability were competition and the drying out of the water source, particularly spring water. Government assistance was rare among independent irrigators. Smallholder support services tend to be distributed unevenly among South African smallholders, usually leaving independent irrigators unsupported. Lastly, irrigators experience constraints in their farming that government existing services have the potential to address. Therefore, this study proposes that the government recognize independent irrigators as possible drivers of poverty and food insecurities. The study recommends institutional inclusion and the extension of support systems to independent irrigators.

Keywords: Independent irrigation, Agricultural extension, Irrigation development, Land access

[1] PhD candidate. School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Private Bag X01, Pietermaritzburg, 3209, South Africa. Email: dubesnethemba@gmail.com. ORCID: 000-0001-8517-7208

1. INTRODUCTION

Historically, investment in smallholder irrigation has been one of the national strategies to improve livelihoods by reducing poverty and food insecurity in South Africa, particularly in rural areas. Post-apartheid, part of these investments included transferring management of existing irrigation schemes to farmers, a process called Irrigation Management Transfer (IMT) (Van Averbeke & Mohamed, 2006; Van Averbeke, 2012). In addition to the IMT and revitalising of these schemes, additional irrigation schemes were built to improve livelihoods and quality of life for informal urban settlement dwellers and rural people (Van Averbeke, 2012). In these projects, smallholders were given access to a plot of land and irrigation water. In addition to such investments, the South African government extended agricultural extension and training services as institutional support systems for these smallholders. The support systems provide farmers with training, information, and links to input and output markets (Rivera, Qamar & Van Crowder, 2001; Ortmann & King, 2007).

Despite such support and a massive investment of public funds, these public irrigation schemes continue to perform poorly, failing to meet the goals for which they were designed (Tlou, Mosaka, Perret, Mullins, & Williams, 2006; Fanadzo, Chiduza & Mnkeni, 2010). The inability of irrigation schemes to accomplish such goals necessitates the consideration of other irrigation pathways. In South Africa, there are four categories of smallholder irrigators, including irrigated home gardens, independent irrigators, plot holders on irrigation schemes and irrigated community garden plot holders (De Lange, 1994; Du Plessis, Van Averbeke & Van der Stoep 2002; Van Averbeke, Denison & Mnkeni, 2011). Independent irrigators are “smallholders who have direct access to a supply of irrigation water and employ privately owned equipment to collect, transport, and apply this water” (Dube, 2017). Worldwide, these independent smallholder irrigators lift millions of households out of poverty, reduce food insecurity and create jobs, notably in Asia and sub-Saharan Africa (Giordano, 2012; Giordano & De Fraiture, 2014, De Fraiture & Giordano, 2014). As a result, these regions recognise independent irrigation as an appropriate poverty reduction tool.

One thing that independent irrigators worldwide have in common is that they generally fund and develop the irrigation initiative independently, with no government assistance. Namara *et al.* (2010) pointed out that independent irrigators usually operate beyond the eyes of policymakers, donors, and the scientific community; hence they are excluded from most official irrigation data, governmental policy, or agricultural support systems. In turn, data on independent irrigators is limited (Van Averbeke, Denison & Mnkeni, 2011; Beekman, Veldwisch, & Bolding, 2014; De Fraiture & Giordano, 2014). Independent irrigators exist in South Africa as well. Still, the research community and government continue to overlook them (Van Averbeke *et al.*, 2011), as their focus remains on state irrigation schemes, despite their dismal performance. This study seeks to bridge this information gap by adding to the limited literature and creating awareness for policymakers.

The current study focuses on institutional arrangements since they significantly determine smallholders' access to resources, especially land and water. Institutional arrangements, organisational issues, and power dynamics influence resource access (Scoones, 1998). For example, policies and land tenure institutions mediate access to land in rural regions (Scoones, 1998), and the security of access rights, often known as tenure security, is a crucial aspect of access to land. Registration of these tenure rights provides security (Masiya & Van Averbeke, 2013). At the same time, land tenure uncertainty prevents farmers from making long-term decisions on land, including investments (Tenaw, Islam & Parviainen, 2009). Access to inputs, finance, agricultural extension, and training support for smallholder farmers is crucial to their success and contribution to addressing poverty, unemployment, and food insecurity. Access to support services, particularly extension advice and training, is a major determinant of agricultural production (Purcell & Anderson, 1997). At the same time, data on constraints is essential for policymakers in designing bottom-up intervention strategies to deal with the challenges faced by smallholders. Therefore, the study will address the following questions:

- What institutional arrangements exist for independent irrigators to access production land and irrigation water?
- Are agricultural support systems and mechanisms in place to support independent smallholder irrigators?
- What are the challenges and constraints faced by independent smallholder irrigators?

2. METHODOLOGY

2.1. Description of the Study Area

The study site was Msinga, a local municipality of KwaZulu-Natal province in South Africa. The municipality is in the South-Western part of the uMzinyathi district and covers 2500km^{2,} and has an estimated population of 184 494 (Statistics South Africa, 2017). The area experiences a subtropical climate in most parts, an annual rainfall of 350-740 mm and temperatures between 8 to 35◦C (Zindove & Chimonyo, 2015). In the province, Msinga is one of the poorest municipalities, with high unemployment and poverty levels. Agriculture is crucial in the livelihoods of Msinga residents, but most are still subsistence farmers. Statistic South Africa (2017) found that 55% of the 38 372 households practised agriculture in 2016. However, agriculture in the area is subject to the limited capacity of the land due to low soil quality, climatic conditions, and overstocking (Msinga Local Municipality, 2020).

2.2. Sampling of Independent Irrigators

Study participants included independent smallholder irrigators operating within the boundaries of Msinga's local municipality. The study participants were chosen using the snowball sampling technique. During the initial round of data collection, the researcher and field assistants were guided to other elements with similar characteristics by the independent irrigators they contacted. The process resulted in a responder trial with 101 respondents. Additionally, four focus groups were purposively selected from the survey sample.

2.3. Data Collection and Analysis

Survey data were collected using a standardised questionnaire. The questionnaire collected information on institutional arrangements concerning agricultural land and irrigation water access. Data on access to agricultural advisory services, training, and finance was collected to represent support systems. At the same time, data on farming challenges indicated vulnerability and constraints. The interviews were conducted in IsiZulu face-to-face with the respondents and recorded on the interview schedule. The data collected through the survey was entered into Microsoft Excel after coding. After that, it was exported to the Statistical Package for Social Sciences for analysis. Descriptive statistics were then used to analyse this data. The qualitative

phase included data from interview transcripts and voice recordings collected through Focus Group Discussions (FGD). There were four FGD discussions, with nine to 12 participants per group. Homogeneous purposive sampling was adopted, and the method of extracting irrigation water from the source and the location of the irrigators were the criteria for grouping. For analysis, the qualitative data was re-organised into consumable themes and patterns.

3. RESULTS AND DISCUSSION

3.1. Demographic Characteristics of the Independent Irrigators

The results from the analysis of the demographic characteristics of independent irrigators are presented in Table 1. Most of Msinga's independent smallholder irrigators (61) were 51 years or older. On average, irrigators were 53 years old, the youngest irrigator was 18 years old, and the oldest was 87 years old. The youth (less than 31 years) was rare, constituting 4% of the sampled irrigators. The average age from these results aligns with other South African independent irrigator studies that suggested that irrigators are middle-aged or older than 50 (Oosthuizen *et al.*,2005; Tapela, 2012; Denison *et al.*,, 2016; Dube, 2017). Table 1 also shows that 63.4% of independent irrigators in Msinga were females, contradicting studies that reported that independent irrigation is male-dominated (Oosthuizen *et al.*, 2005; Tapela, 2012; Denison *et al.*, 2016; Dube, 2017).

TABLE 1: Independent Irrigator's Demographic Characteristics (n=101)

Variable	Mean	Std. Deviation
Age of irrigator (years)	53.0	11.93
Gender (% female)	63.4	-
Formal education of irrigator (years)	2.3	3.78
Farming experience (years)	17.8	11.77
Irrigation experience (years)	17.8	11.77
Occupation (%)		
Full-time farmer	86.1	-
Temporary job	2.0	-
Self-employment	10.9	-

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Student	1.0	-

Sampled independent irrigators had low levels of formal education. On average, independent irrigators went to school for two years (Table 1). Their formal education years ranged from none (66%) to grade 12. None of the sampled irrigators in Msinga acquired tertiary education. Independent irrigators were experienced in irrigated agriculture, as indicated by the years they had practised irrigated farming. On average, irrigators had 17.8 years of experience in irrigated agriculture. About 84.1% had practised irrigated farming for more than five years. The current study's findings align with Greater Tzaneen independent irrigators, who had an average of 17.9 years of irrigated farming experience (Denison *et al.*, 2016). Over four-fifths of the sample considered themselves full-time irrigators, while 10.9% were self-employed in other activities. Temporary job holders were rare, and there was only one student.

3.2. Institutional Arrangements

3.2.1. Access to Land and Irrigation Water

Land and water are crucial resources in irrigated agriculture. Access to these two resources is essential for the success of the irrigation enterprise. Institutions, in this case, the government, have policies and laws in place to determine access and control to these resources by smallholder farmers. Regarding land, Msinga independent irrigators had four arrangements to access land for crop production. These arrangements included registered ownership, unconditional usufruct, sharecropping, and unregistered ownership. In registered ownership, the land was registered in the name of any household member. It was called unconditional usufruct when ownership lay with a person who was not a household member but had the right to use land without compensation. Sharecropping arrangement was when ownership lay with a person not part of the household, but a sharing agreement existed between the irrigator and the other person. Unregistered ownership refers to using the land without permission from the authorities or the owner if it belonged to a household. In the current study, registered ownership was the most common, found in 81.2% of the 101 households. This type of access was granted by traditional authorities and through inheritance. Accessing land through traditional authorities reported in this study was consistent with other independent irrigator studies in South Africa (Oosthuizen *et*

al., 2005; Tapela, 2012; Denison *et al.*, 2016; Dube, 2017). Other land access arrangements, including unconditional usufruct (8.9%), sharecropping (6.9%), and unregistered ownership (3.0%), were rare.

The results show that the allocation of land in Msinga favours males. The study results show that irrigation land sizes for male-headed households (M=981, SD=2015.68) and female-headed households (M=455, SD=483.33) were different, where the male-headed households had larger plots than households headed by women. The results are confirmed by a t-test analysis, showing statistical significance (t=4.993, p=0.028) at a 95% confidence level. In line with the current study, Sinyolo, Sinyolo, Mudhara and Ndinda (2018) pointed out that land distribution in Msinga benefits men. Women in that region access land through inheritance, an internal female-only system in which unmarried women are assigned land within the family plot (Sinyolo *et al.*, 2018). The same study also pointed out how men within the irrigation scheme are more likely than women to own upper-end plots. In the upper-end plots, water reaches the top plots before the scheme's tail end, which women occupy. It is a limiting factor for smallholders in this irrigation scheme as the water reaches the upper plots before the scheme's tail end. Men occupying these upper-end plots meant that women in the irrigation scheme also faced limited access to irrigation water.

In contrast, there were no limitations by gender regarding water access by independent irrigators. Independent irrigators extracted irrigation water wherever they could find access as long as there was a piece of land nearby to cultivate. Independent irrigators also did not pay for the water but only for the extraction in the case of the pumping irrigators. In South Africa, irrigated agriculture is one of the water users described by the National Water Act 36 of 1998. Consequently, the users need to obtain legal authorisation to use water from the Department of Water and Sanitation. These irrigators did not know laws and regulations concerning legal water use rights.

On the contrary, some of the irrigation scheme farmers knew about the laws to the extent of having water use licenses. For example, in Limpopo province, Van Averbeke (2012) reported that 27 of the 48 irrigation schemes in the Vhembe district had water use licenses they had obtained from the Water and Sanitation Department (formerly known as the Department of

Water Affairs). However, the Department of Agriculture officials usually assist smallholders with those legal requirements. The situation is different for independent irrigators, as they operate outside the view of such institutions or departments.

3.3. Support Services

3.3.1. Agriculture Extension and Training Support

Institutions not only determine access to resources but also support smallholders to improve production. Support may be advice, training, input support, infrastructure, or output market support. In South Africa, the Department of Agriculture assigns agricultural advisors to smallholder farmers for such purposes. The agricultural advisors assist smallholder farmers with farming advice on their varied farming practices, production inputs, and training. In the case of Msinga independent smallholder irrigators, access to these services was limited. Agricultural support services tend to focus on public irrigation schemes or projects. In the current study, only 20.8% of the sampled independent irrigators indicated that they had received agricultural advice from the department's agricultural advisors. Only eight stated that they had received training in production. Advice on other aspects such as irrigation, marketing, business, and finance was rare to non-existent. Also, none of the sampled irrigators had received equipment and production loans or grants. Independent irrigators typically used their households' savings and income from other sources to finance their independently irrigated plots. These results are consistent with other independent irrigator studies in South Africa, indicating that South African irrigators rarely received assistance from the government or other institutions. Evidence in Limpopo province for Thulamela (Dube, 2017) and Greater Tzaneen independent irrigators (Denison *et al.,* 2016) indicated that 38.8% and 27.6% of irrigators in these regions had received some production advice, respectively. At the same time, only 28.6% and 24.1% claimed that they had received irrigation assistance.

In contrast, irrigators on South African irrigation schemes including, but not limited to, Dzindi (Van Averbeke, Letsoalo, Mohamed, & Khosa 2004; Denison *et al.,* 2016), Tugela Ferry (Sinyolo, Mudhara & Wale 2014; Zegeye & Chipfupa, 2018) and Bululwane (Wale & Chipfupa, 2018) have had high-level access to these services. This evidence supports the study's conclusions that agricultural support services tend to focus on public irrigation schemes or

projects. The uneven distribution of support and focus of the government on projects resulting in support benefiting a few individuals were also indicated by Sinyolo *et al.* (2018). The government built the irrigation schemes, which could explain the disparity in access to agricultural support services between independent and scheme irrigators, or it could be motivated by the state's investments in these projects.

Apart from uneven distribution, government departments duplicate support to similar groups instead of identifying new beneficiaries. For example, the Agri-park initiative by the Department of Rural Development and Land Reform (Now known as the Department of Agriculture, Land Reform, and Rural Development) provides projects or cooperatives with agricultural support. The programme offers smallholders the support of agricultural extension, production inputs, infrastructure, and output markets. Each district has a Farmer Production Support Unit (FPSU) or two as part of this initiative. The FPSU is a one-stop location where all produce storage, packaging, farmer training, and other services are delivered. Surprisingly, some of the irrigation schemes (e.g., Nsuze irrigation scheme, Tugela Ferry, Shinga irrigation scheme) are identified as FPSUs. Irrigators on those schemes benefit from the current Department of Agriculture support programmes and the new FPSU initiative by Rural Development. In contrast, this initiative could benefit many goal-driven individual farmers, especially the youth who may be interested but facing resource limitations.

3.4. Irrigators Constraints

Irrigators face various challenges and constraints in their farming; the ability to recover lies in the strength of the capital endowment, household strategies employed, and available support systems. On the four responses Likert scale, independent irrigators were asked to rate their experience with constraints they face in their farming. Table 2 shows the relative distribution (%) of constraints faced by respondents.

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TABLE 2: Relative Frequency Distribution (%) of Constraints Faced by Irrigators (n=101)

	Never	Rarely	Sometimes	Most of the times	Always
Lack of capital	3	1	23	54	20
Insufficient land	38	21	23	19	0
Lack of access to inputs	8	14	41	36	2
High increase in input prices	4	6	19	67	4
Production below normal	4	4	53	39	1
Declining market prices for outputs	8	26	55	11	0
Land tenure not secure	92	6	2	0	0
Local and political conflict	89	10	1	0	0
Lack of support services	8	3	6	47	37
High pump and maintenance cost	81	1	5	13	0
Water availability	8	7	54	25	6

The table shows that independent irrigators perceive lack of capital (74%), access to inputs due to high price (71%), and support services (84%) as major significant constraints they experience most or all the time. All these factors are very important for an irrigated enterprise's success. The low levels of opportunities for economic activity in the municipality and high social grants dependency (96%) among irrigator households exacerbate households' lack of financial resources. Furthermore, water access is very crucial for the success of an irrigation enterprise. Springwater was the most prevalent source of irrigation water in Msinga (69%). Another significant source was direct extraction from the river, found in one-third (31%) of the sampled irrigators. Water issues were prevalent among all four FGDs but differed in several aspects. The first two FGDs in Mashunka village voiced concern over the drying out of the water source. As a result, the competition for water was high, and one had to get up early to access irrigation water. Fortunately, no confrontations have resulted from this, simply intense competitiveness. Regrettably, irrigators could not utilise two seasons of the year due to water drying. Irrigators

who extract irrigation water by pumping were the third FGD in the same village. The pumper group had no problems accessing water because they extracted it from the river, but they complained about the high price of petrol, which limited them to irrigating once a week. The last group in Paraffin village extracted water from the Tugela River; the source was not an issue but transporting the water from the river to their plots was a more significant constraint. The irrigators in this area were mostly older women. Finally, through FGD, it was learnt that fencing of the plots was a significant constraint. Irrigators utilise tree branches to keep livestock from entering their plots. These efforts were often ineffective since they lost their crops to cattle anyway.

4. CONCLUSION AND RECOMMENDATIONS

This paper aimed to describe institutional arrangements, support systems, and challenges faced by independent smallholder irrigators in Msinga's local municipality. The study results suggest that independent irrigators usually operate outside the government's view. Independent irrigators are not registered for authorised water use, so they fall outside the water management department. However, it is not because independent irrigators are unwilling to acquire legal authorisation to use water but because they lack access to such information. The absence of interaction between irrigators and the department’s extension services could be one of the reasons for this. Their unofficial water abstraction did not hinder or affect their irrigation enterprises. Still, the means of extracting water from the source exacerbated by limited resources, including financial resources to procure physical capital, poses a limitation.

The drying of their irrigation water sources, particularly the spring, hinders full utilisation throughout the year. Many independent irrigators are females, and current land access practices limit women irrigators’ to smaller plots than male irrigators. Existing land access arrangements for all genders should be prioritised on the policy agenda. It is proposed that the existing land tenure and administration systems be improved. Another significant finding from this study is that support systems are limited to a few independent irrigators. However, the lack of support is not a matter of lacking resources or capabilities by the South African government but rather a matter of identifying and extending support services to other beneficiaries. Independent irrigators’ existence should be made known among the different support services since, with the

proper resources, they might significantly contribute to agricultural productivity and address poverty and food insecurity. Providing extension and training support should be prioritised. Independent irrigators' access to physical resources, such as pumping technology for manual lifters, should be prioritised.

The findings of this study make a significant contribution to the literature on "South African independent smallholder irrigators," as there is limited literature. However, further broad research needs to be done to shed more light on the issues faced by independent irrigators. This study provides groundwork about what could be used to develop targeted interventions for independent irrigators. Lastly, systematic research on who these irrigators are and how they make a living is necessary to understand their impact on rural development and thus justify the investment.

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Using Logistic Regression to Characterise Communal Cattle Farmers in Botswana

Madisa-Maseko, G.[1], North, D.[2] and Zewotir, T[3]

Corresponding Author: G. Madisa-Maseko. Correspondence Email: madisag@ub.ac.bw

ABSTRACT

This paper aims to characterise and profile subsistence cattle farmers according to selected attributes to establish their influence on the type of cattle breed kept by farmers in Botswana. The development of communal cattle production can be a sustainable way to improve the livelihoods of the rural population in Botswana. However, there needs to be more information or research conducted to characterise and profile communal cattle farmers with a precondition that the farmers can keep any of the three breeds (Tswana, Cross, or Exotic). A logistic regression model was fitted to determine the influence of 11 predictor variables on the type of cattle breed kept by the farmers. Results revealed that female-headed households were 50% more likely to have the Tswana breed of cattle than male-headed households. In contrast, female-headed households were 30% less likely to have cross-breed or exotic-breed cattle than male-headed households. Results further show that resource-poor farmers tend to keep Tswana breed cattle. These are holdings with no farm labour, no other economic activities, female-headed households, and their primary source of income specified as "other".

Keywords: Cross-breed, Exotic breed, Tswana breed, Odds ratio, Subsistence farming

1. INTRODUCTION

Botswana is a semi-arid and landlocked country located in southern Africa. It shares borders with Namibia, South Africa, Zambia, and Zimbabwe. Botswana's mean annual rainfall varies from a maximum of 650 mm in the Northern part (Kasane) to a minimum of less than 250mm

[1] PhD student at the University of KwaZulu-Natal and Lecturer: University of Botswana, Department of Statistics, Private Bag 00705, Gaborone, Botswana. Tel +00 267 3555705; E mail: madisag@ub.ac.bw

[2] Dean and Head of School of Mathematics, Statistics and Computer Science, University of KwaZulu-Natal, P.O. Box X54001, Durban, 4000, South Africa, Tel 031 260 1022, Email northd@ukzn.ac.za

[3] Lecturer, School of Mathematics, Statistics and Computer Science, University of KwaZulu-Natal, P. O. Box X54001, Durban, 4000, South Africa, Tel 031 260 7819, Email: zewotir@ukzn.ac.za

in the Southern region (Tsabong) (Ministry of Environment, 2011). The semi-arid climate makes crop production risky. Therefore, most farmers practice livestock farming. About 36.1% of the population in Botswana lives in the rural parts of the country (Statistics Botswana, 2018), where agricultural production is the principal economic activity that sustains the livelihoods of rural households. About 70% of rural households derive their livelihoods from agriculture through subsistence farming (Seanama Conservation Consultancy, 2012). Thus, the need for rural development to improve agricultural productivity cannot be overemphasised. For instance, according to Garwi (2022), smallholder agriculture has been promoted as a key driver for rural development in Chipinge rural district in Zimbabwe. Livestock production is a significant component of rural agriculture in southern Africa (Moorosi *et al.*, 2001; Schwalbach *et al.*, 2002; Tavirimirwa *et al.*, 2013; Malusi *et al.*, 2022; Garwi, 2022). For generations, livestock has played a key role in rural subsistence farming in Botswana. In Botswana, the agricultural sector is dominated by subsistence farmers who make up 85% of the farming population (Mrema, 2004). Cattle farming dominates the agricultural sector's contribution to the Gross Domestic Product (GDP) (Mosalagae & Mogotsi, 2013; Statistics Botswana, 2019). The agricultural sector's contribution to the GDP has declined from 40% at the time of independence (1966) to 2.0% in 2018 (Statistics Botswana, 2019). This decrease is attributed to erratic rainfalls, recurring droughts, and the discovery of diamonds in 1967 (Debswana, 2007).

The livestock sector in Botswana is characterised by two land tenure systems: communal and commercial farming. Communal grazing (open-access grazing lands referred to as cattle posts) accounts for 86% of the national cattle herd, and 71% of Botswana farmers use open-access grazing lands for their herds. In comparison, private grazing in ranches (fenced system) accounts for 14% of the cattle, with 29% of farmers on private grazing fenced ranches (Mahabile *et al.*, 2005; Mosalagae & Mogotsi, 2013). This paper aims to characterise and profile subsistence cattle farmers according to various attributes to establish their influence on the type of cattle breed kept by farmers in Botswana. The development of communal cattle production can be a sustainable way to improve the livelihoods of the rural population in Botswana. However, there is little information or research conducted to characterise and profile communal cattle farmers with a precondition that the farmers can keep any of the three breeds. This is corroborated by Uchendu *et al.* (2021) research on demographic profiling and the characterisation of cattle and cattle farmers in Botswana. Uchendu *et al.* (2021) cited that most

published data on Botswana's cattle population neither represents the demographics of cattle and cattle ownership nor captures political or gender factors that affect cattle farming. These authors demonstrated the need to characterise and profile communal cattle farmers before any intervention, as the general perception that these farmers are similar is incorrect (Schwalbach *et al.*, 2002).

This paper is divided into four sections. The first section provides an introduction to the study. The second section presents the materials and methods, which covers and explains the sampling method and procedure. The third section provides the study results and discussion. This section is concerned with characterising the study's household heads and agricultural holders. A logistic regression model was fitted to determine the influence of 11 explanatory variables on the type of cattle breeds (Tswana, Cross, or Exotic) kept by the farmers. The last section is the conclusion which summarises the findings of the study. It entails how the farmers are characterised and profiled in the study.

2. MATERIALS AND METHODS

Agricultural surveys are conducted once a year in Botswana, where 255 enumeration areas (EAs) are selected from a total of 1202 EAs. This study focused on the 2012 annual agricultural survey data collected from 246 EAs that were enumerated. Approximately 94% of the farmers were sampled. A detailed questionnaire consisting of 65 questions was administered by trained personnel in face-to-face interviews. The questionnaire was made up of three forms: Form I was used to list all the dwellings in the rural areas of Botswana, including large villages. It contained information on agricultural activities. Agricultural holdings were identified from the listed dwelling units. Form II covered questions on demographic characteristics of household members, particulars of the holding and holder, and particulars about the ownership of land. Form III covered livestock owned, crop production, water supply, farm equipment, machinery inventory, and farm enterprise (Statistics Botswana, 2012).

The sampling frame was such that there was implicit stratification according to rural ecological zones, namely villages, lands, and cattle-post. Implicit stratification is a multi-stage geographic technique combining systematic and stratified sampling elements for each stratum to be represented. The implicit stratification was undertaken so that all agricultural districts became their own strata. The implicit stratification was expected to increase precision and improve data accuracy. The enumeration areas were listed in independent subgroups (i) village, (ii) lands,

and (iii) cattle posts in each agricultural district. Of the 255 EAs selected for the survey, 119 were allocated to the village stratum, while 83 and 53 were allocated to lands and cattle-post strata, respectively (Statistics Botswana, 2012).

A stratified two-stage probability sample design was used to select subsistence agricultural holdings for the sample. The first stage entailed selecting enumeration areas (EAs) as primary sampling units (PSUs). The EAs or PSUs were chosen with probability proportional to the measure of size (PPS) (Statistics Botswana, 2012).

The data set consists of 1904 agricultural holdings, four of which were not used when fitting a model because of missing values. The respondents did not provide information on some of the questions asked. The response variable is the type of cattle breed kept by farmers. The predictor variables are gender, educational level, age of the household head, household size, marital status, farming status, source of income for the holding, other economic activities undertaken, the awareness level of farming programs, beneficiation from farming programs, and use of farm labour. A unit of study was a holding, and the respondent was an agricultural holder or a person responsible for the day-to-day operations of the holding and may not necessarily be the holding owner. The data in this study were analysed using Statistical Analysis System (SAS) Version 9.3 (SAS Institute, 2002-2010).

3. RESULTS AND DISCUSSION

3.1. Descriptive Statistics

TABLE 1: Personal Characteristics of Household Heads

Variable	**Frequency (%)**
Gender	
Male	1309 (68.75)
Female	595 (31.25)
Educational level (highest attained)	
Illiterate	749 (39.34)
Primary	706 (37.08)
Secondary	449 (23.58)
Variable	**Measures of location/dispersion**
Age	

Mean	51.89
Median	53.00
Mode	65.00
Household size	
Mean	3.54
Median	3.00
Mode	1.00
Standard deviation	2.72

From Table 1 above, 68.75% of the household heads were males, indicating male dominance in cattle farming. The results of this study concur with those of Uchendu *et al.* (2021), who stated that there was more male than female cattle farmers in Botswana. Similarly, Olbrich *et al.* (2014) found that most principal decision-makers on farms in Namibia were males (94.7%), which also shows male dominance in the agricultural sector in Namibia. The reasons why men dominate the cattle farming sector may be attributed to the fact that few women own land due to cultural norms and practices, as indicated by Kalabamu (2006). In Botswana, women were largely excluded from land ownership during the pre-colonial era (Kalabamu, 2006). Traditionally, women were responsible for producing food crops and looking after goats and sheep, while men were responsible for cattle management and hunting (Kalabamu, 2001; Larsson, 1989; Larsson, 1990). Women could only access land through men - a father, husband, son, or paternal uncle (Kalabamu, 2006).

Only male siblings had the right to be allocated land from their fathers' holding, the tribal reserve, or to inherit it from their fathers (Schapera, 1994). Schapera (1994) revealed that women were excluded from grazing areas, including visiting cattle posts. According to Fosbrooke (1971a, 1971b), the government encouraged arable farmers (mostly women) to migrate permanently to their ploughing fields to boost food production. Kalabamu and Morolong (2004) reported that land boards and the government tolerated and condoned the self-allocation of arable fields in Botswana. Nearly two-fifths (39.34%) of household heads were illiterate, while 37.08% and 23.58% had primary and secondary school education. These results are consistent with a survey conducted on livestock production by Kunene and Fossey (2006) in South Africa, where more than half of the farmers had never attended school. A study in the Vhembe district, South Africa, revealed that about 18.81% of participants in irrigated

smallholder agricultural enterprises were completely illiterate, 27.84% had primary education, and 39.86% had secondary school education (Mavhungu *et al.*, 2021).

The current study has revealed that more than half (54.41%) of the household heads were aged 50 years and above in Botswana. The mean age of the household heads was 51.89 years, with a standard deviation of 18.34 years. A study by Mmopelwa and Seleka (2011) reported an average age of the household head of 58 years for communal cattle farmers in Botswana. The results are similar to the findings of Olbrich *et al.* (2014), whose study revealed differences amongst the age of farmers, with a mean age of 55.4 years and 4.3% of the farmers aged 35 years or younger in Namibia. The mean household size was found to be 3.54 people per holding, with a standard deviation of 2.72. The slight standard deviation of 2.72 people means that the number of people in each holding in the data set is close to the mean, on average. There is less variation in the number of people per household. This result is consistent with Mmopelwa and Seleka (2011) findings, who reported an average household size of four individuals for such holdings. Olbrich *et al.* (2014) reported similar results in a survey in Namibia, with an average household size estimated to be 3.7 members, with 38.2% of the households having two members. Kunene and Fossey (2006) reported that most households were headed by males (89.5%), with 75% of the households headed by females being widowed, and the rest had husbands who were migrant workers.

TABLE 2: Personal Characteristics of Agricultural Holders

Variable	Number of holders (%)
Marital Status	
Never married	264 (13.87)
Married	1045 (54.88)
Living together	170 (8.93)
Separated	14 (0.74)
Divorced	36 (1.89)
Widowed	375 (19.70)
Farming Status	
Full-time	1481 (77.78)
Part-time	423 (22.22)

Table 2 shows that more than half (54.88%) of the holders were married, followed by 19.70% who were widowed, and 13.87% who never married, which is consistent with an earlier study by Mmopelwa and Seleka (2011), where about 59% of the household heads were married. Oladele and Moilwa (2010) reported that a little over half (50.8%) of the farmers in Mahalapye, Botswana, were married. Most of the farmers (77.78%) were full-time farmers. Agricultural holders further engaged in other economic activities for income generation. In 2012, almost one in every five (18.32%) holders reported being engaged in other economic activities. Schwalbach *et al.* (2002) said that 77% of farmers engaged in other economic activities for commercial gain. Cash income from cattle farming activities was generally low, with three-quarters (75.4%) of farmers having income less than or equal to R1000 from cattle farming activities (Schwalbach *et al.*, 2002).

There were several possible sources of income for the holdings. Almost one in every five (18.54%) holdings reported the sale of livestock as their primary source of income, compared to 81.46% who reported "other" as their primary source. Abeygunawardena *et al.* (1997) cited that more than two-fifths (45%) of the cattle farmer's income came from selling the animals for meat, followed by the sale of milk (34%), manure (12%), and draught (9%). Through the Ministry of Agricultural Development and Food Security, the Government of Botswana introduced several farming programs aimed at stimulating agricultural output. The majority (95.96%) of the farmers indicated they were aware of the farming programs, with 19% of the farmers being aware of one farming programme, 29% of the farmers were aware of two farming programs, 23% of the farmers were aware of three farming programs, 13% were aware of four farming programs, and 12% were aware of five farming programs. Half (50.32%) of the farmers had benefited from the farming programs.

Although the agricultural sector is labour-intensive, only two-fifths (39.13%) of the holdings employed someone, either on a full-time or temporary basis, to work on the holding. The reason why 39.13% of the holdings employed someone to work on the farm may be attributed to the fact that most holdings rely on family members to work on the farm. Mdiya and Mdoda (2021) reported that 70% of the households were married and played a key role in providing family labour for households. Uchendu *et al.* (2021) indicated that family size translates directly to the available family workforce, with an average family size of four. The mean household size for our study was found to be 3.54 people per holding; hence only 39.13% of the holdings employed someone to work on the farm. Most farmers (70.85%) keep the indigenous Tswana

breed of cattle because of the adaptation to the local environment. In comparison, 40.60% and 13.66% keep the cross and exotic breeds of cattle, respectively. The Tswana breed, cross breed, and exotic breed of cattle constitute 33.63%, 57.82%, and 8.55% of this study's total cattle population.

3.2. Statistical Modelling

A logistic regression model was fitted to determine the influence of 11 explanatory variables (gender, age, and educational level of household head, household size, marital status of the holder, farming status of the holder, source of income for the holding, other economic activities undertaken in the holding, awareness level of farming programs, benefiting from farming programs, and the use of farm labour) on the type of cattle breed (Tswana, Crosses or Exotic) kept by the farmers. A logistic regression model was chosen because the response variable is dichotomous. The farmers can keep any type of the three breeds: coded as one if the farmer owns the breed and zero otherwise. Three logistic regression models were fitted for each type of breed. Logistic regression is an optimal method for analysing dichotomous dependent variables (Allison, 2012). We were modelling for the probability that the farmer keeps a particular type of breed. A few farmers in the study had at least two types of breeds, with Tswana breed being indigenous to Botswana. The logistic regression model is

$$logit(\pi_i) = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + - - - - - - + \beta_{11} x_{ik}$$
$$for\ k = 11\ explanatory\ variables\ and\ i = 1,2,3, \ldots . 1904\ farmers$$

The parameter β_i refers to the effect of x_i on the log odds that $y = 1$ (we were modelling for the probability that the i^{th} farmer keeps a particular breed) controlling the other x_j. For example, exp (β_i) is the multiplicative effect on the odds of a 1-unit increase in x_i, at fixed levels of other x_j (Peng *et al.*, 2002, Agresti, 2002, Allison, 2012, Mdiya & Mdoda, 2021). The assumptions of a binary logistic model are:

- The true conditional probabilities are a logistic function of the explanatory variables (Midi *et al.*, 2010). Logistic regression requires that the explanatory variables are linearly related to the log odds.
- The response variable should be measured on a dichotomous scale.
- One or more predictor variables can be either continuous or categorical variables.

- The predictor variables are not linear combinations of each other. Logistic regression requires little or no multicollinearity among the independent variables.
- The observations are independent of each other. In other words, the observations should not come from repeated measurements or matched data (Gregory-Scheiber, 2018).

TABLE 3: Explanatory Variables and Their Levels

Variable	Levels
Gender	Female; male
Educational level	Illiterate; primary; secondary
Age of household head in years	
Household size (number of people who spent the night in the holding)	
Marital status	Never married; married; living together; separated; divorced; widowed
Farming status	Full-time farmer; part-time farmer
Source of income for the holding	Sale of livestock; other
Other economic activities undertaken in the holding	Yes; no
Awareness level of farming program	0,1,2,3,4 and 5 depending on the number of farming programs the holder was aware of
Benefiting from farming programs	Yes; no
Use of farm labour in the holding	Yes; no

3.3. Logistic Regression Results

Several diagnostics were used to check the goodness of fit of the fitted models. The p-values for the Likelihood ratio, Score, and Wald tests for the three models fitted for the different types of breeds were all significant at 5% level, which indicated that there was at least one explanatory variable in the models that was statistically significant, with an impact on the type of breed. The Receiver Operating Characteristic (ROC) curve value was 0.738 for the Tswana breed, 0.749 for the cross-breed and 0.774 for the exotic breed, indicating the model fit was fair for all three breeds. The p-value for the Deviance was significant for the Tswana breed and cross-bred, which signified that the model did not fit the data. In contrast, the Pearson goodness

of fit had a p-value greater than 0.05 for both Tswana breed and cross-bred, which means the fitted models were appropriate. Conversely, the p-values for both the Deviance and Pearson goodness of fit tests were insignificant, indicating that the fitted model was adequate for the exotic breed. Similarly, the Hosmer-Lemeshow goodness of fit tests had p-values greater than 0.05 for all three models, indicating the adequacy of the fitted models.

Males were set as the reference category to test gender differences amongst household heads (see Appendix 1). The odds of a female household head having a Tswana breed of cattle were 1.5 times that of a male household head. In other words, female-headed households were 50% more likely to have Tswana cattle breed than male-headed households. In contrast, the odds of a female household head having a cross-breed or exotic breed cattle was 0.7 times what it was for an identical male household head having a cross-breed or exotic breed cattle, so we can conclude that the male-headed households were more likely to have a cross breed or exotic breed of cattle, compared to the female-headed households with the same background. Same background refers to farmers with the same characteristics concerning other variables (that is, holding other variables constant), the only difference between them being gender.

The odds of a full-time holder having the exotic breed of cattle was found to be 0.8 times the odds of a part-time holder. Compared with a full-time holder, a part-time holder was consequently more likely to have the exotic breed cattle. This may be due to costs associated with maintaining exotic breeds. There was no significant difference between full-time and part-time holders concerning having Tswana breed or cross-breed cattle on their holdings. The odds of having Tswana breed cattle with no other economic activities undertaken was 1.3 times the odds of a holding with other economic activities. In other words, in comparison to a holding with other economic activities, a holding with no other economic activities undertaken was more likely to have the Tswana breed cattle.

Kunene *et al.* (2006) reported that many farmers in northern KwaZulu Natal in South Africa kept the local Nguni breed because of its disease resistance. These results are consistent with the findings of Amimo *et al.* (2011) in Western Kenya, who revealed that most farmers kept the indigenous Zebu breed because of the adaptation to the local environment and disease resistance. In a study conducted in South Africa, Malusi *et al.* (2022) cited that one of the advantages of rearing indigenous cattle breeds by communal farmers is that they can survive drought and cope with natural forages.

Alternatively, a holding with no other economic activities was less likely to have the exotic breed cattle. That is, the odds of a holding with no other economic activities having the exotic breed was 0.8 times that of a holding with other economic activities. This may be due to costs associated with maintaining exotic breeds. The holdings with other economic activities undertaken or not were not statistically different concerning having cross-breed cattle. The p-value was 0.065, indicating no significant difference amongst the holdings with or without economic activities undertaken having cross-breed cattle. This may explain why cross-breed cattle constitute the largest percentage (57.82%) of the total cattle population in the study.

For holdings whose primary source of income was the sale of livestock, the odds of having a Tswana breed of cattle was 0.6 times what the similar odds were for a holding with the main source of income specified as "other". In other words, a holding with the main source of income as a livestock sale was less likely to have a Tswana cattle breed than for a holding where there were "other" sources of income. In contrast, holdings with the main source of income as sale of livestock were more likely to keep cross-breed and exotic cattle breeds compared to holdings whose main source of income was "other". The odds of a holding with the main source of income as the sale of livestock having cross-breed cattle was 1.8 times that of a holding whose main source of income was "other". Furthermore, the odds of a holding with the main source of income as the sale of livestock having an exotic breed of cattle was 1.4 times the odds of a holding whose main source of income was "other". Kunene *et al.* (2006) cited that farmers kept the Brahman breed for meat production because of its large body and Jersey breed for high milk production. Amimo *et al.* (2011) reported that some cattle farmers kept cross-breed cattle for increased milk production, and a few kept exotic dairy breeds for higher milk yields.

On awareness of farming programs and the influence thereof on the cattle breed type kept by the holder, the logistic regression model revealed that the odds of a holder who was aware of five farming programs, having cross-breed cattle, was 2.5 times the odds of a holder who was not aware of any farming program having cross-breed cattle. Conversely, the odds of a holder who was aware of at most three farming programs having an exotic breed of cattle was found to be 0.4 times the odds of a holder who was not aware of any farming program. A holder who was aware of at most three farming programs was less likely to have exotic breeds compared to a holder who was unaware of any farming program. This is counterintuitive as one would expect the farmers to utilise farming programs to increase production. The variable awareness

of farming programs was not related to Tswana breed cattle, as none of the p-values was significant.

Compared with holdings with farm labour, holdings with no farm labour were more likely to keep Tswana breed cattle but less likely to keep cross-breed and exotic cattle breeds. The odds of a holding with no farm labour having Tswana breed cattle was 1.7 times that of a holding with farm labour having Tswana breed cattle. On the other hand, the odds of a holding with no farm labour having cross breed and exotic breed of cattle was 0.58 and 0.55 times the odds of a holding with farm labour having cross and exotic breeds, respectively. Nsoso and Rabasima (2004) reported that about 86% of beef cattle farmers in southern Botswana farmed under an extensive management system. These farmers use small inputs of labour, fertilisers, and capital. Cattle farming brings a modest income since labour which accounts for 89.2% of the cost, is supplied by the family unit at no cost (Abeygunawardena *et al.,* 1997; Mdiya & Mdoda, 2021; Uchendu *et al.,* 2021). The age and education level of the household head, household size, marital status of the holder, and beneficiation from the farming programs appeared to have no statistically significant effect on the type of breed kept by the farmers.

4. CONCLUSION

The paper aimed to characterise and profile subsistence cattle farmers according to selected attributes to establish their influence on the type of cattle breed kept by farmers in Botswana. Almost one in every five (18.54%) holdings reported the sale of livestock as their primary source of income, compared to 81.46% who reported “other” as their main source. The low cattle off-take makes it difficult for farmers to sustain their lives by selling cattle. Full-time holders and holdings with no other economic activities undertaken were less likely to have exotic breed cattle. This may be due to costs associated with maintaining exotic breeds. The holdings with no farm labour were more likely to keep Tswana breed cattle and less likely to keep cross-breed and exotic cattle breeds. The findings that we have presented suggest that low-income holders tend to keep Tswana breed cattle. These are female-headed households and the holdings with the main income as “other”, no farm labour, and no other economic activities. On the other hand, affluent farmers keep cross-breeds and can sustain their lives by selling cattle as a source of income.

Since 70% of rural households derive their livelihoods from agriculture (Seanama Conservation Consultancy, 2012), developing the cattle farming sector is imperative.

Botswana's government has initiated programs meant to assist farmers, but the programs are underutilised due to the high contributions required before the grants can be disbursed. A little over three-quarters (77%) of farmers are full-time holders who may not be able to pay the required high contributions. However, half (50.32%) of the farmers have benefited from such farming programs. The study has demonstrated the need to characterise and profile the communal cattle farmers before any intervention, as the general perception that these farmers are similar is incorrect. The results of this study are important for strategic planning initiatives in a developing Botswana, where agriculture forms a large part of the economy.

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APPENDIX 1: ODDS RATIO AND P-VALUE BY THE BREED TYPE

	Tswana		**Cross**		**Exotic**	
	OR	**P-value**	**OR**	**P-value**	**OR**	**P-value**
Gender (Reference: Male)		**<.0001**		**<.0001**		**0.0017**
Female	1.510	**<.0001**	0.714	**<.0001**	0.716	**0.0017**
Age	0.998	0.6641	0.997	0.3461	0.992	0.0951
Educational level (Reference: Secondary)		0.1232		0.3853		0.6905
Illiterate	1.189	0.0412	0.896	0.1707	0.910	0.3923
Primary	0.938	0.4079	1.044	0.5588	1.027	0.7916
H/hold size	0.999	0.9721	0.989	0.5973	0.992	0.8041
Marital status (Reference: Widowed)		0.9206		0.1149		0.2784
Divorced	0.821	0.5686	0.734	0.3656	0.954	0.9250
Living together	0.938	0.7562	0.961	0.8356	1.305	0.3663
Married	0.981	0.9002	1.262	0.0955	1.350	0.1861
Never married	1.065	0.7386	0.904	0.5633	0.871	0.6261
Separated	1.084	0.8869	1.368	0.5259	0.806	0.8115
Farming status (Reference: Part-time)		0.5046		0.8980		**0.0465**
Full-time	1.048	0.5046	1.009	0.8980	0.843	0.0465
Economic activities (Reference: Yes)		**0.0005**		0.0655		**0.0016**
No	1.272	**0.0005**	0.883	0.0655	0.772	**0.0016**

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Source of income (Reference: Other)		**<.0001**		**<.0001**		**<.0001**
Livestock	0.634	**<.0001**	1.805	**<.0001**	1.448	**<.0001**
Farming programs awareness (Reference: 0)		**0.0205**		**<.0001**		**0.0011**
Aware of 5 farming programs	0.709	0.2636	2.477	**0.0034**	0.678	0.2776
Aware of 4 farming programs	1.026	0.9330	1.465	0.2113	0.807	0.5473
Aware of 3 farming programs	0.986	0.9603	1.585	0.1134	0.386	**0.0066**
Aware of 2 farming programs	1.130	0.6762	1.229	0.4766	0.396	**0.0080**
Aware of 1 farming program	1.427	0.2394	0.958	0.8840	0.473	**0.0362**
Benefited (Reference: Yes)		0.0641		0.8330		0.7572
No	0.897	0.0641	0.988	0.8330	0.976	0.7572
Farm labour (Reference: Yes)		**<.0001**		**<.0001**		**<.0001**
No	1.670	**<.0001**	0.588	**<.0001**	0.552	**<.0001**

Boldfaced p-values indicate that the explanatory variables are significant at 0.05. The baseline category for each predictor variable is stated in the brackets and all odds ratios will be interpreted with reference to the baseline category.

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Knowledge Validation and Nutritional Qualities of Fodder Trees Browsed by Goats in the Gumela Rural Area in Limpopo Province, South Africa

Kujoana, T.C.[1], Mugwabana, J.T.[2], Tyasi, T.L[3]. and Chitura, T.[4]

Corresponding Author: T.C. Kujoana. Correspondence Email: tlou.kujoana@gmail.com

ABSTRACT

In sub-Saharan Africa, goat farming has shown to be a significant intervention in the fight against poverty. However, the productivity of goats is threatened by several challenges, such as limited forage availability, especially during dry seasons when the quantity and quality decline. The study aimed to gather smallholder farmers' knowledge on the identity and nutritional qualities of fodder trees browsed by goats in the study area. Fourteen smallholder goat farmers were interviewed using a semi-structured questionnaire. Botanical identification and nutritional analysis of mentioned browse plants were conducted at the Animal Production Laboratory, University of Limpopo, South Africa. Capparis tomentose, Euclea crispa and Cassine transvaalensis had higher ($p<0.05$) dry matter content. Ziziphus mucronata had higher ($p<0.05$) ash content. Maerua angolensis had higher ($p<0.05$) crude protein content, while Colophospermum mopane had a higher ($p<0.05$) energy content. Colophospermum mopane was ranked the most browsed plant (43%), whereas Ziziphus mucronata and Maerua angolensis were ranked the least browsed plants. Colophospermum mopane and Sclerocarya birrea were classified as bad sources of goat feed. Most of the identified feed materials had crude protein and energy levels higher than the recommended minimum required levels for the maintenance of essential functions of goats.

[1] MSc Student, University of Limpopo, Department of Agricultural Economics and Animal Production, Email: tlou.kujoana@gmail.com, Orcid 0000-0002-7078-2736

[2] Senior Lecturer, University of Limpopo, Department of Agricultural Economics and Animal Production, Email: joseph.mugwabana@ul.ac.za

[3] Associate Professor, University of Limpopo, Department of Agricultural Economics and Animal Production, Email: louis.tyasi@ul.ac.za, Orcid 0000-0002-3519-7806

[4] Lecturer, University of Limpopo, Department of Agricultural Economics and Animal Production, Email: teedzai.chitura@ul.ac.za, Orcid 0000-0001-9676-7166

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Findings from this study indicate that farmers had some knowledge of the feed materials available for goat feeding, even though most farmers in the study area did not know how to determine the nutritional qualities of the available feed materials. The knowledge gathered from this study contributes to the body of literature on the use of indigenous feed resources to improve goat production, which has the potential to alleviate poverty and reduce unemployment in line with the National Development Plan 2030 of the South African government.

Keywords*:* Browsed plants, Crude protein**,** Capparis tomentose, Colophospermum mopane, Smallholder goat farmers

1. INTRODUCTION

Goat rearing has proved to be an important intervention to alleviate poverty in sub-Saharan Africa. In South Africa, 50% of the indigenous goat population is in the hands of small-scale farmers (Ng'ambi *et al*., 2013). Goats are known to adapt to various agroecological zones, and their hardiness presents an opportunity to increase their population, especially among smallholder farmers (Rout & Behera, 2021). Milk from goats is highly-priced because of its quality. It can also be used as a replacement for human milk in immune-compromised patients since it is rich in proteins compared to milk from cows (Department of Agriculture, Fisheries and Forestry [DAFF], 2019). However, optimal productivity in all classes of animals, including goats, can only be realised when the nutritional qualities of feeds are improved. The main challenge to improved goat production performance in rural areas of South Africa is limited forage availability (Brown *et al.,* 2016). This challenge is more pronounced during the drought and dry winter periods, often leaving goats to feed on fodder materials low in energy and proteins, reducing their production performance (Luthuli, 2018). In addition, smallholder goat farmers often lack the modern management skills necessary for improved goat production and resort to low-input farming.

The farmers depend mainly on indigenous knowledge of the feed types that are mostly preferred and consumed by their animals. However, knowledge of the feed and animal factors that may influence the choice of feed as well as the nutritional qualities of the feeds is often lacking (Hundal *et al.,* 2016). Ramukhithi *et al*. (2018) identified low productivity in rural goat farming as a threat

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to sustainability. There is considerable scope for raising rural income and food security through improvements in goat production. Feed conservation during the rainy season could address challenges associated with feed shortage during the drought and dry periods. Improved goat production can help reduce poverty and the unemployment rate; these are in line with the National Development Plan 2030 of the South African government (NDP, 2012). Therefore, this study tried to solicit rural goat farmers' knowledge on the utilisation and nutritional qualities of fooder trees in the study area.

2. LITERATURE REVIEW

Communal goat production relies mainly on natural pastures, as indigenous goats normally receive fewer or no supplements, even during the dry seasons (Mbiriri *et al*., 2012). The farmers utilise indigenous fodder tree knowledge to optimise goat production during the dry seasons. Since fodder trees are readily available in these regions, there is great potential for improved goat productivity. Nonetheless, there is limited reference to scientific data due to various constraints, such as a lack of resources and information. Habermann *et al*. (2019) observed that even though forage quality and availability are often high during the rainy seasons, palatability is soon lost because of the rapid growth associated with the high temperatures in tropical regions. Gebremedhin *et al.* (2020) and Das *et al*. (2021) indicated that the quality of forages and grasses in tropical areas could fall below 8% crude protein during dry seasons. Deterioration in feed quantity and quality during the dry seasons severely affects goat productivity in those areas, even though most indigenous goat breeds can survive these harsh conditions, partly due to their ability to utilise various plant species as feed (Nair *et al*., 2021). Mehmood *et al.* (2020) recommended harvesting forage during this time of excess production for use during periods of feed scarcity. Other recommended measures include using stored feed materials such as silage, hay, postponed pastures and feeding leguminous tree pods as nutritional feed supplements (Garcia-Torres *et al.*, 2003). William (2015) recommended using *Acacia karroo* species (leaves and seed pods) for goat feeding, especially in the communal areas where this plant species is in abundance.

3. METHODOLOGY

3.1. Study Site

The study was conducted in the Gumela indigenous goat farming area, which smallholder farmers dominate. Gumela lies in the Southern African Lowveld vegetation system in the Thulamela Local Municipal area of the Vhembe District, Limpopo province, South Africa (Figure 1). The Venda ethnic group dominates the Thulamela Local Municipal area. The municipality is classified as a sub-tropical type of climate, with most rain falling from October to March in the summer months. Climatic conditions in Thulamela Local Municipality are suitable for the growth of perennial plants (Nell & Van der Walt, 2017). The unique topographical position of the area, its diverse plant communities, the Vhembe Biosphere Reserve, which falls within this municipality, the grasslands with scattered trees, short open woodland and bushes of different kinds that cover the entire municipality made Thulamela Local Municipality a good area for our study.

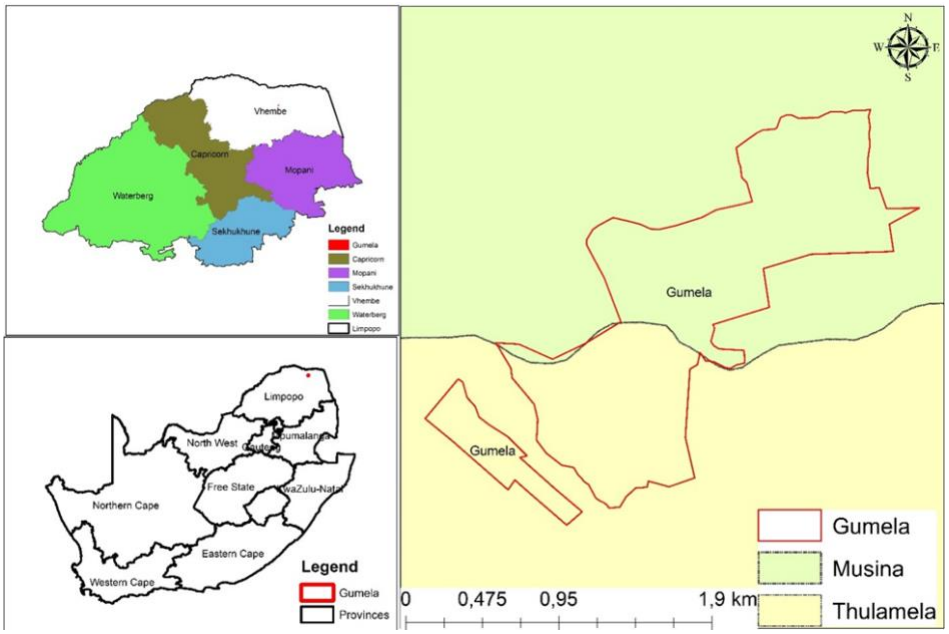

FIGURE 1: The Geographical Map Indicating the Location of Thulamela and Musina Local Municipalities with the Gumela Area Highlighted (Source: Municipal Demarcation Board, 2015).

3.2. Sampling Process

The researchers used the purposive sampling method to select indigenous goat farmers who participated in the study. Fourteen goat farmers who owned a minimum of 50 goats under an extensive management system were selected based on the list of goat farmers in the study area as provided by the local office of the Limpopo Department of Agriculture and Rural Development (LDARD). The selected farmers were all males within the 60 – 70 years age group.

3.3. Data Collection

Ethical clearance for this study was obtained from the University of Limpopo Turfloop Research and Ethics Committee (PN: TREC/298/2020: PG). The researchers developed a semi-structured questionnaire to guide the discussions during data collection, carried out from July to September 2020. Questions were designed in the local vernacular language (Tshivenda) for better understanding by the selected farmers. Focus group discussions and field-based cross-sectional surveys followed by personal interviews. These were critical to harmonise the findings gathered from individual interviews and facilitate information sharing. During the field walks, goats were followed to find and collect samples of plants browsed and reported during the interviews. Results from individual participants were related to more general data emerging from the focus group discussions. Following the collection of browsed feed materials from the field, each respondent was further asked to judge each feed material as either good or bad, comment on their nutritional qualities, and give reasons behind the outcome of their judgment. Issues related to the knowledge of trees and shrubs and information on availability and acceptability by the animals were discussed during the interviews. Photographs of the plant samples collected were taken to facilitate their identification. Collected plant samples were placed in brown envelopes and taken to the Department of Biodiversity at the University of Limpopo for botanical identification. Samples were dried in the Animal Production Laboratory at the University of Limpopo, then grounded to a fine powder using an electric grinder (Model: FZ-102) with a mesh size of 0.5 mm and stored in well-labelled airtight polythene bags for chemical analysis.

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3.4. Chemical Analysis

The collected samples from feed materials were taken to the Animal Production Laboratory at the University of Limpopo for dry matter, ash, energy and crude protein analysis. DM determination (AOAC., 2005): the dry matter of the collected samples from the identified browsed fodder plant species was determined according to the AOAC (2005). Thoroughly cleaned crucibles were placed in the oven at 105°C for 30 minutes, then transferred to a desiccator and cooled to room temperature (25 ºC). The crucibles were then weighed. Samples were weighed, placed into crucibles, and placed in the oven overnight at 105 ºC. The crucibles and contents were weighed as soon as possible to prevent moisture absorption. Dry matter was calculated as follows:

DM (%) = Weight of the sample before drying/Weight of the sample after drying x 100

Determination of ash (AOAC., 2005): Air-dried browsed plant samples (2 g) were weighed and placed in pre-weighed clean-labelled crucibles. The sample plus the crucible were placed in the muffle furnace at 550 ºC overnight. The crucible and content were weighed as soon as possible to prevent moisture absorption. Ash determination was calculated as follows:

Ash weight = (Weight of beaker + ash) - (Weight of beaker)

Ash (%, DM basis) = (AWt/Dry sample weight) x 100

Determination of nitrogen content (AOAC., 2005): Nitrogen contents of the browsed plant samples were determined using the Kjeldahl procedure (AOAC., 2005). The formula for the calculation of the nitrogen content of the samples was as follows:

N (%) = (ml acid titrated - ml blank titrated) x (Acid N x 0.014 x 100)/Weight of sample in grams (g).

Determination of energy content (AOAC., 2010): the energy content of the browsed plant samples was determined using The Bomb Calorimeter (AOAC., 2010). The formula for the determination of the energy content was as follows:

Energy (joules) = Mass of water (g) × 4.2 (J/g ºC) × Temperature increase (ºC)

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3.5. Statistical Analysis

Data collected using semi-structured questionnaires were fully transcribed, translated into English, and entered in Microsoft excel. Data was further transferred to International Business Machines (IBM) Statistical Package for the Social Sciences (SPSS), version 25 (IBM SPSS Statistics, 2017) for analyses of rankings, categorisation, reasons for the judgment and quality assessment criteria by the respondents. Furthermore, the data on the chemical composition (DM, ash, CP, and energy contents) of the collected samples on the identified fodder trees browsed by goats at the Gumela indigenous goat farming area was subjected to General Linear Model (GLM) procedures using the Statistical Analysis of Software (SAS, 2010). Treatment means were compared using the Tukey test for multiple comparisons at the 5% probability level. The following model was used:

$$Y_{ij} = \mu + T_i + e_{ij}$$

whereby:

Y_{ij} = The nutrients (Dry matter, Ash, Energy, and Protein content)

μ = Overall mean,

T_i = Effect of feed materials (tree leaves and grass) and

e_{ij} = Residual error.

4. RESULTS AND DISCUSSION

4.1. Plant Species Browsed by Goats in the Study Area

As reported in Table 1, 15 fodder trees were reported to be available and browsed by goats at the Gumela indigenous goat farming area of Vhembe district in Limpopo province and were further identified by the respondents in their local Tshivenda names. Furthermore, the identification of the browsed fodder plants through their botanical names was carried out at the botanical laboratory of the Department of Biodiversity, University of Limpopo. Goats utilised either leaves, fruits, pods, and seeds of the following fodder trees; *Dichrostachys cinerea* (Murenzhe), *Boscia albitrunca* (Muthobi), *Ziziphus mucronata* (Mutshetshete*)* and *Maerua angolensis (*Mutambanamme) while the rest of the fodder plant species had their leaves as the browsed parts.

The current study results show that all the respondents in the Gumela indigenous goat farming area had some knowledge of fodder trees utilised by their goats. Based on the current findings,

leaves were the most used parts of the plants, followed by fruits and pods/seeds. These results align with the findings of Mutie *et al*. (2020), who reported that goats mostly consume flowers, fruits, stems and leaves. Moreover, goats can select different plant parts and species from those they encounter (Mellado, 2016; Berman *et al.,* 2017).

TABLE 1: Plant Species Browsed by Goats, Their Habitats and Favoured Plant Parts at Gumela Communal Goat Farming Area

Local names (Tshivenda)	Botanical name	Habitat	Plant parts utilised
Mupani	*Colophospermum mopane*	Tree	Leaves
Muvhuyu	*Adansonia digitata*	Tree	Leaves
Mufula	*Sclerocarya birrea*	Tree	Leaves
Muṱwari	*Terminalia prunioides*	Tree	Leaves
Musingizi	*Combretum apiculatum*	Tree	Leaves
Munanga	*Senegalia galpinii*	Tree	Leaves
Gwambazi	*Capparis tomentos*	Tree	Leaves
Mutangule-Ngele	*Euclea crispa*	Tree	Leaves
Musu	*Vachellia tortilis*	Tree	Leaves
Murenzhe	*Dichrostachys cinerea*	Tree	Leaves and Pods
Muthobi	*Boscia albitrunca*	Tree	Leaves and Fruits
Mutshetshete	*Ziziphus mucronata*	Tree	Leaves and Fruits
Muembe	*Annona senegalensis*	Tree	Leaves
Mutambanamme	*Maerua angolensis*	Tree	Leaves and seeds
Mulumanamana	*Cassine transvaalensis*	Tree	Leaves

Nutritional Composition of Browsed Fodder Plant Species

Data presented in Table 2 shows that *Capparis tomentos* (Gwambazi), *Euclea crispa* (Mutangule-Ngele), and *Cassine transvaalensis* (Mulumanamana) browsed plant species had higher ($p<0.05$) dry matter (DM) content .*Ziziphus mucronata* (Mutshetshete) had higher ($p<0.05$) ash

content.*Maerua angolensis* (Mutambanamme) had higher ($p<0.05$) crude protein (CP) content, while *Colophospermum mopane* (Mupani) had higher ($p<0.05$) energy content.

According to the information the farmers revealed during the data collection process, Gumela communal goat farming area experienced excessive drought before the data collection period. Brown *et al*. (2016) indicated that due to erratic rainfall patterns, the quality and quantity of available fodder declines and goats utilise feedstuffs from low-quality natural pastures which are low in proteins. However, some smallholder goat farmers in the study area provided minimal supplemental feeds in the form of pellets. Other smallholder goat farmers cut tree branches to increase feed accessibility, especially during the dry winter when the veld is dry. Couch et al. (2021) also noted and recommended such practices. During the interviews, the respondents indicated that most livestock mortalities are experienced during dry periods, although the exact cause for this could not be ascertained. One of the possible explanations for the high mortalities during the dry periods is the lack of availability of fodder plants which leads to animals consuming poisonous plants.

Luginbuhl (2020) reported that poisonous plants are primarily consumed when animals are faced with situations of acute feed shortage. The nutritional value of fodder plants depends on factors such as the plant species, plant part, maturity stage, and climate. Ibrahim and Usman (2021) reported that, unlike other grass or plant species that dry off and lose their nutritional value during dry seasons, most browse species can maintain their greenness and nutritional value throughout the year. However, the nutritional value of browsed fodder plants depends on factors such as moisture content, intake and digestibility (Hart *et al*., 2022). Determining the DM content would be important since optimal DM intake improves rumen microbial populations (Kinley, 2020). Yousfi (2016) stated that, on average, goats consume 3-4% of their body weights (BWs). Other factors such as palatability of the available feed and physiological statuses such as growth phase, pregnancy and lactation state were also reported to affect DM intake even though it is often the concentration of crude protein in the feedstuffs that has the most impact on the performance of animals (Yusuf, 2020).

The ash content indicates the degree of mineral deposit in plant materials (Hihoto *et al*., 2022). Therefore, the nutritional composition of browsed fodder plant species in the Gumela indigenous

goat farming area was lab-analysed. The study's findings revealed that *Annona senegalensis* had the highest ash content (16%) and *Capparis tomentose, Euclea crispa,* and *Cassine transvaalensis* had high DM contents of above 90%. Ash values for the browse species reported in the present study are higher than those reported by Habte *et al*. (2012), which could be due to variations in the soil types from where the samples were collected. As a result, it is critical to investigate further the DM and mineral contents of the browsed species in the study area since no scientific study has been conducted on the DM and ash contents of those plant species identified at the Gumela communal goat farming area. Browse species analysed in this study had lower crude protein (CP) levels than those reported by Habte *et al.* (2021); however, they were comparable to those reported by Rivera- Méndez *et al*. (2017) and Dalle (2020). Kasale (2013) mentioned that proteins are the most significant nutrients in livestock feeding for optimal feed intake and microbial functions. However, in ruminant nutrition, nitrogen and its different compounds are of greater relevance than proteins and amino acids. The CP content of the barks of *Maerua angolensis* reported in the present study is similar to the findings of Williams *et al*. (2019) and higher than the recommended minimum levels of 8% crude protein for optimal ruminal microbial functioning and hence optimal feed intake (Brown *et al*., 2018). However, Mamer (2017) reported lower CP levels for the leaves of *Maerua angolensis*. Considering its high CP levels, barks of *Maerua angolensis* are recommended for inclusion as supplements to meet the animal body's daily protein requirements.

Moreover, all the browsed species reported in our study had CP contents higher than the recommended minimum levels (Fan *et al*., 2017) except for *Annona senegalensis* leaves, similar to the findings of Fayum *et al.* (2018). However, Mathew *et al.* (2018), Leite *et al.* (2020), and Al Kazman *et al.* (2022) reported higher CP levels for the leaves and seeds of *Annona senegalensis* of 9% and 17%, respectively. The results revealed that *Colophospermum mopane* leaves had higher energy content than the other browse plants reported in the present study. The energy levels are acceptable for goat feeding (Kabir *et al.,* 2022). The importance of energy in animal health cannot be overemphasised since energy is considered essential in the diets of browsers (Jiwuba *et al*., 2021). However, Makhado *et al*. (2016) and Jiwuba *et al.* (2021) reported lower values of 19 MJ/kg and 11 MJ/kg for *Colophospermum mopane* leaves.

TABLE 2: Nutritional Composition (% DM) of the Identified Browsed Plant Materials from Gumela Indigenous Goat Farming Area

Plant species	DM	Ash	CP	Energy
Colophospermum mopani (Mupani)	93.74^{abc}±0.19	3.96^{ij}±0.32	16.33^{c}±0.43	22.67^{a}±0.12
Adansonia digitata (Muvhuyu)	89.27^{e}±0.12	8.36^{cde}±0.22	14.60^{d}±0.12	11.67^{g}±0.09
Sclerocarya birrea (Mufula)	85.67^{f}±0.14	5.43^{ghi}±0.58	10.33^{e}±0.15	17.10^{d}±0.17
Terminalia pruniodas (Mutwari)	93.61^{abc}±0.44	7.76^{cdef}±0.28	8.50^{f}±0.17	16.73^{d}±0.15
Combretum hereroense (Musingidzi)	91.18^{cde}±1.75	5.23^{hi}±0.21	10.70^{e}±0.06	17.97^{bc}±0.23
Acacia galpinii (Munanga)	93.29^{abcd}±0.04	2.67^{j}±0.32	14.97^{d}±0.02	16.84^{d}±0.18
Capparis tomentosa (Gwambazi)	95.33^{a}±0.33	7.31^{defg}±1.11	18.90^{b}±0.17	12.67^{f}±0.09
Euclea crispa (Mutangule-Ngele)	94.83^{a}±0.17	6.02^{fgh}±0.21	18.83^{b}±0.15	6.83^{j}±0.18
Acacia tortilis (Musu pods)	93.20^{abcd}±0.76	3.13^{j}±0.32	14.93^{d}±0.26	18.73^{b}±0.12
Dichrostachys cinerea (Murenzhe)	94.20^{ab}±0.10	2.22^{j}±0.24	14.93^{d}±0.13	9.9^{h}±0.21
Boscia albitranca (Muthobi)	90.77^{de}±0.21	9.67^{c}±0.16	19.19^{b}±0.20	12.24^{fg}±0.18
Ziziphus mucronata (Mutshetshete)	93.83^{abc}±0.17	8.93^{cd}±0.19	18.63^{b}±0.15	15.20^{e}±0.21
Annona senegalensis (Muembe)	91.56^{bcde}±0.26	15.99^{a}±0.35	2.96^{g}±0.17	17.27^{cd}±0.20
Maerua angolensis (Mutambanamme)	89.86^{e}±0.26	13.98^{b}±0.13	21.81^{a}±0.11	16.97^{d}±0.23
Cassine transvaalensis (Mulumanamana)	94.80^{a}±0.12	9.13^{c}±0.12	17.27^{c}±0.19	9.00^{j}±0.21

a, b, c, d = mean values along the same column with different superscripts are significantly different ($p<0.05$)

4.2. Ranking, Categorisation, Judgment and Quality Assessment Criteria of the Browsed Plant Species by the Respondents

The identified fodder trees at the Gumela communal goat farming area were ranked according to their utilisation (Table 3). *Colophospermum mopane* (Mupani) was highly ranked by 43% of the respondents as the most browsed plant species, while only % of the respondents ranked *Ziziphus mucronata* (Mutshetshete) and *Maerua angolensis* (Mutambanamme) as the least browsed fodder trees. The field walks undertaken by the researchers also revealed the same plants mentioned by the respondents as the preferred ones during browsing. The results showed that only two fodder plants, namely: *Colophospermum mopane* (Mupani) and *Adansonia digitata* (Muvhuyu), were classified as bad by 14 and 21% of the respondents, respectively, while the rest were classified as being good for goat feeding (Table 4). *Sclerocarya birrea* (Mufula) (86%) and *Terminalia prunioides* (Mutwari) (71%) were classified highly as good fodder plants, and the least mentioned

fodder plants were *Senegalia galpinii* (Munanga) (21%), *Dichrostachys cinerea* (Murenzhe) and *Vachellia tortilis* (Musu) both at 29%.

Respondents used the nature of the leaves (dry vs wet), water content, health response of the animals following feeding, leaf colour, palatability, and seed and pod preference when judging browed plants as either good or bad sources of goat feed (Table 5). *Colophospermum mopane* (Mupani) (14%) and *Adansonia digitata* (Muvhuyu) (21%) were classified as bad sources of goat feed since, according to the respondents, goats would fall sick after browsing them. *Combretum apiculatum* (Musingizi) (29%) was classified as a good source of goat feed since according to the respondent's goats prefer its green leaves. Moreover, *Capparis tomentos* (Gwambazi) (21%) was mentioned as the most palatable feed material, while *Boscia albitrunca* (Muthobi) (50%) was preferred for its seeds and pods. Goat farmers used their indigenous knowledge to assess the quality of the identified fodder plants. A combination of criteria such as feed preferences, skin appearance, birth rate and weight gain as indicators of the nutritional quality of the fodder trees (Figure 2).

Colophospermum mopane was the most utilised browse species, while *Ziziphus mucronata* and *Maerua angolensis* were the least used browse species in the study area. Interestingly, results for chemical analysis indicated that *Maerua angolensis* had higher CP when compared to the other browse plants. Most of the browse plants reported in this study were classified as good sources for goat feed except for *Colophospermum mopane*, and *Adansonia digitata*, where the respondents had mixed views since consuming parts of these plant species was associated with the development of signs of ill health in animals. Makhado *et al*. (2016) and Makhado (2020) reported that green leaves of *Colophospermum mopane* possess high levels of secondary metabolites, such as tannins and phenols can lead to a loss of appetite and digestive problems. Additionally, Scogings *et al*. (2021) further stated that phenolic compounds reduce the palatability of plant leaves. *Adansonia digitate* was less popular among the respondents because its leaves are thick, and green and have a high-water content which could lead to digestive problems. Obidiegwu *et al.* (2020) reported that these green leaves contain high levels of anti-nutritional compounds such as phytic acid, oxalic acids, hydro carbonic acid and tannins. Several studies reported an association between the nutritional quality of the feed materials and the

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behaviour the animals exhibited in terms of high birth rate and weight gain (Cantalapiedra-Hijar *et al*., 2018; Patel *et al*., 2018; Oduro-Mensah *et al.*, 2020). However, no studies support the idea that an animal's skin response and feed selection (preference) are a criterion for the nutritional value of the field-available diet. As a result, in addition to laboratory analysis, there is a need to learn more about the nutritional assessment standards used by indigenous goat farmers in the rural areas of South Africa.

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TABLE 3: Ranking by Utilisation of Identified Plant Species from the Most Utilised to the Least Utilised by Goats as Presented by Respondents in the Gumela Indigenous Goat Farming Area

Plant name	Rankings and Frequency (%)															
	Most 1	2	3	4	5	6	7	8	9	10	11	12	13	Least 14	15	Missing (%)
Colophospermum mopane (Mupani)	42.9	21.4	7.1	-	-	-	-	7.1	-	-	-	-	-	-	-	21.4
Adansonia digitata (Muvhuyu)	-	21.4	28.6	14.3	-	7.1	7.1	-	-	-	-	-	-	-	-	21.4
Sclerocarya birrea (Mufula)	-	14.3	28.6	14.3	7.1	-	14.3	7.1	-	-	-	-	-	-	-	14.3
Terminalia prunioides (Mutwari)	28.6	7.1	-	21.4	7.1	-	-	7.1	-	-	-	-	-	-	-	28.6
Combretum apiculatum (Musingizi)	7.1	7.1	14.3	-	7.1	21.4	-	-	-	7.1	-	-	-	-	-	42.9
Senegalia galpinii (Munanga)	-	-	-	-	7.1	14.3	-	-	-	7.1	-	7.1	-	-	-	57.1
Capparis tomentos (Gwambazi)	-	7.1	-	7.1	-	-	7.1	7.1	-	-	14.3	-	-	-	-	42.9
Euclea crispa (Mutangule-Ngele)	-	7.1	-	-	7.1	7.1	7.1	7.1	7.1	-	-	-	-	-	-	64.3
Vachellia tortilis (Musu)	-	-	-	-	7.1	-	-	-	14.3	-	-	-	-	-	-	71.4
Dichrostachys cinerea (Murenzhe)	-	-	7.1	-	7.1	-	7.1	-	-	-	7.1	-	-	-	-	71.4
Boscia albitrunca (Muthobi)	21.4	-	-	14.3	-	-	-	-	-	-	-	7.1	-	7.1	-	50.0
Ziziphus mucronata (Mutshetshete)	-	-	-	-	7.1	-	-	-	7.1	-	7.1	7.1	-	-	7.1	64.3
Annona senegalensis (Muembe)	-	-	-	-	-	-	-	-	-	-	-	7.1	7.1	7.1	-	71.4
Maerua angolensis (Mutambanamme)	-	-	-	-	7.1	-	-	-	-	-	-	-	21.4	-	7.1	64.3
Cassine transvaalensis (Mulumanamana)	-	-	-	-	-	-	-	-	-	7.1	-	-	-	7.1	14.3	71.4

Missing (%): Percentage of farmers who did not state browsed plant species

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TABLE 4: Categorisation of Browsed Plant Species as Either Good or Bad Sources of Goat Feed by Respondents from Gumela Communal Goat Farming Area

Plant name	Frequency (%)		
	Good	Bad	Missing (%)
Colophospermum mopane (Mupani)	64.3	14.3	21.4
Adansonia digitata (Muvhuyu)	64.3	21.4	14.3
Sclerocarya birrea (Mufula)	85.7	-	14.3
Terminalia prunioides (Muṱwari)	71.4	-	28.6
Combretum apiculatum (Musingizi)	57.1	-	42.9
Senegalia galpinii (Munanga)	21.4	-	78.6
Capparis tomentos (Gwambazi)	57.1	-	42.9
Euclea crispa (Mutangule-Ngele)	42.9	-	57.1
Vachellia tortilis (Musu)	28.6	-	71.4
Dichrostachys cinerea (Murenzhe)	28.6	-	71.4
Boscia albitrunca (Muthobi)	50.0	-	50.1
Ziziphus mucronata (Mutshetshete)	35.7	-	64.3
Annona senegalensis (Muembe)	28.6	-	71.4
Maerua angolensis (Mutambanamme)	21.4	-	78.6
Cassine transvaalensis (Mulumanamana)	35.7	-	64.3

Missing (%): Percentage of farmers who did not state browsed plant species

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TABLE 5: Reasons Given by the Respondents When Judging the Browsed Plants Species as Either Good or Bad Sources of Goat Feed

Plant name	Reasons and Frequency (%)						
	Dry leaves	High water	Sickness	Green leaves	Palatable	Seeds and pods	Missing (%)
Colophospermum mopane (Mupani)	28.6	-	14.3	14.3	7.1	-	28.6
Adansonia digitata (Muvhuyu)	7.1	28.6	21.4	-	7.1	-	21.4
Sclerocarya birrea (Mufula)	64.3	9.1	-	7.1	-	-	21.4
Terminalia prunioides (Muṱwari)	7.1	7.1	-	21.4	14.3	-	35.7
Combretum apiculatum (Musingizi)	21.4	-	-	28.6	-	-	50.0
Senegalia galpinii (Munanga)	7.1	7.1	-	7.1	7.1	-	64.3
Capparis tomentos (Gwambazi)	7.1	-	-	7.1	21.4	7.1	50.0
Euclea crispa (Mutangule-Ngele)	14.3	-	-	7.1	7.1	-	64.3
Vachellia tortilis (Musu)	-	--	-	7.1	-	28.6	71.4
Dichrostachys cinerea (Murenzhe)	-	-	-	-	-	7.1	74.4
Boscia albitrunca (Muthobi)	-	-	-	-	-	50.0	50.0
Ziziphus mucronata (Mutshetshete)	-	-	-	7.1	14.3	14.3	64.3
Annona senegalensis (Muembe)	-	28.6	-	-	-	-	71.4
Maerua angolensis (Mutambanamme)	-	14.3	-	-	7.1	14.3	64.3
Cassine transvaalensis (Mulumanamana)	7.1	-	-	7.1	7.1	-	71.4

Missing (%): Percentage of farmers who did not state browsed plant species

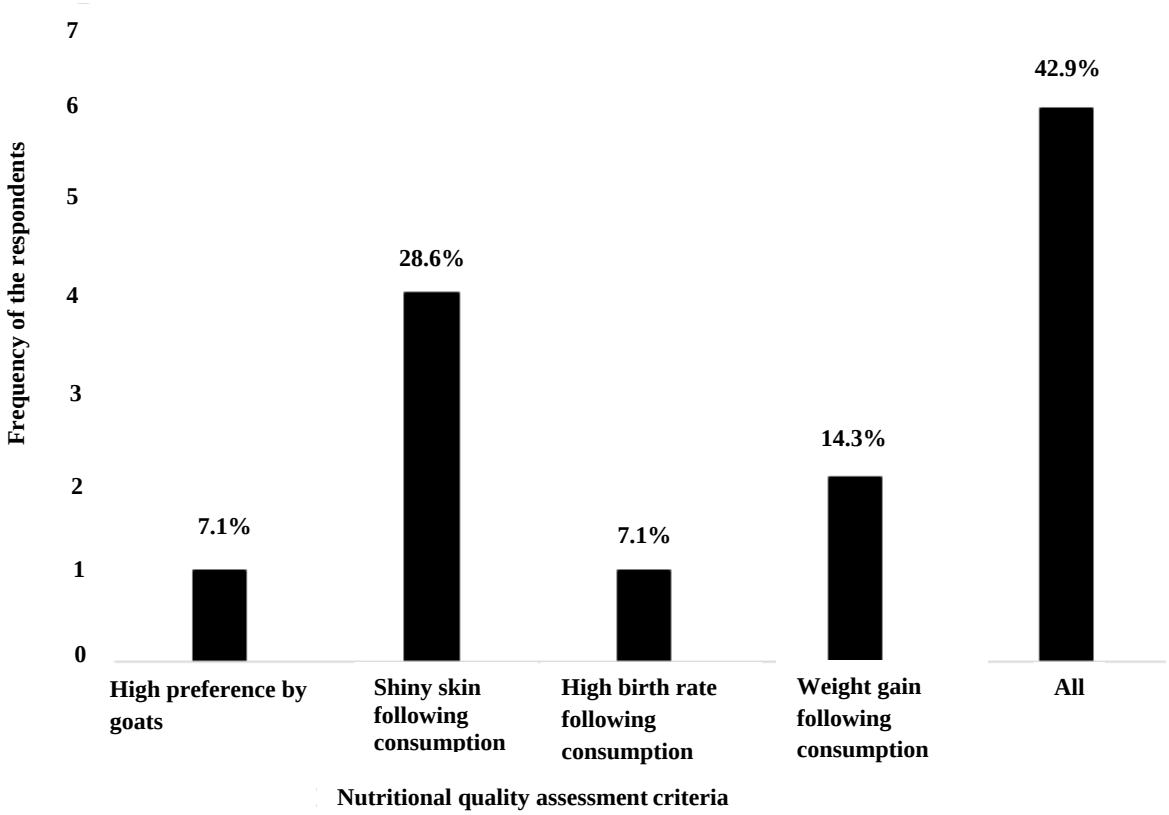

FIGURE 2: Feed Quality Assessment Criteria Used by Goat Farmers at Gumela Communal Goat Farming Area

5. CONCLUSION

The purpose of the study was to assess the knowledge of smallholder farmers regarding the identification and nutritional value of fodder trees that goats in the study area browse. Using a semi-structured questionnaire, 14 smallholder goat farmers were interviewed. The Animal Nutrition and Botany laboratories of the University of Limpopo in South Africa provided nutritional analysis and botanical identification services. The study results showed that the respondents had some knowledge of fodder plant materials browsed by their goats. It can be concluded from the present study's findings that most of the browse species reported in this study are good sources of goat feed since their CP levels were above the recommended minimum values. Generally, the respondents did not know how to determine the nutritional qualities of the available feed materials. For this reason, methods for determining the nutritional quality of fodder that are user friendly to the farmers can be developed and brought to the farmers through training programs

by the extension officers. These initiatives would contribute towards the increased productivity of goats, hence contributing to improved livelihoods and food security in line with the National Development Plan 2030 of the South African government.

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Livelihood Analysis of Gasela Community in Amahlathi Local Municipality of the Eastern Cape Province

Mkhungela M.N.[1] and Khwidzhili R.H.[2]

Corresponding Author: MN. Mkhungela. Correspondence Email: mabutomkhungela@yahoo.com

ABSTRACT

The study was conducted to distinguish the livelihood activities that need sustainable development intervention in the Gasela rural community. A sample survey procedure was done on a population of 77 community household heads. A sample size of 65 was randomly selected. It was found that cabbage, spinach, and potatoes were the most crops produced by the community. Wattle forest was used for cooking, housing, and kraal fencing. The households were affected mostly by pests, diseases, environmental stresses, and weather-related shocks. These sources of vulnerability are cited to limit sustainable crop production. Therefore, the recommendations were interventions for the sustainable production of cabbage, spinach, and potatoes. A further suggestion was to investigate the alternative resource for wattle that will provide the same livelihood outcomes for the Gasela rural households when biological control of this invader species is implemented.

Keywords: Livelihood activities, Sources of vulnerability, Sustainable development intervention

1. INTRODUCTION

Livelihood is the means of securing physiological survival needs and other physical essentials at a primitive level. The poverty category begins below this level. The vast bulk of absolute and relative poverty is found in developing countries (Baulch & Hoddinott, 2000). South Africa

[1] Scientific Technician, Dohne Agricultural Development Institute, Livestock Production Improvement research and Development Directorate, P/ Bag X15, Stutterheim, 4930, Tel. 043 683 4004; Email: mabutomkhungela@yahoo.com

[2] Senior Lecturer, University of Mpumalanga, P/Bag X11283, Nelspruit, 1200, Tel. 013002 0144, Email: Humphrey.khwidzhili@ump.ac.za, Orcid 000-00021964-1102

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is an example of a country where poverty is prevalent, with unequal societies having persistent high levels (World Bank & Statistics SA, 2018). The Eastern Cape Province is the second-largest and poorest in South Africa (Adekunle, 2013). The primary goal of the 2030 Agenda for sustainable development recognises ending poverty in all its forms. To attain this, the Agenda realises the strategies that build the economy, address social needs, tackle climate change, and protect the environment as key. One such strategy is sustainable development. Only drafts and guidelines delineate South Africa's intentions toward sustainable agriculture (Khwidzhili & Worth, 2017). Hence, there is a need to approve policies on this.

The Gasela community in the Amahlathi Local Municipality was established through land redistribution in 2001. According to Kepe and Cousins (2002), when land, resource rights, and income are secured, people are more likely to invest efforts and resources in conservation and land-use practices that meet the present needs without compromising the ability of future generations to meet theirs. The Eastern Cape Agricultural Economic Transformation strategy (2016-2021) is informed by the overarching Rural Development Framework Policy directive outcome 7. The strategy ensures that life quality, services, livelihoods, and income are improved in rural communities. However, the programs implemented to solve the problems of poverty and food insecurity are continuously failing to produce the desired results (Musemwa, 2013). The study examined the characteristics of the Gasela community's livelihood to distinguish forms of livelihood activities that need sustainable development intervention. A sample size of 65 was randomly selected. It was found that cabbage, spinach, and potatoes were the most crops produced by the community. Wattle forest was used for cooking, housing, and poles for kraal fencing and selling. The households were affected mostly by pests, diseases, environmental stresses, and weather-related shocks. Therefore, the recommendations are interventions for the sustainable production of these most produced crops and investigating the alternative resources for wattle that will provide the same livelihood outcomes for the community.

1.1. Objectives and Purpose of the Study

The study's main objective was to determine how the rural community within the vulnerability context develops livelihood strategies to achieve the desired livelihood outcomes. The purpose was to identify the different types of livelihood assets and activities used by household categories to support their livelihood. Further, determine institutions, policies, and processes

that influence community livelihood strategies. Lastly, provide livelihood outcomes that suggest entry points for sustainable development approaches at the micro and macro-economic levels.

2. METHODOLOGY

2.1. Study Area and Research Design

The study was conducted at Gasela local rural community situated 8 km away from Stutterheim under Amahlathi local municipality of Amathole District in the Eastern Cape Province with GPS coordinates: 32º 37' 58" S 27º 28' 52"E. The area falls under Montana Grassland (Rutherford *et al*., 2006). A survey method was chosen to sum up the community characteristics and make general statements about the study population using information obtained from the sample (Yin & Heald, 1975). The method is a personal interview survey in the respondent's home. The qualitative and quantitative methods were used to collect information on human behaviour and numerical data, respectively. The mixing method of qualitative and quantitative research presents a comprehensive discussion of the theoretical, methodological, and practical issues (Brannen, 2017). A semi-structured questionnaire collected data from 65 randomly selected household heads. The data was collected in October 2019.

2.2. Unit of Analysis and Sampling Procedure

The study was conducted on key informants and household heads of the Gasela community in Amahlathi local municipality of the Eastern Cape Province. The participants were selected using a sample survey procedure to obtain a sample representing the community household heads population. Based on the rural household head population size of 77, a confidence level of 95%, a confidence interval of 5%, and a response distribution of 50%, it was calculated that a random sample of 65 household heads would be sufficient for a survey of this nature (Raosoft, 2004).

2.3. Data Collection Techniques

A semi-structured questionnaire collected data from key personnel and 65 randomly selected household heads. The type of questioning used to collect data was closed, demographic, contingency, skilled-based, dichotomous, side-by-side matrix, and open-ended questions. The information collected through questionnaires included demographic information, community profile, vulnerability context, livelihood assets, institutions, policies, processes, livelihood

strategies, and livelihood outcomes. Key personnel and household heads were individually visited in their homes. Interviews were conducted face-to-face using the respondent's home language, and responses were recorded manually on the questionnaire. Participation in the survey was voluntary and treated with confidentiality.

2.4. Data Analysis and Interpretation

The Sustainable Livelihood Framework of the UK DFID was used as a checklist for livelihood analysis. The framework depicted Gasela's rural community as operating in a vulnerable context within which the community has to access livelihood assets. The vulnerability context decisively shapes the livelihood strategies open to people in pursuit of their self-defined beneficial livelihood outcomes (Sife *et al.*, 2010). The Survey data was analysed using Statistical Package for the Social Science (SPSS) version 25.

3. RESULTS AND DISCUSSION

The results present the different livelihood assets and activities household categories use to support their livelihood. Further, the results cover institutions, policies, and processes that influence community livelihood strategies. Lastly, it included the livelihood outcomes that suggested the entry points for a sustainable development approach at the micro and macro-economic levels.

3.1. Human Capital

Human capital is an individual's productive capacity, inherited and acquired through education and training (Goodwin, 2003). The choices and options to develop strategies for sustainable livelihood are widened by an increase in this capital (Kanel & Niraula, 2017). The education level enabled the Gasela rural community to make informed decisions on livelihood activities that support their livelihood. The education level of respondents is summarised in Table 1.

TABLE 1: The Education Level of Respondents

Education level of respondents	Frequency	Percentage
Never been to school	11	16.9
Grade R to Grade 8	36	55.4

Grade 9 to Grade 12	18	27.7

3.2. Natural Capital

The study covered only renewables used by the Gasela rural community. Land, water, and forest were used to support livelihood. It is the pattern that rural households in low- and middle-income countries create employment using livelihood assets (Berchoux *et al*., 2020). Hence, the Gasela rural community used land, water, and forest for livelihood activities. The main natural capital the households had access to is shown in Table 2.

TABLE 2: Main Natural Resources the Households Had Access To

		No of households	**Percentage**
Land	No	0	0
	Yes	65	100
Water	No	5	7.7
	Yes	60	92.3
Forest	No	6	9.2
	Yes	59	90.8

The land was used to produce watermelons, beans, green pepper, potatoes, pumpkin, onion, beetroot, spinach, cabbage, maise, and carrots. The main crops produced were cabbage, spinach, and potatoes. According to Perret *et al*. (2000), cabbage, spinach, and potatoes are the most produced crops in rural communities in the Eastern Cape Province. Table 3 shows crops grown by households.

TABLE 3: Crops Produced by the Households

		Households		**Percentage**
Watermelons	No	62		95.4
	Yes	3		4.6
Beans	No	55		84.6
	Yes	10		15.4
Green Peppers	No	60		92.3
	Yes	5		7.7

Potatoes	No	32		49.2
	Yes	33		50.8
Pumpkin	No	53		81.5
	Yes	12		18.5
Onion	No	46		70.8
	Yes	19		29.2
Beetroot	No	45		69.2
	Yes	20		30.8
Spinach	No	32		49.2
	Yes	33		50.8
Cabbage	No	27		41.5
	Yes	38		58.5
Maise	No	46		70.8
	Yes	19		29.2
Carrots	No	52		80.0
	Yes	13		20.0
None	No	48		73.8
	Yes	17		26.2

The reasons for households to produce crops were consumption, feeding livestock, and consumption and selling. The research participants who produced crops for consumption and sale constitute 68.8%. Raleting and Obi (2015) support the findings that rural communities produce crops for sale and consumption. Figure 1 presents the household reasons for producing crops.

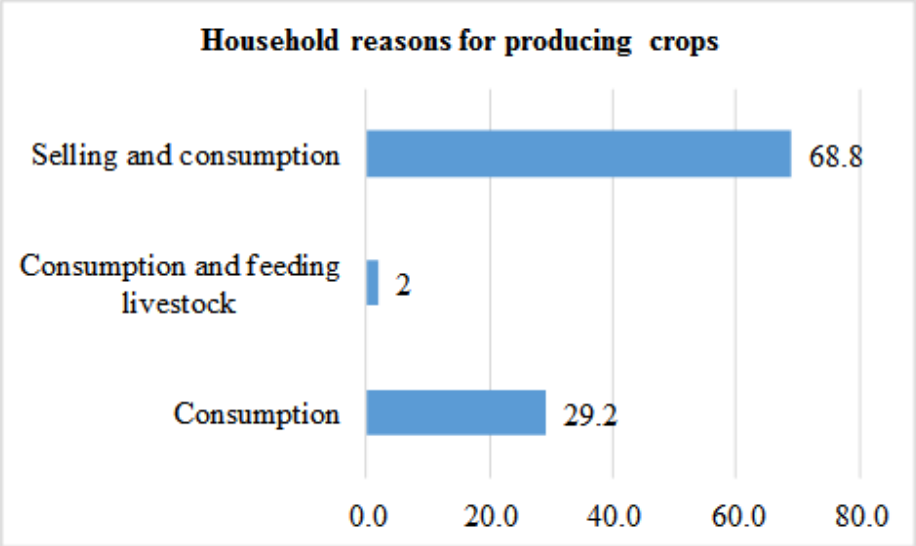

FIGURE 1: Household Reasons for Producing Crops

The range of activities of the community was based on the natural capital. Such activities included collecting and gathering in the forest, food cultivation, non-food cultivation, livestock keeping, and pastoralism. Activities of the community are summarised in Table 4.

TABLE 4: Natural Resource-Based Activities of Respondents

Natural resource-based activities		**Percentage**
Collection and gathering in the forest	No	3.1
	Yes	96.9
Food cultivation	No	40
	Yes	60
Non-food cultivation	No	98.5
	Yes	1.5
Livestock keeping and pastoralism	No	56.9
	Yes	43.1

The wood produced from wattle was used for cooking, making fires, housing, and poles for building kraals and selling. The study supports Johnson and Bryden (2012) that most rural communities use firewood as the primary energy source for livelihood activities. The use of the forest by the community is shown in Table 5.

TABLE 5: Uses of Forest Resources by Households

Uses of wood	Frequency	Percentage
Cooking and making fire	7	11
Housing and making livestock kraals and selling	58	89

3.3. Physical Capital

The households accessed water through the community piped water, household piped water, delivered by the municipality, river, and other (nearby farm reservoir). Most Eastern Cape rural communities access drinking water through groundwater supply (Lehloesa & Muyima, 2000). Even though the source of water accessed by the Gasela rural community was groundwater, the scarcity remains a challenge. Water scarcity burdens rural women as they have to walk more distances in search of water (Sigenu & Pelser, 2009). The access to water resources by households is presented in Table 6.

TABLE 6: The Access to Water Resources by Households

Access of water	Frequency	Percentage
Community piped water	14	22
Household piped water	1	1.5
Delivery by municipality	12	18.4
River	2	3.1
Other (nearby farm reservoir)	36	55

Water was used for consumption, washing, bathing, and irrigation. The Water Poverty Index (WPI) of Amahlathi local municipality falls at 51 (Cullis, 2005). The WPI of 100 is considered a perfect score. However, South Africa falls below that; hence it stands at 52 (Lawrence *et al*., 2002). Integrated Water Resources Management (IWRM) is recommended for the Gasela community with low WPI. The IWRM encompasses different stakeholders at different levels using water resources to manage water to achieve sustainable development goals of the 2030 agenda. The use of water resources by households is shown in Table 7.

TABLE 7: Uses of Water Resources by Households

Uses of water	Frequency	Percentage
Consumption, washing, and bathing	21	32
Consumption, washing, bathing, and irrigation	44	68

The rural community needs equipment and machinery that are economically affordable and environmentally safe to be used locally to produce crops. The types of manual implements used by the participants to produce crops were spade and hoe, and others combined spade, hoe, and rake. The results support Phezisa (2016) that households mostly use manual implements to produce crops from home gardens. Relatively few research participants used a tractor. Adekunle (2014) highlights that the lack of machinery makes most rural communities rely on labour-intensive crop production. Table 8 indicates the implements and machinery used to produce crops.

TABLE 8: Implements and Machinery Used to Produce Crops

Implements and machinery used to produce crops	Frequency	Percentage
Spade, hoe	38	58
Spade, hoe, rake	13	20
Tractor	14	22

3.4. Financial Capital

The Gasela rural community creates financial capital from different sources such as employment, farming, off-farm activities, forest products, pension, and child grants. The unemployment rate was relatively high compared to the Eastern Cape Provincial unemployment of 37.4% in the first quarter of 2019. The Gasela rural community can improve financial capital through support services, including agricultural and entrepreneurship, networking, and financial education. According to Hamdan (2019), entrepreneurship offers a means to overcome present challenges through sustainable development. Table 9 illustrates the principal occupation of the research participants.

TABLE 9: Principal Occupation of the Research Participants

Principal occupation	Frequency	Percentage
Employed	8	12
Unemployed	35	54
Self-employed	2	3
Pension and child grant	20	31

3.5. Social Capital

Most research participants know each other, enabling the community to act collectively. Conversely, the productive results in the community were not created by components of social structure. The structural social capital of the community was poor; hence 98.2% were not members of any organisation or social group, and 9.8% were members of Ilima. Bebbington (1997) emphasises the importance of civil society actors in improving agriculture, livelihoods, and resource use.

3.6. Institution, Policies, and Processes

The Ilima is a government grant that helps vulnerable communities increase agricultural production. The research participants that were participating in this project were 9.8%. South African agricultural policy on conserving natural resources promotes sustainable resource use. Nevertheless, no organisation was found to promote sustainable resource use in the Gasela community. The social process indicated no interactions that could improve the livelihood quality. Bachke (2019) emphasises that organisation membership has been used to improve market access, access to information, and capacity to increase production. Table 10 shows the membership of the research participants in an organisation or social group.

TABLE 10: Community Membership to an Organization or Social Group

Membership in an organisation or social group	Frequency	Percentage
Yes	6	9.2
No	59	90.8

3.7. Livelihood Strategies

The livelihood strategies are a set of economic actions influenced by social context to source the location of internal and external resources. The rural community commonly follows a traditional livelihood strategy by adopting two widely known adaptations: intensification of agricultural production and diversification of income sources. The research participants practised no agricultural production intensification. However, the diversification of income sources was a phenomenon; hence there were combinations of off-farm and on-farm activities and revenue generated from crops, livestock, and forest. Diversity is an intrinsic attribute of many rural livelihood strategies (Warren, 2002).

3.8. Livelihood Outcomes

The sources of vulnerability found in the community were weather-related shocks, pests, disease shocks, economic shocks, seasonal stresses, environmental stresses, idiosyncratic shocks, and structural shocks. The three main sources of vulnerability with the highest percentages were pests and diseases, environmental stresses, and weather-related shocks. As per Dhanush *et al.* (2015), climate change changes the stages and rates of pathogen development and host resistance, ultimately resulting in changes in the physiology of host-pathogen interactions. To alleviate the effects of pests and diseases, Climate-Smart Pest Management (CSPM) can be used, which reduces pest-induced crop losses, improves the ecosystem, and reduces greenhouse gas emissions (Heeb *et al*., 2019). The abiotic and biotic stresses were the second-highest sources of vulnerability experienced by the Gasela rural community. Amongst the abiotic stress mentioned by the research participants was the drought that caused the planted seeds not to germinate and seedlings to perish because of water stress. Drought caused some research participants not to participate in crop production.

Biotic stresses mentioned by the research participants were moles in potatoes and aphids in cabbages. According to Hanawalt (1922), with no interest in vegetables, moles primarily eat earthworms, centipedes, millipedes, slugs, and snails. In addition, *Pocket Gophers* are burrowers that create mounds on the soil in the same way that moles do and feed on vegetables (Hafner, 2004). Therefore, it might be inaccurate that the moles are biotic stress in potato production when *Pocket Gophers* are responsible for vegetable damage. The recommendations were that further research be conducted to accurately identify the pests responsible for potato damage in Gasela rural community gardens. Aphids were mentioned as another biotic stress on

vegetable production. The cabbage aphid, *Brevicoryne brassicae* (L.), significantly reduces the percentage of epicuticular wax, dry weight, sugar, and amino acids in cabbages (Khattab, 2007).

The *Green Peach Aphid* is a significant pest of *brassica* vegetables and a vector of more than a hundred viruses (Ahmed *et al*., 2018). It was further recommended that research be conducted to accurately identify the type of aphids responsible for cabbage damage in the Gasela community gardens. Plants develop specific mechanisms that enable them to withstand the damaging effect of environmental stress (Chelli-Chaabouni, 2014). Hence, crops with identified stress-responsive genes and overexpression within sensitive crop species are recommended to withstand environmental stress (Ahanger *et al*., 2017). Figure 2 indicates the Gasela community's sources of vulnerability.

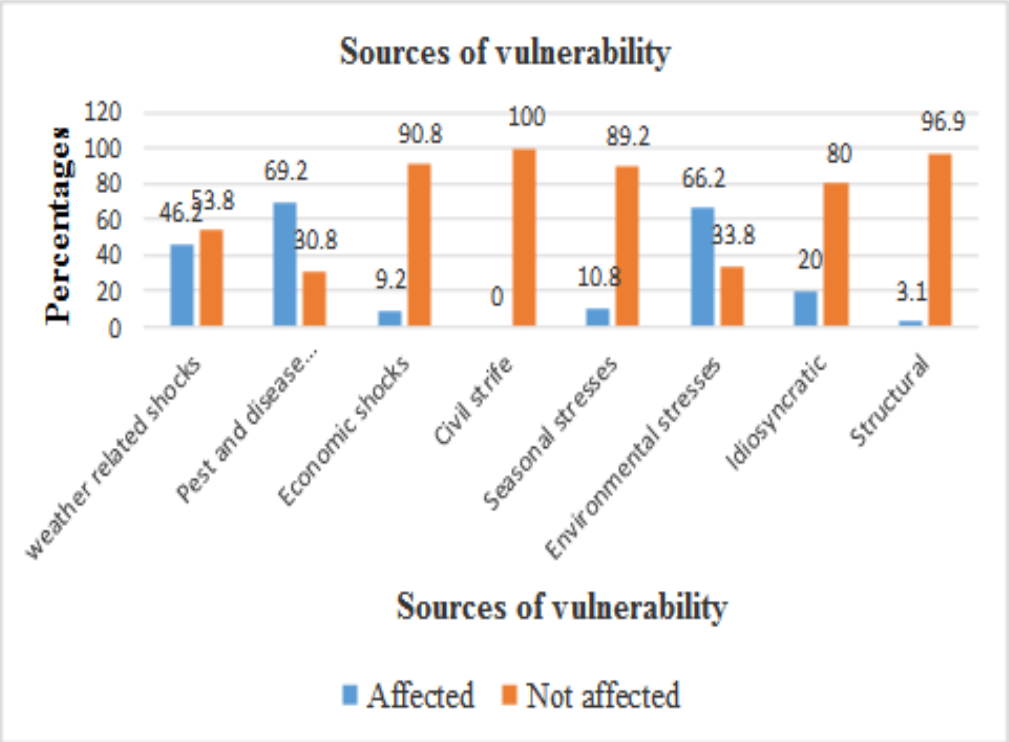

FIGURE 2: Sources of Vulnerability

The environment in South Africa is characterised by shocks, with a significant percentage of households being affected, and that threatens daily sustenance (Carter & Maluccio, 2003). The frequency of the sources of vulnerability experienced by the Gasela community on a yearly basis was 55, with 84.6% of people being affected. The principal abiotic stress experienced by

the research participants was drought which led some of the community members to a coping strategy by not participating in crop production. The Eastern Cape Province is highly vulnerable to drought, and the determination to reduce the impact should be a significant research effort (Mdungela *et al.*, 2018). Appropriate risk management strategies, such as prevention, mitigation, and coping, are recommended to manage shocks. The major shocks to be managed in the Gasela community are pests and diseases, environmental stresses, and weather-related shocks. Figure 3 illustrates the frequency of shocks and the percentage of the affected people in the community.

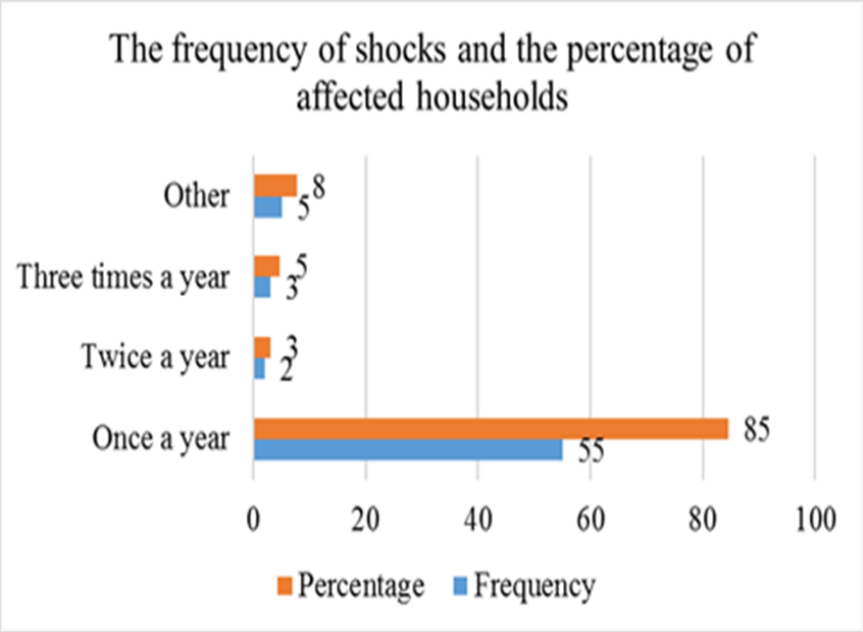

FIGURE 3: The Frequency of Shocks and the Percentage of Affected Households

4. CONCLUSION AND RECOMMENDATIONS

Livelihood analysis of rural communities is essential because these communities have the potential to produce or reduce natural resources by their action or inaction. This, in turn, can significantly affect the micro and macro economy. The study was to determine how the rural community within the vulnerability context develops livelihood strategies to achieve the desired livelihood outcomes. The intention was to provide livelihood outcomes that suggest entry points for a sustainable development approach at the micro and macro-economic levels. Crop production was the main livelihood activity in Gasela rural community. The most produced crops were cabbage, spinach, and potatoes. The wattle forest was used to collect firewood, poles for building houses, livestock kraals, and selling. Crops were produced for

consumption, feeding livestock, and selling. The Gasela rural community was affected mostly by three main sources of vulnerability: weather-related shocks, pests and diseases, and environmental stresses. Research participants cited these sources of vulnerability as limiting crop production. Thus the study recommends the IWRM for weather-related shocks existing in Gasela rural community. CSPM is recommended to reduce pest-induced crop losses, improve the ecosystem, and reduce greenhouse gas emissions to alleviate the effects of pests and diseases. The number of gaps that will benefit these findings and enhance this study within the Gasela rural community is:

- To assess soil and water suitability for sustainable production of cabbage, spinach, and potatoes.
- To conduct a Cost-Benefit Analysis (CBA) for sustainable production and marketing of cabbage, spinach, and potatoes.
- To improve their control and management, determine the type of pests and diseases of cabbage, spinach, and potatoes.
- To investigate the alternative resources for wattle that will provide the same livelihood benefits when biological control of this species is implemented.

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Exploring the Role of Indigenous Vegetables in Rural Livelihoods: Perceptions from the Ntuze Community

Qwabe Q.N.[1] and Pittawaty, T.[2]

Corresponding Author: T. Pittaway. Correspondence Email: timothy.pittaway@mandela.ac.za

ABSTRACT

An increasing number of countries face growing food insecurity levels, severely impacting rural livelihoods. South Africa is no exception, mainly because it meets the worst forms of socio-economic issues: the triple challenge of poverty, the inequality gap, and non-inclusive economic growth. Influenced by a growing number of people in underprivileged communities who face food poverty, the researchers bring to the fore the value of wild indigenous vegetation, which is often neglected and perceived as food for the poor. To articulate this, data was collected from participants who utilise indigenous vegetables. Among the themes that were inductively identified were (i) household food security, (ii) the perceived medicinal benefits to improve their health conditions, and (iii) the source of income. The study proposes that promoting the production and utilisation of indigenous vegetables be considered an approach to raising awareness to dismantle the stigma around these foods and to further respond to the food insecurity crisis in underprivileged communities. There is an underappreciation of local varieties such as imifino yasendle (wild leafy vegetables) and stigmatisation of utilisation of these foods. This study re-imagines a renewed perception of indigenous vegetation in the quest to contribute to livelihood development and improve food security in underprivileged communities.

Keywords: Agricultural extension; Sustainable livelihoods, Indigenous vegetation, Climate variation

[1] Lecturer, Department of Sustainable Food Systems and Development, University of the Free State, 205 Nelson Mandela Dr, Park West, Bloemfontein, 9301, South Africa, Email: qwabe.academics@gmail.com, https://orcid.org/0000-0002-0406-7339

[2] Lecturer, Department of Agricultural Sciences, Nelson Mandela University, Port Elizabeth, North Campus, Email: timothy.pittaway@mandela.ac.za

1. INTRODUCTION

Household food security, as defined by the Food and Agricultural Organization (FAO), exists when all people constantly have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for a healthy lifestyle (FAO, 1996). This definition identifies the four pillars of food security: availability, accessibility, utilisation, and stability. While food availability is not a significant concern within the South African context, it differs across all nine provinces of South Africa. Labadarios *et al.* (2011) indicate that food variety was low in all South African provinces except for the Western Cape. This is especially true in predominantly rural provinces compared to their high-income and urban household counterparts. This imbalance in food availability challenges the United Nations' assertion that the availability of food only proves true when there is an adequate supply of basic food that can sustain people in terms of consumption and counterbalance variations in production and prices (United Nations, 1975). However, the greatest challenge in the South African food discourse is the lack of access due to prevailing socio-economic challenges, such as high unemployment, which makes it difficult for vulnerable groups to acquire some of the foods necessary for a healthy lifestyle. The groups most affected are usually the previously disadvantaged and the rural poor, often left in isolation since low-income households are primarily concentrated in poor communities (Altman *et al.*, 2009). Based on this premise, there is a disconnected rural economy with the rural poor relying on a vulnerable food source. This disconnect raises the question of producing and utilising indigenous vegetables as a solution to a sustained livelihood and a step towards attaining food security.

1.1. Living Conditions in Underprivileged Communities

Twenty-six years after South Africa transitioned to democracy, the country still struggles with the triple threat of poverty, unemployment, and inequality**.** These livelihood challenges mainly affect the rural poor, whose socio-economic status seems to be one of constant insufficiency. Previous reports from Statistics South Africa (SSA, 2011a) and other formal institutions indicate that underprivileged communities are often at the lower end of the socio-economic stratification, which is typically marked by poor access to essential services, such as lack of access to clean water, electricity, poor infrastructure, and gravel roads (Perret *et al.*, 2005). In the north of KwaZulu-Natal (KZN), from which the Ntuze community was selected, Lewu and Mavengahama (2010) reported that in KZN, most underprivileged communities achieve resilience through agriculture, they do not generate income that could significantly cater for

household needs. Lewu and Assefa (2010) further indicated that one of the challenges people from underprivileged communities face is their inability to access markets for market participation. This lack of market access places vulnerable groups at a disadvantage, as this could be a possible way to improve the rural economy.

1.2. Value of Indigenous Vegetables in the Agricultural System

For many years, indigenous vegetables have formed an essential part of indigenous people's livelihood in both the developed and underdeveloped parts of the world. However, these indigenous species have declined in recent years because of the increasing pressure of land development in natural habitats and improper resource management practices. An investigation into the roles and values of wild foods in agricultural systems, Barucha and Pretty (2010) points out that despite the importance of wild indigenous foods, these foods are still excluded from official statistics on the economic value of natural resources. Similarly, Shackleton *et al*. (2007) raise a concern that there is a lack of information regarding the association between non-timber forest products (in the context of this study, this is used synonymously as wild indigenous vegetation), rural livelihoods, and poverty in South Africa. Therefore, this study aims to respond to the link between indigenous vegetation, livelihood development, and food security.

2. METHODOLOGY

2.1. Profiling the Study Area

This research was undertaken at Ntuze, an underprivileged rural community on the outskirts of Richards Bay within the King Cetshwayo District (KCD) Municipality in the north of the KwaZulu-Natal (KZN) province. Lewu and Assefa (2009) indicate that the rural farming systems in the northern region of KZN are dominated by smallholdings of tracts of land not more than 0.9 ha. While this agrees with our findings, it is important to emphasise that most households grow sugarcane at a scale that ranges between three to eight hectares. However, only farmers participating in small-scale vegetable farming land were considered for this study. Based on the national census by Statistics South Africa (SSA, 2011b), the KCD Municipality consisted of 48.9% female-headed households, most of whom were unemployed. According to Lewu and Mavengahama (2010), the poverty rate in northern KZN affects 64.4% of the population, 78.2% of whom primarily reside in rural communities and rely on the government for financial support (Lewu & Assefa, 2010). The KCD Municipality has a subtropical climate

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with annual rainfall temperatures ranging from 1640 mm to 1740 mm. The maximum mean summer and maximum mean winter temperatures are 32°C and 18°C, respectively.

2.2. Gaining Access to the Community

Access to the community was gained through consultation with the tribal leaders. This undertaking was influenced by Tindana *et al*. (2006), who avow the importance of explaining the research and seeking permission from tribal authorities before accessing the community. Similarly, household leaders gave written consent as evidence that they understood the study and that their participation was willing and voluntary.

2.3. Sampling Procedure

The study participants from the Ntuze community were selected using a non-probability sampling technique, employing a snowball sampling method. Snowball sampling is a purposive sampling technique that relies on participants to identify further and encourage other participants to participate in the study (Taherdoost, 2016). This method helped identify households actively involved in similar small-scale agricultural activities, and it worked to the study's benefit and the researchers' convenience. A total of 40 participants (n=40) were drawn to build a case of the Ntuze community based on their lived experiences and perceptions about the role of indigenous vegetables in their livelihoods.

2.4. Data Collection and Analysis

Before the primary data collection, a preliminary study was conducted to pre-test the research instrument. While the use of preliminary research does not give any guarantee about the results of the main study, it points out the critical research deficiencies that need to be addressed. According to Moore *et al*. (2011), it is not necessary to justify the size of a preliminary study, although issues of practical feasibility must be considered. For this reason, the researchers piloted the study in a community neighbouring Ntuze. Data was collected using an interview schedule whereby interactive one-on-one interviews with the study participants were held and recorded. The open-ended questions and discussion data were then analysed using Computer-Assisted Qualitative Data Analysis Software (CAQDAS). This research adopted a qualitative approach to provide an instrument for understanding the 'contexts and settings' of the agricultural environment. Data were analysed using systematic inductive coding methods for qualitative research to develop towards theory or phenomenon. This qualitative method study

utilised an interpretivism paradigm (Denzin & Lincoln, 2011). In this analysis, perceptions from different participants were compared, and their differences or similarities contributed to the thematic development. The data were further used to ascertain patterns that led to general concepts or themes (Glaser, Strauss & Strutzel, 1968).

2.5. Ethics

Ethical clearance was obtained from Nelson Mandela University's Faculty of Science RTI Committee (reference number H17-SCI-AGR-001). Because the study involved human participants, ethical approval was necessary to ensure the 'participants' protection. These ethical guidelines are outlined in the Belmont Report, which contains three basic ethical principles: (i) respect for persons, (ii) beneficence, and (iii) justice; this report provides research-based protective guidelines for informed consent, risk/benefit assessment, and participant selection (NCMHD, 1978).

2.6. Rationale for the Study

Livelihood development and food security co-exist. Despite the threats of vulnerability, such as high unemployment rates, poverty, and systematic segregation, the resilience of some underprivileged communities, such as the Ntuze community, rests on harnessing indigenous vegetables. Therefore, it is of utmost importance to learn and document the perceptions of the knowledge holders (mostly the elderly) in the context of indigenous vegetables and to lay a foundation for future generations interested in advancing their knowledge of the subject matter. The study also promotes the production and utilisation of indigenous vegetables as a solution to livelihood development and food security.

3. RESULTS AND DISCUSSION

3.1. Value of Indigenous Vegetables

The findings suggest that the participants association of indigenous vegetables with terms such as 'rural', 'poverty', 'hunger', 'food for the poor', and 'low-status food' is one of the reasons behind the stigmatisation of these vegetables. This perception dates back to the early 1960s when South Africa saw the introduction of agricultural extension officers who were deployed to promote high-production, exotic crops. According to Akinola *et al.* (2020), extension officers referred to indigenous vegetables as 'weeds' to stigmatise these crops while fast-tracking the mass adoption of conventional, exotic crops. Our findings indicate that, in Ntuze,

these indigenous vegetables are primarily utilised based on preference and convenience rather than on circumstances of unfavourable poverty. Two elderly women were recorded expressing their appreciation for indigenous vegetables:

1. "…*mina ungibona nje, angiziboni ngiphila ngaphandle kokudla kwesintu. Ngingaka nje kungenxa yakho*." (…I do not see myself living without indigenous food. I am this old because of it.)
2. "*Lapha ekhaya yimi kuphela odla imfino yesintu, uma ngiyivunile elami ibhodwe liphekwa lodwa eceleni.*" – meaning that she is the only one in the household that eats indigenous leafy vegetables and that if she has harvested these vegetables, her food is prepared separately in a different pot.

It is worth noting, however, that there is a possibility of preferential bias due to a generational gap since it was mostly the older generation that favoured indigenous vegetables. One of the common themes that emerged was that the attitude of most of the younger generation was condescending towards indigenous vegetables, and they considered them to be 'poverty' food with which they did not want to be associated.

3.2. The Younger Generation's Perspective

In most communal areas of Africa, many kinds of culture-specific cuisines determine what foods should be valued and in what form they should be consumed. During the interviews, participants indicated that the older generation highly favoured indigenous vegetables in the community. They (the older generation) produced and consumed these vegetables, while the younger generation was less inclined to include them in their diets. According to the study participants, the youth often associate indigenous vegetables with low socio-economic status and poverty. This finding corroborates that of van Rensburg *et al.* (2007), who reported that South African youth generally tend to associate the consumption of indigenous vegetables with poverty. However, Hanemaayer *et al*. (2020) reported a positive association between the youth of first-world nations and their perception of traditional foods. This finding indicates that, in some parts of the developed world, the younger generation identifies with certain indigenous foods. At the same time, those from poor counties are indifferent to local, wild-grown foods.

3.3. Influence of Westernisation on Heritage

Our findings indicate that indigenous vegetables play an important part in people's culture and heritage. For this reason, the older generation expressed concern about the loss of indigenous

knowledge and the youth's rejection of the consumption of indigenous vegetables, which is part of their growing western socio-cultural identity (Sibani, 2018). A common response to the question of the cause of this stigmatisation was that social media and the westernised education system greatly influence western teachings. A primary concern voiced by the elderly is that they value the convenience indigenous vegetables provide and fear that they face extinction if the younger generation is not educated about their perceived benefits. The older generation sees this attitude as a threat since indigenous foods form an essential part of the peoples' heritage, an assertion supported by Akinola *et al*. (2020), who refer to indigenous foods as a symbol of heritage, a trademark, and a part of culture.

3.4. Household Food Security

The status of household food security in South Africa has been in decline for almost three decades. As far back as 1996, the FAO reported that South Africa was food secure as a nation but severely lacked nutritious food at the household level. Over two decades later, a similar report by Statistics South Africa indicated that the country is food insecure at the individual household level (SSA, 2018). The Ntuze community, as a previously disadvantaged rural community, is characterised by high levels of poverty, inequality, and unemployment. This research revealed that most households were headed by elderly women who relied on a government pension grant as their primary source of income, which was R1600.00 (112 USD) when this study was conducted. The study participants reported that the community faced high levels of food insecurity, which does not entail food inadequacy alone, but also difficulty accessing a variety of nutritious foodstuffs due to socio-economic challenges. In line with the FAO's definition of food security as a situation that exists at all times when people have access to adequate and nutritious foods that are necessary for a healthy lifestyle (FAO, 1996), the Ntuze community utilises indigenous vegetables as their survival strategy. These vegetables are believed to be a significant contributor to hunger alleviation. One of the neglected aspects of indigenous vegetables is recognition as superfoods that offer healthy, accessible, and affordable nutrient-dense alternatives able to address nutrition gaps (Maseko *et al*., 2017). These vegetables contribute to food security and the existing conditions of vulnerability (national disasters, seasonal changes, and governance) in northern KwaZulu-Natal, which impacts agriculture. Indigenous vegetables can also withstand seasonal changes and conditions and provide a reliable food source for the Ntuze community.

3.5. Water Insecurity

The Ntuze community is a rural community marked by poor access to water and receives limited water service. Residents rely on the local municipality to fill up the communal water tanks. However, one of the respondents expressed the following grievance regarding the delivery of water:

> "*… do not tell me about the municipality; they are useless! Their water trucks only visit the community once or twice a month, only when it suits them, and that water does not last even a day because so many of us rely on it. And some of these truck drivers illegally sell water to some of the individual households that have water tanks which leave many of us even more deprived*."

Considering that the Ntuze community lies in a humid subtropical climatic region, the prevailing water challenges pose a significant threat to conventional farming, which often requires high water consumption for commercial crop species. Maseko *et al*. (2017) confirm that exotic crops, such as Swiss chard, are not as tolerant to abiotic stresses such as drought and heat stress as their indigenous leafy crop counterparts. The lack of resilience and the inability to withstand such stressors indicates that the water challenges experienced by rural communities do not favour the conventional production of exotic crops, thus threatening the state of household food security. Discussions about the water challenges with smallholder farmers in Ntuze, revealed that the production of indigenous vegetables was convenient because they withstand prolonged periods of water deficit. This characteristic provides an opportunity to acknowledge the importance of producing and using indigenous vegetables in rural communities. They are more resistant to biotic and abiotic challenges and are further considered to require less production effort than exotic crops. With the onset of climate variation and increasing heat in some areas of South Africa, indigenous crops will become an essential water-wise crop option for rural communities.

3.6. Perceived Medicinal Benefits

There exist perceptions around the medicinal value of indigenous vegetables in Ntuze. Some of the participants stated:

> "I also use *intshungu* (wild cucumber) to suppress blood pressure." _ P1
>
> "I know that *uqadolo* (blackjack) is used when one has heart problems." _ P2
>
> "*Imbuya* (pigweed) is used for a runny stomach." _ P6

"*Intshungu* is popular in this area because almost everyone who is above the age of 60 uses it to cure BP." _ P10

The Ntuze residents believe that the indigenous vegetation they utilise has curative effects able to heal specific ailments, such as blood pressure which is cured by consuming wild cucumber (*Cucumis africanus L*.). Other indigenous vegetables regarded as having health benefits were blackjack (Bidens pilosa L.) and pigweed (Amaranthus hybridus), believed to cure heart-related complications and diarrhoea. One of the common characteristics of these vegetables is that they are all leafy vegetables that generally occur naturally in the wild. Only their vegetative parts are utilised, not necessarily the fruits they produce. These findings are consistent with those of Kimiywe *et al*. (2007) and Njume *et al*. (2014), who stated that indigenous leafy vegetables have healing powers and are rich sources of nutrients and antioxidants, indicating that, in addition to household food security, indigenous vegetables can provide medicinal benefits to the residents of the Ntuze community.

3.7. Income Generation

Some of the Ntuze community members sold indigenous vegetables to generate income which, in turn, is used for other household's needs, such as purchasing food, paying school fees and transport. These crops were primarily sold in a local town on the streets, sold to street vendors, or to neighbours. Unlike the group of vegetables that are used for medicinal purposes (indigenous leafy vegetables), vegetables used to generate profit were cultivated indigenous vegetables, which included *amadumbe* (taro), *ubhatata* (sweet potatoes), *izindlubu* (jugo beans), *imbumba* (cowpea) and *umdumbulu* (cassava). However, agricultural products are not always a good source of income; some respondents indicated that non-agricultural related businesses (such as spaza shops, buildings, and sewing) assisted with individual income generation.

3.8. Extension Services

Agricultural extension support services are a challenge in the Ntuze community. Most participants explained that they had never interacted with the extension officer deployed in the community. Extension officers and government support services have yet to make house-to-house visits to small-scale 'farmers' homes. Participants attribute this to laziness, favouritism, lack of resources and a poor work ethic on the part of extension personnel. One of the participants raised a question asking:

"*But how would you expect her (extension officer) to travel the entire community knocking door-to-door when she does not even have a vehicle? – She doesn't have wings, does she*?"

Evidently, there needs to be effective extension services in the community to help farmers develop their farming systems, become commercially productive, and link them to potential markets. However, we argue that this is an issue of local governance rather than individual inefficiency. Efficient extension and advisory services are essential for successful rural development and for farmers to realise the full potential of their crops (Davis, 2016).

4. CONCLUSION

Subsistence farming communities have survived many environmental changes since the Paleolithic period and have carried valuable indigenous knowledge for centuries; they are repositories of information about adaptations that could be vital in the context of climate variation. However, the indigenous knowledge of how these communities have coped and adapted has received limited recognition. In most cultures, this indigenous knowledge is practical and generally transferred by elders when youths are involved in subsistence, harvesting and foraging. Indigenous communities have been framed as ignorant and primitive, with nothing to offer modern western society. Still, there has never been a more critical time in history when the transfer of this traditional knowledge is becoming a crucial resource as in the present rapid decline and extinction of plant life species. This research has shown that, as youth are becoming more interested in Western culture, they are losing interest in following indigenous practices.

Rural communities face increasingly high unemployment rates, especially among young men; simultaneously, the number of woman-headed households involved with small-scale agriculture is increasing. The survival arrangement of these households means they rely entirely on state grants, becoming a threat to long-term generational wealth creation and sustainable rural economic development. The impact of climate variation and increased global temperatures will increase the risk to standard agriculture practices and crop selection. Further research is required on how indigenous vegetables can provide more resilience in the changing environment that climate variation will cause. Water-wise crops will be important in areas that need new options for hardy and resilient forms of cultivation. This is especially important because rural communities such as Ntuze have water deficit challenges. In this research, the

sale of indigenous vegetables was part of livelihood survival. It formed an essential part of the mix of household strategies that seek to use available resources in the rural context.

5. RECOMMENDATIONS

To enhance the use of indigenous vegetables as an official livelihood strategy, the value of the crop needs to be realised and promoted as a potential commercial agriculture crop. Successful promotion would assist in enhancing the image of indigenous vegetables and reducing their stigma as a poor man's crop. Further, pharmaceutical companies need to recognise the medicinal benefits of indigenous vegetables. Such recognition could lead to indigenous vegetables being farmed on a large, more intensive scale, as has been the case following the recent change of cannabis policies for medicinal use in South Africa. If the potential of indigenous vegetable crop production is realised for large-scale commercial ventures, further financial investment would follow, and the involvement of a younger, entrepreneurial generation would be developed.

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Reproductive Performance of Extensively Managed Beef Heifers Mated at 14 Or 26 Months in the Central Bushveld Bioregion

Grobler, S.M.[1], Scholtz, M.M.[2], Neser, F.W.C.[3], Morey, L.[4] and Greyling, J.P.C.[5]

Corresponding Author: S.M. Grobler. Correspondence E-mail: mgrobler@arc.agric.za

ABSTRACT

In South Africa, little local information is available on the value of early mating of extensively kept beef heifers. In contrast, international information is mainly restricted to dairy cattle and intensive production systems. The research was undertaken to evaluate the calving percentage of Bonsmara heifers mated for the first time in an extensively managed beef herd at either 14 or 26 months. Fifty percent of the heifers were mated at 14 months, while the other 50% were mated at 26 months of age for 90 days during the summer mating season (January to March). The research was conducted over six years (2009 to 2014). A 2^3 factorial analysis of variance (ANOVA) was performed using the six years as block replications. This was done because different animals were evaluated every year. The calving percentage of heifers mated at 26 months was significantly higher than heifers mated at 14 months. From the current study, it seems unlikely that mating heifers at 14 months of age can improve on the traditional extensive system of mating heifers at 26 months on natural veld in the Central Bushveld Bioregion.

Keywords: Age at mating, Bonsmara heifers, Calving percentage

[1] S.M. Grobler. Researcher. Agricultural Research Council, Animal Breeding and Genetics, P/Bag X02, Irene, 0062; PhD graduate. University of Free State, Department of Animal, Wildlife, and Grassland Sciences, PO Box 339 (70), Bloemfontein, 9300. E-mail: mgrobler@arc.agric.za. Orcid 0000-0002-8395-7865

[2] M.M. Scholtz. Specialist Researcher. Agricultural Research Council, Animal Breeding and Genetics, P/Bag X02, Irene, 0062; Affiliated Professor. University of Free State, Department of Animal, Wildlife, and Grassland Sciences, PO Box 339 (70), Bloemfontein, 9300. E-mail: GScholtz@arc.agric.za. Orcid 0000-0002-1342-3294

[3] F.W.C. Neser. Professor and head of department. University of Free State, Department of Animal, Wildlife, and Grassland Sciences, PO Box 339 (70), Bloemfontein, 9300. E-mail: NeserFW@ufs.ac.za. Orcid 0000-0002-2202-6418

[4] L. Morey. Senior Research Technician. Agricultural Research Council, Biometry, PO Box 8783, Hatfield, 0001. E-mail: MoreyL@arc.agric.za

[5] J.P.C Greyling. Emeritus Professor. University of Free State, Department of Animal, Wildlife, and Grassland Sciences, PO Box 339 (70), Bloemfontein, 9300. E-mail: greylijpgoats@gmail.com

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1. INTRODUCTION

Within-herd sourcing of replacement heifers is an important component in small-scale, communal, and commercial beef production systems in South Africa (Bergh, 2012). These heifers are better acclimated to the production system and accustomed to the herd management strategy. Growth, phenotype, robustness, and temperament can also be better evaluated from heifers born on-farm. In addition, health risks (e.g., venereal diseases, bovine viral diarrhoea, and respiratory diseases) can be minimised and better controlled when fewer animals are brought in from unknown origins (Schulz & Gunn, 2014).

A heifer's lifetime productivity as a productive beef cow is influenced by puberty, age at first conception, and calving interval (Wathes, Pollott, Johnson, Richardson & Cooke, 2014). When a heifer calves for the first time, it marks the beginning of her productive life. One of several ways suggested to improve beef-cow lifetime productivity is to reduce the age at first calving (van der Merwe & Schoeman, 1995). However, this may be less economical if seasonal conditions are poor, as extra feed costs may not be compensated for by the additional return when heifers are fed to calve at two years of age (Kroker, Clarke & Clarke, 2022).

The sustainability of different types of beef production systems differs between countries and climatic zones due to differences in available natural resources, rainfall distribution, access to livestock feed, as well as the robustness of the economy (Smith, Gotoh & Greenwood, 2018). This highlights the need for local research results and information. In South Africa, extensively kept heifers are usually mated for the first time at 26 months. However, various previous studies advocate the mating of heifers at one year of age (Fahmy, Lalande & Hidiroclou, 1971; Meaker, Coetsee & Lishman, 1980; Nunez-Dominguez, Cundiff, Dickerson, Gregory & Kock, 1991; van Niekerk, Kernick & Lishman, 1990). The theoretical advantage of mating heifers one year earlier lies mainly in the potential increase in lifetime productivity and the expectation of an extra calf (Meaker, Coetsee & Lishman, 1980). However, while extension officers may be confronted with this question, little new information on the biological or economic value of early mating of extensive beef heifers in South Africa is available.

Most of the literature available is restricted to dairy cattle (Abin, Visser & Banga, 2018; Mostert, Theron & Kanfer, 2001; Muller & Botha, 2000) and intensive production systems. In addition, most South African studies were done more than 30 years ago (Morris, 1980; Scholtz, Lombard & Enslin, 1991; van der Merwe & Schoeman, 1995). There seems to be no consensus among farmers on the

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advantages of early mating of extensively managed beef heifers in South Africa, which makes it challenging for extension officers to give reliable advice to farmers. Although results obtained from projects under research station conditions can take years to be fully adopted by farmers (Conradie, 2019), agricultural extension officers are uniquely positioned to strengthen farmers' capacity to innovate by providing access to knowledge and information (Hameed & Sawicka, 2016). This is especially important regarding on-farm decision-making for sustainable production.

The aim of this study was thus to establish whether mating replacement heifers at 14 months of age have a reproductive performance advantage over mating heifers at 26 months of age in an extensively managed beef herd grazing natural veld in the Central Bushveld Bioregion. This study formed part of a much larger project, which included two rotational grazing strategies, among others (Grobler, 2016; Grobler, Scholtz, Neser, Greyling & Morey, 2019). However, the current paper only focuses on heifer age at mating. Although they were obtained at a research station simulating an extensive commercial beef production system, the results from this study are equally relevant to small-scale and communal beef producers farming in the Central Bushveld Bioregion of South Africa.

2. MATERIALS AND METHODS

2.1. Study Area

The study was conducted from 2009 to 2014 at the Roodeplaat Experimental Farm (REF) (25°34'11.27''S; 28°22'05.36''E) of the Agricultural Research Council (ARC). Bonsmara heifers were used as the experimental animals. The vegetation in the study area has been described as Savanna (Rutherford & Westfall, 1994), Sourish Mixed Bushveld (Veld Type 19) (Acocks, 1988), and Marikana Thornveld (Mucina & Rutherford, 2006) in the Savanna Biome of the Central Bushveld Bioregion. The average annual rainfall for the specific study period was 858 mm (AgroClimatology Staff, 2015), with mean daily minimum/maximum temperatures ranging from 16°C (minimum) to 32°C (maximum) in February (summer) and 1°C (minimum) to 23°C (maximum) in July (winter).

2.2. Research Design

All the Bonsmara heifers and the available multiparous cows were randomly divided into two herds and subjected to two grazing strategies (traditional rotational grazing and low selective grazing). The grazing strategies did not impact animal production (P = 0.44) and are therefore not discussed in further detail (Grobler, 2016). Within each herd, the heifers were divided into two sub-herds where half of the available heifers were mated at 14 months of age – relating to between 8 and 12 animals

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– while the other half were mated at 26 months of age – relating to between 8 and 18 heifers (see Table 1). Half of the heifers in each sub-herd were subjected to oestrus synchronising before mating, while the other half were mated naturally without oestrus synchronisation. The synchronisation protocol followed the principle of keeping the animals off heat with a progestogen device (CIDR®, manufactured by Pfizer Laboratory, Sandton, RSA). The resultant flushing effect of oestrogen and luteinising hormone after removal of the device caused ovulation.

One fertility-tested breeding bull was used in each sub-herd (2009–2011) for 90 days after the onset of the mating season. The ratio of bulls to females (multiparous cows and heifers included) varied between 1:21 and 1:34. From 2012 onwards, two breeding bulls were used in each group as no animals were culled from 2012, and animal numbers increased, leading to a ratio of 13–21 females per bull. It must be noted that the heifers were kept with multiparous cows throughout the study and received no additional feed or special managerial treatment.

2.3. Statistical Analysis

To evaluate the calving percentage of the heifers, a 2^3 factorial analysis of variance (ANOVA) was performed using the six years as block replications. This was done because different animals were evaluated every year (Snedecor & Cochran, 1967). To evaluate heifer body weight at calving, a four-factor ANOVA was performed. The Shapiro-Wilk test was performed on the standardised residuals to test for deviations from normality (Shapiro & Wilk, 1965). In cases where significant deviation from normality was due to skewness, outliers were removed (n = 3) until the standardised residuals were normal or symmetrically distributed (Glass, Peckham & Sanders, 1972). Fisher's Least Significant Difference (LSD) was calculated at a 5% significance level to compare means of significant source effects. All analyses were performed using SAS version 9.4 statistical software (SAS Institute, 1999).

3. RESULTS AND DISCUSSION

There was no significant difference between the two herds for calving percentage ($P = 0.6643$) and heifer weight at calving ($P = 0.9673$). Furthermore, no significant difference ($P = 0.8078$) could be found between heifers being synchronised and those not synchronised before the mating season. There was, however, a significant difference between years for heifer body weight at calving ($P < 0.0001$) as well as calving percentage ($P = 0.0245$).

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The calving percentage of heifers mated at 26 months was significantly higher than that of heifers mated at 14 months of age ($P < 0.0001$). The calving percentage of 14-month-old mated heifers varied between 0 and 67%, and the calving percentage of 26-month-old mated heifers ranged between 58% and 100% over the six-year project period (Table 1).

The average calving percentage over the six-year project period was 74% for the heifers mated at 26 months – much higher than the 18% for heifers mated at 14 months (Table 1). Studies have shown that up to 46% of heifers calving as 2-year-olds may experience calving difficulty (Bellows, 1968). However, in the current study, only one dystocia case was reported in the 14-month-old group. The calving percentage of heifers mated at 26 months was in line with the average calving percentage of 71% of multiparous cows within the same herd (Grobler, 2016). These results are in line with van der Merwe and Schoeman (1995), who concluded that early mating of extensively managed Simmentaler heifers should not be considered a standard management practice. It must be noted that this project was conducted in an extensive production system, and available literature indicates that conception rates of 14-month-old heifers may be higher in semi-extensive production systems (Lepen, Schoeman & Venter, 1993; Meaker, Coetsee & Lishman, 1980; Nunez-Dominguez *et al*., 1991). The economic advantage of early mating is therefore counterbalanced by biological limitations (breed and body weight), and management constraints of the environment (Ahmadzadeh, Carnahan & Autran, 2011; Patterson, Wood & Randle, 2000; Short, Bellows, Staigmiller, Berardinelli & Custer, 1990), as well as financial input (Kroker, Clarke & Clarke, 2022). As shown by Meaker (1986), optimising rather than maximising, and the impact thereof on efficiency and sustainability, is still of imperative value.

TABLE 1: C**alving Percentage of Heifers ± SD Over the 6-Year Project Period (2009-2014)**

	14-Month-old heifers calving %			**26-Month-old heifers calving %**		
Year	**Sub-herd A**	**Sub-herd B**	**Mean***	**Sub-herd A**	**Sub-herd B**	**Mean***
2009	50.0 ± 23.6 (n = 6)	83.3 ± 23.6 (n = 6)	66.7 ± 27.2 (n = 12)	50.0 ± 70.7 (n = 4)	100 (n = 4)	75.0 ± 50.0 (n = 8)
2010	33.3 ± 0.0 (n = 6)	16.7 ± 23.6 (n = 6)	25.0 ± 16.7 (n = 12)	100 (n = 6)	100 (n = 6)	100 (n = 12)
2011	16.7 ± 23.6 (n = 6)	0 (n = 6)	8.33 ± 16.7 (n = 12)	100 (n = 6)	58.3 ± 11.8 (n = 7)	79.2 ± 25.0 (n = 9)

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2012	0 (n = 4)	0 (n = 4)	0 (n = 8)	58.3 ± 11.8 (n = 5)	83.3 ± 23.6 (n = 5)	70.8 ± 21.0 (n = 10)
2013	0 (n = 6)	0 (n = 6)	0 (n = 12)	33.3 ± 47.1 (n = 6)	83.3 ± 23.6 (n = 6)	58.3 ± 41.9 (n = 12)
2014	16.7 ± 23.6 (n = 6)	0 (n = 6)	8.33 ± 16.7 (n = 12)	75.0 ± 0.0 (n = 9)	50.0 ± 14.1 (n = 9)	63.3 ± 20.2 (n = 18)
Mean	19.4 ± 22.3[a]	16.7 ± 33.3[a]	18.1 ± 27.8[a]	69.4 ± 36.6[b]	80.9 ± 23.3[b]	74.3 ± 30.3[b]

SD = Standard deviation

[a,b] Means with different superscripts in the bottom row differ significantly ($P \leq 0.05$)

*$LSD_{(p = 0.05)}$ = 16.106

The average body weight at calving for heifers mated at 14 months was 322 kg ± 21 kg. For heifers mated at 26 months, it was 357 kg ± 58 kg. Heifers mated at 14 months had a significantly lower body weight at calving ($P \leq 0.05$) compared to heifers mated at 26 months, except for 2014, where heifers mated at 26 months had an exceptionally low weight at calving (292 kg ± 29 kg). Although body weight at calving differed slightly from year to year, there was no significant difference over the years for heifers mated at 14 months of age. Body weight at calving for the heifers mated at 26 months differed ($P \leq 0.05$) over the six-year project period. Heifer body weight at calving was the highest in 2009 (417 kg ± 36 kg) and 2010 (411 kg ± 33 kg), while the lowest weight at calving was recorded in 2014 for both 26-month-old mated heifers (308 kg ± 29 kg) and 14-month-old mated heifers (292 kg). It must be noted that rainfall was well below average in 2014 (664 mm) and above average in 2009 (1,324 mm). The subsequent forage availability may therefore have influenced heifer weight.

According to Sprott and Troxel (1988), heifers can be mated successfully at an early age when they are separated from the mature cowherd and fed to reach a target weight of 65% of mature weight before mating. In the current study, heifers were managed within the mature cowherd with no extra feed provided to reach target weights. In the case of 14-month-old mated heifers, they weighed 56% of mature cow body weight at mating, whereas the 26-month-old mated heifers weighed 78% of mature cow body weight. This may be one of the reasons why the conception rate of the 14-month-old heifers was low.

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4. RELEVANCE TO EXTENSION SERVICES

Currently, due to the difficult economic conditions, there is an awareness among farmers of becoming more efficient producers (Foster, Fourie & Neser, 2014). Many are turning to extension services for advice on production systems and ultimate profitability. Due to the well-known fact that the reproduction rate directly affects income, one of the common suggestions is to mate heifers at 14 months instead of 26 months of age (Nunez-Dominguez *et al*., 1991). Although this practice is viable with additional feed and input, it must be noted that most beef production in South Africa is dependent on natural rangeland. In addition, the rangeland used for cattle production usually has limited agricultural potential due to high ambient temperatures, low and unpredictable rainfall, and low soil fertility (Meaker, 1984), leading to nutritional limitations. Extension services should not suggest the early mating of extensively managed heifers to extensive farmers as a standard management practice. This is especially true for producers farming on marginal rangeland without additional feed resources.

5. CONCLUSION

The reproductive performance of both the heifers and multiparous cows influences a beef production system's profitability. Theoretically, mating heifers at 14 months instead of at 26 months of age may increase lifetime productivity. However, this may not be viable in extensive systems under local conditions. In the current study, the calving percentage of heifers mated at 14 months (18.1% ± 27.8%) was very low compared to the calving percentage of heifers mated at 26 months (74.3% ± 30.3%). This demonstrates that mating Bonsmara heifers a year earlier is not a practical solution to increase lifetime productivity and profitability under extensive local conditions.

When farmers confront extension officers with the issue of early mating of beef heifers under extensive conditions, the following should be kept in mind:

- The early mating of extensively managed heifers should not be considered a standard management practice since it is unlikely that an early mating system can improve on the traditional practice where heifers, kept under an extensive grazing system with only lick supplementation, are mated for the first time at 26 months of age.
- The successful implementation of mating 14-month-old heifers under extensive farming conditions will depend on additional nutritional and managerial inputs, which may not be cost-effective given the availability and cost of additional nutrition.

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Welfare Implications of Home Gardens Among Rural Households: Evidence from Ingquza Hill Local Municipality, South Africa

Nontu, Y.[1] and Taruvinga, A.[2]

Corresponding Author: Y. Nontu. Correspondence Email: nontuyanga@gmail.com

ABSTRACT

Food insecurity is widely recognised as a global issue that requires immediate attention using multifaceted approaches. There is a generalised consensus about the positive role of home gardens in improving household income and food security. However, there is limited empirical evidence to support the above nexus worth exploring to enhance evidence of based programming. Therefore, this study used cross-sectional survey data from Ingquza Hill local municipality in the Eastern Cape Province of South Africa (n = 200) to estimate the correlation between participation in home gardening, household food security, and household income. Results revealed that income from home garden sales was the least source of income for most households in the study area, contributing an average of 10.4% to total household income. An insignificant negative correlation was confirmed between home gardens and household food insecurity access score, suggesting that home gardens fall short of addressing household food security. A positive linear significant correlation was also confirmed between home garden participation and household income. The study concludes that home gardens designed for cash crop production may have a better food security premise than those intended for home food consumption and the sale of surplus.

Keywords: Food security, Spearman's rho correlation, Household Food Insecurity Score, Income

[1] Master`s Student at the University of Fort Hare: Agricultural Economics and Extension, University of Fort Hare, P/Bag x 1314, Alice, 5700. .Email: nontuyanga@gmail.com, Orcid. 0000-0003-4843-9437.

[2] Senior Lecturer: Agricultural Economics and Extension, University of Fort Hare, P/Bag x 1314, Alice, 5700. Email: ataruvinga@ufh.ac.za, Orcid: 0000-0001-8829-2826

1. INTRODUCTION

Today the world faces the fundamental challenge of ensuring that millions of households living in poverty have enough food to sustain a better life. South Africa is food secure at the national level; however, the case is different at the household level, where households experience inadequate food access (Hendriks, 2014). According to the FAO (2015), South Africa has achieved the Millennium Development Goal (MDG) 1c of halving hunger by 2015. Nonetheless, South Africa is far from food security at the household level (Hendriks, 2014). Slightly over a quarter of households experienced hunger in 2012, while 28.3% were at "risk of hunger" (Hendriks, 2014). Approximately 26.5% of children aged 0-3 years were stunted in the same year. Evidence exists that micronutrient deficiencies (i.e., hidden hunger) are high among samples of South African children and adults. These deficiencies coexist with high levels of overweight and obesity (Steyn *et al.*, 2005).

Statistics South Africa (Stats SA) (2014) reports that about 17% of South African households have inadequate access to food, and about 34.4% of households are experiencing hunger. This means that measures addressing poverty and food insecurity need significant consideration at the household level, especially in rural areas where high unemployment, low literacy rate, and high dependency ratio are prevalent (Mahlangu & Garutsa, 2014). Hendricks (2014) also argues that hunger and unemployment are still significant challenges in South Africa. Galhena *et al.* (2012) state that household food insecurity among South African citizens is worsened by increased prices of services and goods such as electricity and oil, which has led to increased food prices. The items that constitute a staple diet of poor South Africans, mainly maize and wheat, have been the worst hit.

Food insecurity affects both rural and urban settlements. However, it is more pronounced in rural settlements, whereby the current statistics show a 4.5% increase in poverty over the past five years (Stats SA, 2017). In the Eastern Cape Province of South Africa, household poverty increased from 13.6% to 15.5% in the past five years (Stats SA, 2017). Mahlangu and Garutsa (2014) noted that the high poverty levels in the Eastern Cape could be attributed to unemployed households. Thus, it may be inferred that there are often large numbers of job seekers than available jobs, particularly for those considered unskilled. Such high levels of poverty and unemployment require interventions to help mitigate the high levels of food insecurity within the province. The Eastern Cape is the second poorest province in South Africa (StatsSA, 2011). Currently, the Eastern Cape Province poverty gap is 16.5% (Stats SA, 2017). This suggests a

need for the province to focus on poverty alleviation strategies through interventions by government and private organisations.

Over the years, Africa has sought ways to solve food insecurity (Schaetzel *et al.*, 2013). In developing countries, the agriculture industry has been considered a fundamental backbone in rural areas (Fanzo, Remans & Termote, 2016). However, numerous attempts in South Africa to implement home garden programs often fail to improve the food security of the poor (Adekunle, 2013; Reddiar, 2016). Home gardens are considered a community's most adaptable and accessible land-based activity and are essential in reducing vulnerability and ensuring food security (Adekunle, 2013). Also, home gardens form an integral part of urban and rural livelihoods. They are sites where people grow staple foods and cultivate plants for income and medicine (Reddiar, 2016). Home gardening also plays a significant role in household food production, improved household status, income generation, and nutrition (Gebremedhin *et al.*, 2017, Malahlela, 2015.).

Home gardens are vital in providing income and sustenance throughout the year from diverse crops contained within them, harvested at different times of the year (Galhena *et al.*, 2013). Reddiar and Reddiar (2016) assert that the cultural value attached to home gardens has been reinforced by their essential contribution to household food security over the past 50 years. However, income is the principal determinant of household food security (Puett *et al.*, 2014). Walsh and Van Rooyen (2015) argue that home gardening remains the most important method of food production for most people in the developing world. Moreover, household members' daily nutrition and healthy food can be obtained from home garden production (Puett *et al.*, 2014). Thus far, home garden ownership is vital to urban and rural households since both locations encounter food insecurity and poverty (Schreinemachers *et al.*, 2016). Against this background, the study questions the claimed nexus between home gardens and household food security and the income premise, given the high food insecurity and low participation in home gardens among rural communities. Therefore, this paper focused on the contribution of home gardens to a household`s food security and income.

2. PROBLEM STATEMENT

Household food insecurity remains a significant concern in developing countries (von Grebmer *et al.*, 2012). Hunger is not widespread in South Africa as in other Southern African countries (du Toit *et al.*, 2011), but household food and nutrition insecurity persist among the majority

of the Black South African population (Maliwichi *et al.*, 2010). Multiple strategies are required to address the issue of food production and food security (Bhandari *et al.* 2016). It is evident from the literature that home gardens are a part of the agriculture and food production systems in many developing countries and are widely used as a remedy to alleviate hunger and malnutrition in the face of a global food crisis (FAO, 2015; Uzokwe *et al.*, 2016; van Lier, 2017). Furthermore, several studies have documented home gardens as an essential supplemental source of food and nutritional security, livelihoods, and income generation in rural areas (Reddiar & Reddiar, 2016; Walsh & Van Rooyen, 2015). On the contrary, several studies by Masset *et al.*, 2012; Webb, 2013, also question home gardens' food and nutritional security contributions at the household level in rural areas. Therefore, the actual contribution of home gardens to household food and nutritional security remains a highly debated issue worth probing in different geopolitical environments.

From a policy perspective, the South African government developed the National Policy on Food and Nutrition Security in August 2013, intending to increase and better target public spending in social programmes. These programs play an imperative role in food security to increase food production and distribution, including increased access to production inputs for the emerging agricultural sector (DAFF, 2014). Through the National Food and Nutrition Security Policy, the state has set out several programs to support the food and nutrition-insecure population and promote food security across the country (DAFF, 2014; FAO, 2015). Literature, however, highlights that little is documented on the outcomes of the investment towards achieving food and nutrition security at the household level (Aryal *et al.*, 2022). Unfortunately, the blurring between income-based and subsistence rationales within programme and policy provisions frustrates the overall success of community gardening, with implementation processes failing to achieve its objectives (DAFF, 2014). Home gardens, therefore, fail to find a niche within broader production systems, marketing and availability, or as safety nets and social protection (Webb, 2013).

3. METHODOLOGY

3.1. Study Area

Ingquza Hill local municipality is one of the five local municipalities within the OR Tambo District Municipality of the Eastern Cape Province. Ingquza Hill is located to the northwest of the OR Tambo District with the coordinates 32°10′S 28°35′E. The Municipality seat is in

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Flagstaff, and the municipal area is divided into 31 wards (Stats SA, 2017). It covers 2,477 square kilometres (956-metre square) of the municipality's total area (Stats SA, 2008). Inggquza Hill local municipality has approximately 278 481 people (Stats SA, 2008). Flagstaff town is part of Ingquza Hill local municipality of OR Tambo District. Flagstaff is located in the northeast of Umtata, in the former Pondoland.

3.2. Empirical Model Used

The study used a cross-sectional field survey whereby data was gathered from 200 households using the availability sampling method from four randomly selected villages of Ingquza Hill Local Municipality. A correlation analysis was used to estimate the association between participating in home gardens and household income and food security. Daniel (1990) notes that outliers, unequal variances, non-normality, and nonlinearity influence Pearson correlation. Spearman's rank correlation coefficient can be used (Daniel, 1990). Pearson correlation measures the strength of the linear relationship between X and Y. In the case of nonlinear but monotonic relationships, a useful measure is Spearman's rank correlation coefficient, Rho, which is a Pearson's type correlation coefficient computed on the ranks of X and Y values as detailed in equation one below (Daniel, 1990).

$$rho = \frac{[1-6\sum(di)^2]}{[n[(n^2-1)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where;

di is the difference between the ranks of Xi and Yi.

n = the number of (X, Y) observation (ranks).

rs = +1, if there is a perfect agreement between the two sets of ranks.

rs = - 1, if there is a complete disagreement between the two sets of ranks.

4. RESULTS AND DISCUSSION

4.1. Basic sample statistics

This section presents the basic sample statistics of home gardeners and non-home gardeners. Table 1 below summarises the sample statistics from the study area. A sample of 200 participants was selected from the study area, with a mean household head age of 59 years. The mean education level was 2, meaning that participants were educated on average to the primary level.

TABLE 1: Basic Sample Statistics of the Respondents

	Valid	Mean	Std. Deviation	Skewness	Minimum	Maximum
Gender	200	.77	.422	-1.293	0	1
Age	200	58.48	12.651	-.608	27	84
H/size	200	5.63	2.369	-.182	0	12
Education level	200	1.98	1.147	.685	1	4
T/Household income	200	3151.63	2865.708	2.776	0	19000
Distance to markets	200	.66	.477	-.657	0	1
Ext. services	200	.60	.492	-.390	0	1
Member of CBOs	200	.39	.488	.476	0	1
Access to land	200	.87	.337	-2.217	0	1
Market access	200	.43	.496	.306	0	1
Access to credit	200	.40	.491	.411	0	1

Key: Age (number of years), Total household income (total income received by a household per month), distance to market (in kilometres), Gender (0 = male; 1 = female), Education (1 = informal, 2 = primary; 3 = secondary; 4 = tertiary), Access to extension (0 = no access; 1 = access), Membership to CBOs (0 = Non-membership to CBO; 1 = Membership to CBO), Access to credit (0 = no access; 1 = access), Access to market (0 = no access; 1 = access), Access to arable land (0 = no access; 1 = access).

The results also revealed that there were more females than males in the study area, with an average monthly income of R3151.63. Primary sample results show an average household

size of six family members, with a minimum of 0 and a maximum of 12 family members. Most respondents did not have access to markets, membership to CBOs and credits. The distribution asymmetry was positively and negatively skewed, as shown in Table 1 above. Most of the characteristics had skewness values below and close to one (except household income and access to land); this suggests that the distribution did not differ significantly from a normal symmetric distribution.

4.2. Contribution of Home Gardens on Total Household Income

This section presents results for home gardens' contribution to total household income, as illustrated in Figure 2 below. The primary income sources emerging from the study results were old-age pensions, home garden sales, salaries and wages, welfare grants and remittances.

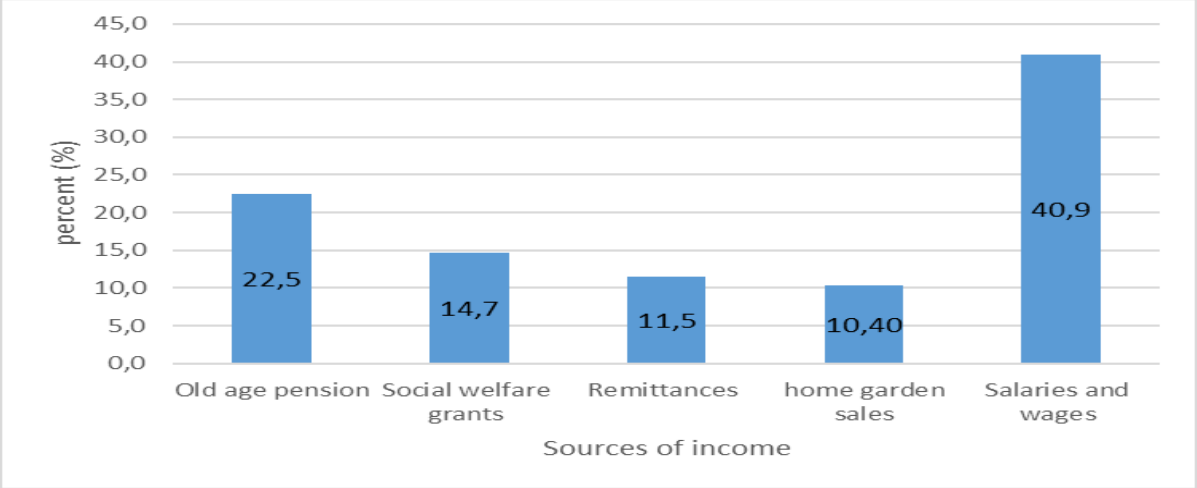

FIGURE 2: Share of Different Sources of Income to Total Household Income

The results presented in Figure 2 above indicate that although being a minor contributor to total household income (10.4%), home garden sales positively represent household income. Similar findings are also shared by several studies that mentioned that surplus produce from home gardens can be sold for additional income and used for other essential household needs (Chauhan, 2015; Uzokwe, Giweze & Ofuoku, 2016). However, Muzawazi *et al.* (2017) caution against the income premise of home gardens since the bulk of home garden crops is used for household consumption.

4.3. The Contribution of Home Gardens to Household Food Security and Income

TABLE 2: Observed Household Food Insecurity Access Score (HFIAS) by Home Garden Participation Status of Respondents

Household Food Insecurity Access Score (HFIAS)	Low	Medium	High
	0 – 9	10-18	19-27
Home gardeners		13	
Non-home gardeners		12	
Food security proxy	Less food insecure	Moderate	More food insecure

The emerging results indicate that HFIAS for the home gardeners was 13, while that of non-home gardeners was 12. These results suggest that although both groups were classified as moderately food insecure, non-home gardeners are relatively more minor food insecure than home gardeners. However, by broad classification, results suggest that there may be no difference in the food insecurity status of home gardeners and non-home gardeners from the study area. The study also tested the significance of the "no difference hypothesis," as suggested above. The results of this are presented in the next section.

4.4. Bivariate Correlation Analysis

This section presents the association between participation in home gardening, household food insecurity status and household income, as highlighted in Table 3 below. A non-parametric correlation model (Spearman's rho) was used to assess the association between participation in home gardening, household food insecurity status, and household income.

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TABLE 3: Correlation Matrix Exploring the Association Between Participation in Home Gardening, Household Food Insecurity Status, and Household Income.

Correlations					
			Participation	HFIAS	total H/income
Spearman's rho	Participation	Correlation Coefficient	1.000	-.018	.133*
		Sig. (1-tailed)	.	.403	.030
		N	200	200	200
	HFIAS	Correlation Coefficient	-.018	1.000	-.617**
		Sig. (1-tailed)	.403	.	.000
		N	200	200	200
	Total H/income	Correlation Coefficient	.133*	-.617**	1.000
		Sig. (1-tailed)	.030	.000	.
		N	200	200	200
*. Correlation is significant at the 0.05 level (1-tailed).					
**. Correlation is significant at the 0.01 level (1-tailed).					

4.5. Household Food Security

Results indicate a statistically insignificant (p-value = 0.403) weak negative correlation (coefficient = -0.018) between home gardening participation and household food insecurity access score. These findings suggest that as participation in home gardening increases, there is a slight decrease in households' food insecurity access score. However, this association is statistically insignificant, implying that the observed negative association may result from chance. As such, results suggest that the observed association is not statistically significant, meaning that, based on the results from the study area, home gardening does not influence household food security. Previous descriptive statistics also confirm a "no difference hypothesis" for home gardeners (HFIAS =13) and non-home gardeners (HFIAS = 12). This may be explained by the low-income contribution of home garden sales to total household income (10.4%), which is spread across several households' cash demands. Also, the diversity

of crops grown from the study area typically under 1ha; [cereals (maize); vegetables and tubers (cabbage, spinach, and potatoes, pumpkin) and fruits (oranges, peaches and plums)] falls short of a balanced food basket to address food requirements for average family size. The dominant home garden crop (yellow maize – 40%) was mainly used for stock feed. In line with these findings, previous studies also cautioned about the home gardens and food security nexus in the absence of an adequate amount of food produced to meet food security requirements at the household level (Caskie, 2000; Vavra *et al.,* 2018).

4.6. Household Income

Results reveal a weak positive significant correlation between home gardening and household income. These results suggest that household income is slightly increased as home gardening participation increases. Although participation in home gardening and household income highlighted a significant positive linear association with the Spearman`s rho p-value (0.030), the coefficient`s (0.133) absolute value was not large enough to give a convincing clue of the observed relationship. These results confirm the slightly higher contribution of home garden sales (10.4%) to total household income. Comparable previous studies note a positive contribution of home gardens to household income (Joel *et al.*, 2018; Neelamegam *et al.*, 2017), arguing that income revenue generated through home gardening sales boosts household purchasing power additional expenditures such as education, savings and other services.

The results also reveal a strong negative correlation (coefficient = -0.617; p = 0.00) between household income and household food insecurity access score. These findings suggest that as household income increases, there is a considerable decrease in households' food insecurity access score. Therefore, this means household income addresses food security through purchasing household foods and indirectly financing other income-generating activities. Consequently, it can be argued that promoting home gardens for cash crops has a better food security premise than promoting home gardens for household food availability from the study area. These findings support Puett *et al.* (2014), who argue that income is the principal determinant of household food security in contemporary South Africa. Several conclusions can be drawn from the above results, as summarised below:

(a) Home gardens generate income for rural households (estimated to be 10.4% of total household income) but fall short of addressing household food security. Therefore, home

gardening participation may be better promoted to address household food security through the income effect, not food availability.

(b) The observed weak association between home gardening participation and household income suggest home gardens are designed for subsistence purposes (stock feed, home consumption and sale of surplus), of which, unfortunately, the diversity and quantities of food groups grown fall short of addressing household food security as suggested by empirical evidence from the study area.

(c) Interestingly, the observed significant negative association of household income and household food insecurity access score, as read with the observed significant positive association of participation in home gardens and household income, suggests a new dimension of home gardens. It can be argued that promoting home gardens for cash crops may address household food security through the income effect much better than promoting home gardens for household food availability.

5. CONCLUSION AND RECOMMENDATIONS

The study concludes that participation in home gardening is more likely to improve household income. However, the results also highlight that the association is weak, suggesting that participating in home gardening to household income, though positive, might not be as high as popularly believed. The study revealed that income from home garden sales might be insufficient to address household food insecurity. Therefore, the study concludes that participation in home gardening may be better promoted to manage household food security through the income effect than food availability. The weak association between home gardening participation and household income suggests that home gardens are designed for subsistence purposes (home consumption and sale of surplus). Unfortunately, the diversity and quantities of food groups grown fall short of addressing household food security. In addition, the observed significant negative association of household income and household food insecurity access score, as read with the observed significant positive association of participation in home gardens and household income, suggests that promoting home gardens for cash crops may address household food security through the income effect much better that promoting home gardens for household food availability.

Thus far, the message for rural households and policymakers is that: Home gardens in their current designs (<1ha and dominated by the production of yellow maize and vegetables) may

be promoted to address household food security through the income effect as opposed to food availability. Therefore, rural households should grow more cash crops in their small gardens that can be traded locally to boost their household income, which has a better promise to address household food security.

The following home garden designs are suggested to promote household food security and income: Empirical findings revealed that home gardens have a more positive impact on household income than household food security. In contrast, household income has a strong positive association with food security. Against this background, home gardens designed to produce cash crops may have a better impact on household food security (through the income effect) than home gardens designed to produce household food crops for consumption and sale of surplus (the current status quo).

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