Utilisation of indigenous knowledge in sustaining water for humans and livestock in resource-limited communities

Report
to the Water Research Commission

by

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The publication of this report emanates from a project entitled *Utilisation of indigenous knowledge in sustaining water for humans and livestock in resource-limited communities* (WRC Project No. K5/2920).

EXECUTIVE SUMMARY

BACKGROUND

Water insecurity is rampant despite the efforts by the United Nations and governments to provide water for all. Natural disasters, such as droughts and floods, poor municipal services and pollution have exacerbated water security challenges. Water challenges affect both humans and agricultural activities. Livestock is at the core of livelihoods in marginalised communities, and water shortages reduce households' resilience by lowering the productivity and survival of animals. Indigenous knowledge systems (IKS) can ensure water security in these resource-limited communities. Indigenous knowledge (IK) however, is threatened with extinction. There is a need to understand the IK methods of ensuring water security to both humans and livestock and determine livestock management methods employed to sustain them during periods of water scarcity.

AIMS

The project aimed to:

1. Provide a general overview of water scarcity among resource-limited households and communities of South Africa;

2. Explore indigenous knowledge, beliefs and attitudes on water shortages, flooding and pollution for household use and livestock production;

3. Determine perceptions on the use of indigenous knowledge on water security among communal resource-limited households;

4. Determine the indigenous knowledge systems of livestock management during periods of droughts and water shortages and

5. Develop recommendations for improving and sustaining water security among resource-limited communal households.

METHODOLOGY

The project was designed in five parts that covered all the aims to provide recommendations for ensuring water security for humans and livestock in resource-limited communities.

1. A comprehensive literature review provided a general overview of water scarcity among resource-limited communities. The review contextualised the term ‘water security’, covered the status of water security, causes of water security challenges, effects of water insecurity and knowledge systems used in water security.

2. The indigenous knowledge, beliefs and attitudes on water shortages, flooding and pollution for household use and livestock production were explored using participatory data collection methods. Data were collected with consultations of the Departments of Water and Sanitation, the Department of Agriculture and Rural Development, and traditional authorities in Umhlabuyalingana and Musina Local Municipalities in KwaZulu-Natal and Limpopo Provinces, respectively. Interviews, focus group discussions and observations were used to gather in-depth knowledge of strategies used.

3. Perceptions on the use of indigenous knowledge on water security among communal resource-limited households were determined using structured questionnaires distributed among 154 respondents in Umhlabuyalingana and 130 in Musina.

4. Indigenous knowledge strategies of livestock management during periods of droughts and water shortages were determined by the use of face-to-face interviews and direct observations, after which thematic analysis was conducted using Nvivo software
5. Recommendations for improving and sustaining water security among resource-limited communal households were developed through the assistance of feedback-feed in workshops conducted in the study site. The recommendations were also established from the findings of the study.

RESULTS AND DISCUSSION

The findings of the project are detailed below:

Literature review

Despite water being a constitutional right to every South African, marginalised and rural communities, who heavily depend on livestock for their livelihoods, struggle to access water. Water shortages also constrain livestock productivity and survival. There is a need to explore the mainstreaming of indigenous knowledge to ensure water security for both humans and livestock. Although both quality and quantity of water are essential when developing strategies to ensure water security, for most resource-limited communities, unlike in cities, it is still the availability and access to water that is critical. Women and children are largely responsible for sourcing water from dams, rivers and streams, boreholes, wells, and rainwater within households. Causes of water insecurity include natural disasters, seasonal variations in rainfall, long distances to water sources, household composition and lack of municipal support. Water shortages reduce water quality and lead to food and nutrition insecurity, deepens poverty levels, compromises the health and well-being of communities, and can cause conflicts among community members. Inadequate amounts of water create forage shortages for livestock, increasing the incidence and prevalence of endemic diseases and parasites and consequently increasing mortality rates. Lack of municipal support in providing water has led the resource-poor to explore and reinvigorate indigenous systems of ensuring water security.

Indigenous methods of water security

The findings indicated that the strategies used were for predicting, avoiding, mitigating and adapting to, and recovering from droughts, indicating the self-sustaining, holistic nature of IK methods of ensuring water security. Strategies of predicting water insecurities (bio-indicators, observations of weather patterns, rituals and astronomy) were used as early warning systems under IKS. At the onset of droughts, households responded by evading them through transhumance and rituals to appease ancestors they believed could reverse the droughts. During droughts, mitigation strategies were used for households and livestock to cope. The strategies used were destocking, digging deep wells, using sacred wells, abolishing night kraaling and rituals. Indigenous knowledge systems further offered strategies that ensured the recovery of households from the impacts of droughts through capitalising on neighbour relations, buying replacement livestock and training the young. During normal, water secure periods, adaptation strategies were used to build the resilience of households to water insecurities.

Perceptions on use of indigenous knowledge on water security among communal resource-limited households

The key findings indicated that the demographic groups perceived IK differently. The perceptions on accuracy, reliability, and decision to use IK were influenced by age group, while all demographic factors influenced the convenience of IK in Umhlabuyalingana. The young adults (under 40 years) considered IK to be accurate and reliable. In Musina, the accuracy of IK methods was influenced by occupation and age group, while the level of education affected reliability. Professionals perceived IK to be accurate. The educated and traditional diviners were likely to be highly knowledgeable on IKS in Umhlabuyalingana.

Indigenous knowledge systems of livestock management during periods of droughts

Indigenous strategies used to sustain livestock during periods of water shortages were holistic and well-rounded. Apart from IK providing drinking water to livestock, they also ensured their health and reproduction and improved adaptive capacity through the selection of stock tolerant to water shortages. The health status of livestock is challenged during droughts, and the presence of helminths further increases their stress levels. Indigenous knowledge systems management of gastrointestinal parasites was done by diagnosing the parasites through the appearance and consistency of faecal matter. The subsequent treatment regime included using medicinal plants and isolation based on loads of the parasites. Through IKS, farmers were able to detect pregnancy, which influenced water rationing among the herds and prioritised pregnant animals. Parturition was also observed, and with IK, farmers ensured that the calf did not get dehydrated when the cow was too weak to mother its calves. Indigenous knowledge guided farmers in selecting animals with drought-tolerant traits.

Workshop proceedings

The workshop was conducted to present findings of the results from the data collected from Domboni and Malale village communities in Musina Local Municipality, and to obtain input on the findings from community. The workshop was conducted over two days (25 and 26 May 2021). Each day was dedicated to a particular village. The invited participants were representatives of traditional leaders, municipality officials, village elders, youths, men, women, Department of Agriculture officials, Department of Water officials, and local livestock association members. After observing strict COVID-19 protocols, the workshop (Day 1 and 2) began by giving an overview of the project and presenting the workshop's objectives. The findings on indigenous methods used to ensure water security (Session 1) and indigenous knowledge systems (IKS) of livestock management during droughts (Session 2) were then presented. Using a handbook, translated to the vernacular language, methods of predicting, mitigating, adapting and recovering from drought were presented. Management strategies of ensuring livestock survival during droughts were presented as methods of providing drinking water, ensuring good livestock health, cow-calf management and livestock selection. After presentations and discussions of Session 1 and 2, the participants developed recommendations emanating from the discussed findings through the feed-in feed-out technique.

CONCLUSIONS

The water security status in South Africa is critical due to the increase in droughts, lack of municipal support and household demography consisting of vulnerable groups, among others. Indigenous knowledge provided all-inclusive strategies that can be used to ensure water security. Indigenous knowledge is well received among young adults and professionals, while traditional diviners and the educated were knowledge holders. The holistic nature of IKS enables it to be used to ensure livestock survival during periods of water shortages. Indigenous knowledge systems therefore, can contribute to drought risk reduction.

INNOVATION AND RECOMMENDATIONS

The following recommendations were made:

- An intervention framework could be used to develop programs that promote the use of IKS to ensure water security for humans and livestock. The indigenous knowledge strategies were used to establish a sustainable, ongoing and holistic self-contained system that considers disaster preparedness and reactive responses to counter water insecurities. In addition, the framework assigns roles to demographic groups based on their strengths and possible contribution in sustaining communities through periods of water shortages. The positive attitudes of young adults towards the use of IK to ensure water security can be used to position them as key implementers. At the same time, the knowledge holders, i.e. traditional diviners and the educated, can be drivers in formulating sustainable IK models. Therefore, the project's highlight was the development of the Indigenous Knowledge Water Security Framework (IKWSF) as a recommendation in efforts to improve the water security situations where water shortages are rampant.

- Further documenting IK in other regions since IK is geography-specific.
- Collective engagement through a change of attitude towards IK, establishing centres of excellence in research institutions, incentivising communities and sourcing funding for IK projects.
- Establishing information hubs in communities for information dissemination.
- Mainstreaming IK in government programs.
- Communities to organise themselves to dig wells during droughts.
- Educating farmers on selecting drought-tolerant stock and further research to capitalise on IKS.
- Encourage rearing of goats and create avenues to market them.
- Develop programs to plant indigenous trees
- Researchers should assess the level of contamination, communities affected, and potential effects downstream

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Reference Group	Affiliation
Mr S.E. Mushavhanamadi	Department of Agriculture and Rural Development (Limpopo)
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Dr M.C. Marufu	University of Pretoria, Department of Parasitology
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Prof V. Mlambo	School of Agricultural Sciences, University of Mpumalanga
Dr B. Mtileni	Department of Animal Sciences, Tshwane University of Technology

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ACRONYMS & ABBREVIATIONS

ABA	Access and Benefit Sharing Agreement
DCM	Drought Cycle Management
IK	Indigenous Knowledge
IKS	Indigenous Knowledge System
IKWSF	Indigenous Knowledge Water Security Framework
PRA	Participatory Rural Appraisal
SMS	Short Message Service
UKZN	University of KwaZulu-Natal
UNIVEN	University of Venda
UN	United Nations

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Water security challenges have grown to alarming levels over the years, with South Africa considering them to have reached a 'crisis state' (SAHRC, 2014). Most water security challenges are attributed to climate change, poor governance and exponential population growth (Muller *et al*., 2009; Kisakye and Bruggen, 2018). Among these water security challenges, drought is one of the biggest natural disasters in Southern Africa, with the latest being the 2015/2016 drought (Baudoin *et al*., 2017). The region is faced with rampant incidences of droughts, which have negatively impacted livelihoods.

Most governments have channelled resources towards ensuring water security through the installation of taps and boreholes, although water security challenges continue to rise (Mothetha *et al*., 2013). Most efforts to attain water security predominantly focused on urban areas, while little attention is paid to rural economies. The focus has also been skewed towards humans, with little consideration towards livestock. As a result, there is a need to find other holistic and sustainable interventions.

Rural households, the bulk of whom are resource-limited, value livestock for various reasons. Cattle are the most highly valued livestock in South Africa, even though goats, sheep and scavenging chickens are important to meet the livelihoods needs of resource-poor households (Beede, 2012). These include socio-cultural and socio-economic functions such as food security, insurance against crop failure during weather extremes and social capital, among other reasons. Water availability in these rural systems should consider both humans and livestock. High livestock mortalities, low reproductive performance, and low health status during water scarcity periods reduce these systems' productivity, thereby negatively impacting sustainable livelihoods (Ndlovu, 2019).

Indigenous knowledge systems have been in existence and have gone through years of trials and experimentation. The IKS is tailor-made for local environments, long-standing traditions and practices of cultural-specific local communities. It encompasses the skills, innovations, wisdom, teachings, experiences, beliefs, language and insights of the people, produced, accumulated over the years and applied to maintain or improve their livelihood (Warren *et al*., 1995). Indigenous knowledge has value for the culture in which it evolves and for conventional scientists and planners striving to improve living conditions in rural communities. Incorporating indigenous knowledge into water management policies can produce cost-effective, participatory and sustainable strategies. For example, when water is contaminated, there are IK options that other communities use to clean and purify the water (Muyambo *et al*., 2017). In South Africa, the IK on livestock management in areas facing water shortages is scarce, yet the occurrence of droughts is on the increase.

When droughts occur, both humans and livestock suffer, yet they are the last leg on which the resource-poor fall on when crops fail (Mahlangu and Garutsa, 2014). Indigenous knowledge has the potential to solve water security challenges, although it is on the verge of extinction. There is need to document, promote and advance it so that it can contribute to solving water security challenges. Communities possessing IKS need to benefit from it, including future generations. Understanding the IK around livestock production benefits humans greatly. It is essential to explore the contribution of IKS in managing water resources for both humans and livestock and the management practices that can ensure livestock survival during water shortages.

1.2 OBJECTIVES OF THE PROJECT

The objectives of the project were, therefore, to:

1. Explore indigenous knowledge, beliefs and attitudes on water shortages, flooding and pollution for household use and livestock production;
2. Provide a general overview of water scarcity among resource-limited households and communities of South Africa;

3. Determine perceptions on the use of indigenous knowledge on water security among communal resource-limited households;
4. Determine the indigenous knowledge systems of livestock management during periods of droughts and water shortages; and
5. Develop recommendations for improving and sustaining water security among resource-limited communal households.

1.3 STRUCTURE OF THE REPORT

Table 1.1 provides an overview of the content of chapters and the respective targeted audience.

Table 1.1: Structure of the report and respective audiences

Chapter No.	Topics discussed	Audience
1	Project background to the water security situation in South Africa and the potential that IK has in addressing these challenges	All
2	Literature review of existing knowledge about the status of water security globally, causes of water shortages, effects of water insecurity to livelihoods and the role of IK in water security of Southern Africa	Decision makers
3	The IK strategies employed to ensure water security in grassroots communities of KZN and Limpopo	Technical chapter
4	The extent of use of IK and roles of demographic groups in ensuring water security	Technical chapter
5	The IK methods of ensuring the survival of livestock during periods of water shortages in KZN and Limpopo	Technical chapter
6	Workshop to present findings to participating communities and for them to comment on the findings	All
7	Conclusions and recommendations	All

1.4 PUBLICATIONS

Title	Publication	Status
Explaining the use of indigenous strategies of ensuring water security for livestock in drought-prone municipalities of South Africa	International Journal of Water Resources Development	Under review
Control of gastro-intestinal nematodes in the in cattle using indigenous knowledge	Tropical Animal Health and Production	Under review
Conferences		
Utilisation of indigenous knowledge in sustaining water security for humans and livestock in resource-limited communities	17th International Scientific Congress 2020, Cuba	Conference postponed indefinitely due to COVID 19 pandemic

1.5 CAPACITY BUILDING

One PhD and Two MSc students were supported from the project. These were:

Name	Post-graduate degree	University	Topic	Progress
Ms Evelyn Tatenda Kamba	PhD Animal Science	University of KwaZulu-Natal	Utilisation of indigenous knowledge to ensure the survival of cattle during droughts	Final stage of thesis write-up
Ms Kamva Getyengana	MSc Agriculture	University of KwaZulu-Natal	Integration of indigenous knowledge in sustaining water security for livestock in resource-limited communities	Completed
Mr Ndivhoniswani Nephawe	MSc Rural Development	University of Venda	Role of indigenous knowledge on cattle productivity under water-scarce conditions	Final stage of dissertation write-up

1.6 ETHICAL CLEARANCE

The design and protocol of the study was approved by the Humanities and Social Sciences Research Ethics Committee at the University of KwaZulu-Natal (Protocol Reference Number: HSSREC/00000932/2020)

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Water is a basic necessity of life. Although water is a constitutional right to every South African, marginalised and rural communities continue to have challenges accessing water (International Fund for Agricultural Development, 2014). The South African Human Rights Commission (2014) reported that more than a quarter of people living in formal settlements have inadequate water resources. About one in 10 households in South Africa, mostly in rural communities of KwaZulu-Natal, Eastern Cape and Western Cape, lack water supply services from their respective municipalities. In addition, nearly a quarter of municipalities in South Africa were in a 'crisis state' concerning the provision of water services (SAHRC, 2014). On the other hand, Southern Africa, in general, has a high coefficient of rainfall variation, which is linked to increased frequency and intensity of droughts and floods (Fauchereau, 2003). Hence, strategies to ensure water security in rural communities should be explored and improved. The review looks at the general overview of the water security situation in South Africa. It explores the contribution of IK in the mitigation, adaptation and management of droughts/ floods to ensure water security.

There are four operational types of droughts: agricultural drought, meteorological drought, hydrological drought, and socio-economic drought (Sheffield and Wood, 2011). Agricultural drought reduces water availability below the optimal level required by a crop during each growth stage, resulting in reduced yields (Wilhite and Glantz, 1985). It can also occur when soil moisture availability to plants has dropped below the threshold level, causing insufficiency for crop growth and maturation. On the other hand, a meteorological drought is a reductive departure from the average amount of rainfall received on a monthly, seasonal or yearly time scale (Mannocci *et al*., 2004). Successive meteorological droughts usually lead to hydrological droughts. Hydrological drought is the effect of periods of precipitation shortfall on surface or subsurface water supply (Wilhite and Glantz, 1985). Lastly, a socio-economic drought refers to the failure of water resource systems to meet water demands for ecological or health-related functions on the environment and people (van Loon, 2015). Droughts are, thus, the primary cause of water shortages. For example, hydrological and socio-economic droughts are relevant to resource-limited households and communities as there will be a shortage of water for household use, livestock use, and cropping.

High rainfall intensity leads to flooding. Flood is defined as the expulsion of water onto land, usually dry, that overtops riverbanks, causing damage (Alexandra, 1993; Grobler, 2001). They are a consequence of meteorological, geomorphological and man-made causes. Meteorological causes include intense and frequent precipitation resulting in coastal, river and flash flooding. Geomorphological causes occur in human settlements constructed on flood plains under a foot slope where rivers flow from mountains with high velocity due to the steep gradient. Man-made causes include poor planning of settlements and dam bursts. Of concern in rural areas are rivers and flash floods. Flash floods are related to short, high-intensity rainfall rates, mainly of convective origin, that occur locally (Bonga, 2010; Nwigwe and Emberga, 2014). River floods result from the exit of a river from its ordinary or minor bed to reach its major bed. It is characterised by a slow rise in water level and recession, which can last for days, weeks or even months. In South Africa, the intensity of high rainfall events increased by 50% since the 1930s (Mason *et al*., 1999).

Apartheid placed most black people in marginalised lands that were agriculturally unproductive. The harsh environmental conditions have contributed to the communal agriculture skewing towards livestock-based agriculture since the land cannot support crop production resulting in over-reliance on livestock derived foods (LDFs). Therefore, there is a positive correlation between the livelihoods of resource-limited communities in South Africa and livestock production. Issues of availability and access to water affect both humans and livestock. For example, 95% of rural households in South Africa consume milk as a source of proteins, and typical household serves either goat or cow milk for breakfast and in-between meals (Viljoen et al., 2005; Idamokoro et al., 2019). Therefore, ensuring water security for humans alone while ignoring livestock is counterproductive and unsustainable because of the reliability of households to the contribution of livestock towards ensuring livelihoods. Looking at water alone will not solve the societal challenges associated with water insecurity. The intervention of water security challenges should be done as a nexus of core issues affecting the livelihoods of households in resource-limited areas.

Marginalised communities heavily rely on the environment for survival. Thus, they are, closely connected to nature (vegetation, climate and animals). They use these resources for their survival. Consequently, they possess vast amounts of knowledge that they exploit to survive and sustain livelihoods. Water security is central to their well-being.

2.2 THE WATER SECURITY CONTEXT FOR RESOURCE-LIMITED HOUSEHOLDS

Water security is the availability and access to the reliable, adequate and acceptable quantity and quality of water that enables sustenance of livelihoods, production and ecosystems within a population (Grey and Sadoff, 2007; Scott *et al*., 2013). Furthermore, water security accounts for protecting life and property against the effects of water-related disasters such as floods, landslides, land subsidence and droughts (Makarigakis and Jimenez-Cisneros, 2019).

Water security, availability, access and quality are of high significance. Water should be available for use and be easily and safely accessible to both humans and livestock. More importantly, the most vulnerable community members such as the elderly and children should have easy access to water. The Sustainable Development Goal (SDG) Number 6 calls for safe and reliable drinking water for all by 2030. Access to water is arguably critical for resource-limited households (WHO, 2015; Sheshen et al., 2016). At times, households have the means to purify and clean water for household use. Although water quality refers to the suitability of water to sustain various uses or processes (Maybeck et al., 1996), it is important only for those communities where access and availability are guaranteed. In resource-limited communities, the deteriorating water quality is primarily a result of scarcity and shortage of water. In these communities, household members and their livestock walk long distances to access water (Agbelemoge and Odubanjo, 2001). Under these conditions, having low-quality water could be considered better than not having water access.

Water should be free of contaminants and pollutants and conform to basic standards for health and well-being and promotion of dignity (Sonaya, 2017). Resource-poor communities are prone to suffer because they are not economically empowered to access treated water. Hence, resource-limited communities are susceptible to water-borne disease conditions such as diarrhoea emanating from poor water quality. Although the water of poor quality can cause diseases to humans, it can be utilised for crop and livestock production without compromising the quality of products. Where there is prolonged drought, water sources dry up, adversely affecting livelihoods of resource-limited households through dehydration and food shortages, resulting in malnutrition to both humans and livestock. A reduction in water quantity also results in loss of income brought about by low agricultural productivity. For the poor who rely on rain-fed agriculture, water quality is, therefore, important when availability and access are guaranteed.

The definition of water security further highlights the importance of ensuring the ecosystem's health. Besides increasing contamination and pollution of water sources, floods are one of the most destructive natural disasters (DBSA, 2016). Floods destabilise the soil, making it prone to mudslides and erosion. On the other hand, droughts deplete soil moisture, increasing the susceptibility of the soil to erosion. In rural production systems, which rely on the natural ecosystem, sustainable livelihoods are negatively affected by land degradation brought about by weather extremes.

Local authorities are mandated with ensuring water security in rural communities. Hence, municipalities are expected to supply water. In turn, municipalities are faced with challenges that include poor governance and mismanagement of resources resulting in conflicts between municipalities and residences (DBSA, 2016). Subsequently, rural communities are forced to integrate indigenous knowledge (IK) with the conventional water supply systems to ensure water security. Indigenous knowledge is a set of skills that originate within a community through observation and experimentation in relation to a specific geographic region. It also refers to the long-standing traditions and practices of culturally specific local communities unique to a given culture or society (Warren *et al*., 1995). Chowdhury (1996) defines IK as complex, traditional beliefs and practices generated by indigenous people in relation to natural resource management, agriculture, and human and animal health care. For centuries, resource-limited households have relied on the IK, as they do not receive adequate services from municipalities and governments. To a large extent, they hardly afford to pay for these services. The extent to which IK is utilised in ensuring water security is largely undocumented, making it difficult to incorporate into mainstream water management systems.

2.3 WATER SECURITY SITUATION IN RESOURCE-LIMITED COMMUNITIES

Ensuring water security in a community requires a responsible authority that oversees water allocation and water use for the sustainable provision of water (Soyapi, 2017). Traditional leaders play a critical role in water management where the local municipalities fail to provide adequate water resources. The traditional leadership governs water management in rural areas by preventing unfair discrimination and promoting equality in access to water. Traditional governance is defined as an institution of rules, and practices, in which there is constant monitoring of proper implementation by traditional leaders to ensure accountability, fairness, and transparency in their decision-making. It plays a vital role in rural areas (Nanda, 2006). The Traditional Leadership and Governance Framework Amendment Act (Act 41 of 2003) acknowledges traditional leadership's authority. It further recognises the role of traditional leaders, namely the king or queen, headmen or headwomen and regent part, to enforce the principles contained in the Bill of Rights of the Constitution of South Africa. Among them is the right to access clean water.

Traditional leadership however, is not involved in the day-to-day water service delivery but is interested in land allocation, water management, and conflict resolution (Kapfudzaruwa and Sowman, 2009). Women and children mainly do water collection for household use. Graham *et al.,*(2016) reported women and children to be primarily responsible for collecting water in 24 Sub-Saharan countries. In South Africa, adult women constitute more than 50% of water collectors (Figure 2.1), followed by girls who constitute about 30% and only 13% males collect water (Geere *et al.,*2010).

Mothetha *et al.,*(2013) identified water infrastructures, such as reservoirs, reticulation networks, street taps, and boreholes, to be servicing rural areas of Limpopo in addition to natural water sources. Water is chiefly collected from dams, rivers and streams, groundwater sources such as boreholes, wells and rainwater. The extent to which these water sources provide water for livestock is poorly understood. Dams are not reliable, as they dry up during winter and spring. On the other hand, boreholes are not fully operational and cannot meet the demand. Additional water infrastructural challenges include poor maintenance resulting in leakages (Figure 2.2 and 2.3).

Water is generally collected in 20 and 25 ℓ narrow-mouthed plastic containers with caps (Figure 2.3) which are subsequently used for storage or are emptied into large drums or plastic tanks (Nieuwoudt and Mathews, 2005; Edokpayi *et al*., 2018). The main mode of water collection is by a small container (Figure 2.1) or cup, which is used to pour water into bigger containers. In some communities, water gourds are used to fetch water, to facilitate water conservation (Risiro *et al*., 2013). Wells are often not protected for the safety of livestock and wild animals or from contamination. Evaporation is also high. Water transportation from water sources to homesteads is mostly done physically by hand, while most women carry the containers on their heads. Donkeys or oxen are often used to carry water containers in scotch carts. In this way, they carry large amounts of water. In some cases, wheelbarrows are used to carry the water containers.

Figure 2.1: Water collection from an unprotected well in Limpopo, South Africa (Source: Potgieter, 2007)

Figure 2.2: Damaged and leaking pipe in a rural community in South Africa (Source: Mothetha et al., 2013)

Figure 2.3: A queue of water containers at a public tap in South Africa indicating the high demand for water from a single source (Source: Mothetha *et al*., 2013)

Household water in rural communities is required for domestic (drinking, cooking and general hygiene) and amenity use (e.g. watering). Water constitutes 70% of the human body, and as such daily water requirements should be supplied through drinking water, food and metabolic water. Drinking water necessary to meet daily needs should be supplied in the correct quantity to prevent dehydration and be acceptable to the consumer. The organoleptic properties that affect consumer acceptability of water include clarity, odour and taste

(Coetzee *et al.*, 2016). Lastly, drinking water should be safe and free from pathogens that can cause water-borne diseases. A decline in the quality of water, in this respect, will reduce the quantity of water available for consumption. The water requirements necessary to prevent dehydration in humans vary with age, physical activity, ambient and water temperature, diet and health status, as shown in Table 2.1.

Water requirements for domestic purposes in rural areas in South Africa average 60 ℓ to 200 ℓ per household per day (Kanyoka *et al.*, 2008; DWA, 2009). The water requirements in rural areas vary from those in urban areas, as shown in Table 2.2. Water requirements in urban areas are generally higher than in rural areas due to the use of appliances not available in a typical household in rural areas. For example, toilets and ablution in an urban household may require 70 ℓ per capita per day (ℓcd); water use appliances like washing machines may consume as much as 140 ℓ per load, and car washing can use 9 ℓcd (Twort *et al.*, 2000). Despite the domestic water requirements in rural areas being lower than in urban areas, rural counterparts tend to suffer more in accessing water for domestic use because of a lack of municipal support.

Table 2.1: Human water dietary reference intake for different age groups

Age group	**Water requirements (ℓ / day)**	
	Males	**Females**
0 – 6 months	0.7	0.7 assumed to be from human milk
7 – 12 months	0.8	0.8 assumed to be from human milk and complementary foods
1 – 3 years	1.3	1.3
4 – 8 years	1.7	1.7
9 – 13 years	2.4	2.1
14 – 18 years	3.3	2.3
19 – 70+ years	3.7	2.7

Source: Food and Nutrition Board (2004)

Table 2.2: Per capita water requirements for different settlements in South Africa

	Per capita water requirements
Category	**Litres/day**
Medium-sized towns	150-200
Small towns (including water needs for animals and gardens)	200-250
Coastal towns	200-250
Rural villages	60-100
Farm villages (including water needs for animals and gardens)	100-150

Source: Department of Water Affairs (2009)

During periods of drought, women and children who spend time searching for water for domestic purposes and their livestock are the most affected. They travel long distances in search of water to meet their daily water requirements (WHO, 1996). Therefore, water shortages drastically reduce women's well-being, empowerment, and emancipation. The distance to water sources influences amount of water collected per person per day for domestic use (Table 2.3). This compromises the health and well-being of households, thereby increasing their vulnerability.

Table 2.3: Average water collected for human consumption in relation to distance to a water source

Country	Distance to a water source	Estimated average water collected per person per day (litres)	Source
Tanzania	Water source close to the dwelling	10 – 16	Lindskog and Lundqvist, 1989; White *et al*., 2002
Mozambique	Less than 300 m from the dwelling	11	Cairncross and Cliff, 1987
	More than 4 km	4	
Lesotho	-	10	Esrey 1992
South Africa	Close to the household	11	Verweij *et al*., 1991
	More than 1 km	9	

In addition to reducing the quantity of water collected, the distance travelled to the water source also affects the quality of water available in rural households. The further away a water source is from a homestead, the lower the organoleptic quality of the water (Nyong and Kanaroglou, 1999). Water will be smelly, has sediments and is not clear (in colour). Table 2.4 shows rural households' perception of the organoleptic quality of water as distance to water source increases from homesteads.

Table 2.4: Proportion percentage of households by distance from water sources and their perception of organoleptic quality of water during the dry season in Africa

	Water Quality			
Distance (m)	**Bad**	**Good**	**Very Good**	**Total**
<100	0.0	11.5	15.9	27.4
100< 500	0.0	18.8	9.6	28.4
500-1000	2.8	15.6	2.8	21.2
>1000	17.9	4.6	0.5	23.0
Total	20.7	50.5	29.4	100

Source: Nyong and Kanaroglou (1999)

Water supply is often an overlooked factor in livestock production. Water constitutes 98% of the animal body and is essential for growth, body temperature regulation, reproduction, lactation, digestion, lubrication of joints, eyesight and waste disposal (Lardy *et al*., 1988). In addition, water constitutes 80% of the blood. Age, species determine an animal's water requirement, production stage, use, type of diet, feed intake, health status and environmental conditions (Ward and McKague, 2007).

Knowledge of water requirements allows the designing of livestock watering systems. In rural communities, livestock travel long distances to access water. Although cattle can survive for 60 days without food, they can only survive for seven days without water. Limiting water intake depresses cattle performance and productivity (Lardy *et al*., 1988). Table 2.5 shows the water requirements for different livestock species. Although goats are hugely popular in marginalised environments, their water requirements are hardly known.

Table 2.5: Water requirements for livestock, excluding waste and assuming water is clean and palatable

Class of species	Requirements (kg/ animal/ day)
Cattle	
Cow	40 - 50
Bull	45 - 55
Dairy cow	5 per kg of milk
Yearling	25 - 40
Calf	15 - 25
Sheep	
Dry ewe	8
Ewe with lamb	11
Ram	11
Lamb	3

Source: Department of Agriculture and Rural Development (2019)

2.4 CAUSES OF WATER INSECURITY IN RESOURCE-LIMITED HOUSEHOLDS

Causes of water insecurity include natural disasters, seasonal variations in rainfall, long distances to water sources, household composition and lack of municipal support.

2.4.1 Natural disasters

In Southern Africa, global warming and climate change are linked to weather inconsistencies stemming from the El Nino and La Nina effects (Baudoin et al., 2017). Water insecurity in rural areas is rampant because of the increased frequency of droughts and floods, which are the effects of climate change and exponential population growth (Kisakye and Bruggen, 2018). Although the droughts, due to the El Nino Southern Oscillations, were recorded every 10 years, their frequencies within a 10-year cycle have increased (Rouault and Richard, 2005). The latest El Nino-induced drought was experienced in 2015-16 (Baudoin *et al*., 2017).

A prediction of an 11% reduction in precipitation by 2050 in Southern Africa was made by Masike and Urich (2008). Although a decrease in precipitation has been predicted, a more significant cause for concern is rainfall variability, which causes seasonal changes in rainfall patterns, sometimes increasing the risk of floods (Tfwala *et al*., 2018). There is an increase in the vulnerability of marginalised and resource-limited households to such natural disasters.

2.4.2 Seasonal variations

Water insecurity can be seasonal or can affect communities for an extended period, especially in times of droughts. In South Africa, water quantity in winter is low, and summer months are wet. As such, rainfall variability is an important factor of water security (Muller *et al*., 2009). Rainfall variability is the deviation in the amount of precipitation that falls in a specified place during a specified period (Morales, 1977).

2.4.3 Long-distance to a water source

Households that live further away from the water source collect lower quantities of water daily for household use (Table 2.3). Households fail to meet minimum daily water requirements for domestic purposes. Consequently, the community becomes vulnerable due to the high risk of dehydration, poor sanitation and disease outbreaks. The unavailability of water sources close to homesteads also exposes households to low-quality water sources. Distance to the nearest water source increases during droughts (Nyong and Kanaroglou, 1999).

2.4.4 Household demography

Households comprised of elderly people are likely to experience water insecurity because of the incapacitation of the members to travel long distances in search of water. In addition, a financially under-resourced household will not have access to technology that assists in water security (Nyong and Kanaroglou, 1999). For example, plastic tanks for storage, piped water, pumps and transport to fetch water from a source.

2.4.5 Lack of municipal support

Water scarcity can also be attributed to the lack of support from municipalities (Soyapi, 2016). For example, migration has increased urban population growth. Demand for clean water in cities is growing (Bradley *et al*., 2002; McDonald *et al*., 2011). Consequently, water resource supply in communal areas receives low attention. The Free Basic Water Policy of 2000 stipulates that municipalities should supply 6 000 ℓ of water per household per month or 25 ℓ per person per day (Mothetha *et al*., 2013). Furthermore, municipalities should provide infrastructure within 200 m from the homestead (Mothetha *et al*., 2013). One out of five households in South Africa does not have reliable and safe water access. These households use unprotected water from rivers and streams (STATSSA, 2017; SAHRC, 2018). Yet, the United Nations has targeted to provide safe and affordable water for all by 2030 (UNDP, 2015).

2.5 EFFECTS OF WATER INSECURITY IN RESOURCE-LIMITED COMMUNITIES

The impacts of droughts on the welfare of rural communities are misunderstood and, to some extent, trivialised (Juana *et al.*, 2014). This section gives an overview of the challenges that resource-limited households face in ensuring water security.

2.5.1 Socio-economic effects of water insecurity on resource-limited households

Water insecurity can directly and indirectly affect household livelihoods and income-generating opportunities. Shortages of water impact more severely on women, children and the elderly. During dry spells, women and children walk long distances searching for alternative water sources and spend a lot of time queuing at water points to access water (Calow *et al*., 2006). Parker *et al.,et al.,*(2016) reported that women and children travel further away from their homes in search of water and disregard water quality. The time spent searching for water disadvantages education and income generation.

A significant effect of drought is food insecurity. Butt *et al.,*(2005) reported a reduction in crop yields and livestock productivity due to water availability. Most rural households in Southern Africa rely on agriculture to produce food for household consumption. Livestock provides milk, meat, household income, asset savings, soil productivity, sustainable livelihoods, transport, agricultural diversification, employment, ritual purposes and social status (Moyo and Swanepoel, 2010). Livestock products account for 30% of human protein consumption. Both hydrological and agricultural droughts reduce the quality and quantity of food produced, leading to an increased risk of hunger and malnutrition.

Droughts also increase poverty levels. Rural communities rely on rain-fed agriculture for their livelihoods. The income from selling surplus food is used to purchase goods and services. Small livestock is kept as insurance against crop failure or during emergencies. Crop and livestock failure means a direct loss of income and increased vulnerability. During droughts, low body conditions and increased livestock supply reduce their prices into the market. Juana *et al.,*(2014) reported a 75% decline in household income in rural areas compared to 64% in urban households after a drought. There was also a reduction in the welfare status of rural households by 5% as compared to 3% for households living in urban areas (Juana *et al*., 2012).

Food insecurity during droughts increased incidences of kwashiorkor, marasmus, cholera and typhoid (Bifulco and Ranieri, 2017). Water-borne infections can be severe, and the mortality rate of children affected is 1 600 per day (UNICEF, 2015). Diarrhoeal disease prevalence increases due to the high temperatures associated with droughts, with the risk of diarrheal diseases ranging from 3-11% for each 1°C increase in ambient temperature (Franchini and Mannucci, 2015). Reducing the amount of flowing water, as rivers dry up increases pathogens' proliferation.

Droughts also cause conflicts among resource-limited households due to competition for water resources. These tensions can arise between competing users who share a borehole, well or central tap. Tensions could even occur between members of the community and responsible authorities.

2.5.2 Effects of drought on livestock production

Literature on the impact of droughts and water scarcity on livestock production is scant. Literature is biased on irrigation of crops (Frone and Frone, 2015; Srinivasan *et al*., 2017; Unver *et al*., 2017; Chew *et al*., 2019) since water that is used for irrigation in South Africa represents 60% of the total water use (Baleta and Pegram, 2014).

Droughts cause the drying up of water bodies and increase water bodies' salinity due to increased evaporation. The evaporation is associated with a high concentration of salts (Mosley, 2015; Mdletshe *et al*., 2018).

Precipitation affects the quality and quantity of forage. Droughts deplete natural grazing, which reduces body weights, body condition, and even deaths. The occurrence of droughts also forces farmers to destock due to a shortage of forage. Juana *et al.,*(2014) revealed a 10% reduction in livestock production after a drought in Botswana. Schreiner *et al.,*(2018) reported a slaughter rate of 23% for cattle and 37% for sheep during the 2015 drought in South Africa. Furthermore, 40 000 cattle died due to the 2015 drought in KwaZulu-Natal (Maré and Willemse, 2016). Masike and Urich (2008) reported a vulnerability index of 8 000 heads of cattle per year for a 0.5 rainfall reliability index in Botswana. Similarly, the 2015/16 drought in Ethiopia resulted in a cattle loss of 41% (Menghistu *et al*., 2018).

Droughts also lower proliferation rates and slaughter weights. Incidences of diseases and parasites are also increased due to the associated high temperatures. During droughts, amounts of blue algae and the concentration of toxic elements also increase. Veterinary and production costs, thus, increase. High drought frequencies also promote bush encroachment (Eriksen *et al*., 2015). Shrubs and bushes can reach deep soil water than grass species. Bushes also survive physical disturbance better than grasses.

2.5.3 Effects of floods on resource-limited households

Floods cause destruction and disruption of livelihoods in rural communities. Floods destroy roads, infrastructure and property, including livestock (Padli et al., 2013). Destruction of roads reduces the accessibility of affected communities to food and medical services. The infrastructural damage of floods in rural areas can be elevated because of poor quality of building materials and lack of reinforcements as compared to urban areas (UNDP, 2015).

Floods result in human fatalities, injuries, emotional and psychological trauma and exposure to diseases and significant economic losses (Mohamed, 2017). High humidity associated with floods encourages the breeding of fungal and bacterial infections. Incidences of malaria and other water-related diseases increase (Bifulco and Ranieri, 2017).

Floods also increase water's turbidity, which reduces the penetration of light into the water. In addition, floods transmit pollutants into water sources, deeming them undrinkable to livestock and humans (Doswell, 2003). Floods also cause physical injuries to livestock and destroy natural pasture, leaving no forage for the surviving livestock. Dip-tanks, lairages, kraals and chicken houses may be destroyed. Veterinary services may be difficult to be accessed due to infrastructural damage.

2.6 KNOWLEDGE SYSTEMS USED IN WATER SECURITY IN SOUTHERN AFRICA

Knowledge systems are techniques used to support human decision-making, learning and action (Avram, 2005). In rural communities, indigenous knowledge systems (IKS), conventional systems and integrated approaches address water security issues.

The role of water is not only socio-economic but has cultural and spiritual connotations (Zenani and Mistri, 2005). Indigenous knowledge systems used in water management are intimately connected to the broader framework of the cosmology and world view, which is embedded within the community's physical, spiritual, and social landscape (Hirsch and O'Hanlon, 1995). They are locally crafted through trial and error and are dynamic, depending on the prevailing conditions of a specific ecosystem.

Hence, IKS are quickly accepted because they give a sense of ownership to the members of that local community. The IKS is naturally understood and exploited by local communities. It is eco-friendly and has sustained communities for centuries (Emery, 1996; Tanyanyiwa and Chikwanha, 2011). Indigenous knowledge is passed on to younger generations verbally through storytelling. Warren (1991) highlighted that IK is dynamic and is strengthened due to continual experimentation and external contact. Table 2.6 shows a comparison of IKS and conventional knowledge systems.

Indigenous planning and decision-making are guided by traditional values and protect natural resources for use by future generations. Since indigenous knowledge is regarded as primitive and backward, its use is typically favoured by the older generation. This distinction stems from a lack of exposure to IKS in formal education instructions (Bartlett et al., 2012).

On the other hand, proponents of conventional knowledge (CK) characterise IK as inefficient, old-fashioned and not scientific (Breidlid, 2009). Kloppenburg (1991) reported that CK is made up of ideas, theories and concepts that are “immutable mobiles” and is transferable and not limited to a single geographic area, unlike IK. Yet CK has failed to solve challenges that the resource-poor face.

Table 2.6: Comparison between indigenous and conventional knowledge systems

Indigenous Knowledge Systems	Conventional Knowledge Systems	Source
Are generated from experiences, observation and experimentation within a local community	Generated from modern universities, research institutions and private firms through observation and experimentation	Tanyanyiwa and Chikwanha, 2011
Are culture and geography-specific	Are universal and transferable	Kloppenburg, 1991 Warren *et al*., 1995
A multi-faceted approach, i.e. socially, ecologically, culturally, spiritually, focused	Usually, one dimensional	Hirsch and O'Hanlon, 1995
Governance involves traditional leadership, men, women and children	Governance involves scientists, government managers and other 'elite' experts	Awume 2018 Kapfudzaruwa and Sowman, 2009

Buthelezi and Hughes (2014) highlighted that the incompetence of scientific methodologies in rural areas is the exclusion of IK. This proposes the integration of CK with IK. There are existing challenges between indigenous and scientific knowledge that are mutually beneficial for sustainable ecological development. Therefore, knowledge systems are dynamic evolutionary entities that will be negated if allowed to work in solitude (Lalonde, 1991). An integrated approach can allow effectiveness and progression.

2.7 IMPROVING WATER SECURITY USING INDIGENOUS WATER MANAGEMENT STRATEGIES IN SOUTHERN AFRICA

Indigenous knowledge plays a crucial role in managing water resources. The interface between IKS and water security should be incorporated in management and protection of water sources (Emery, 1996). Mahlangu and Garutsa (2014) highlighted that rural communities could develop their capacities to achieve sustainable and equitable development through the water knowledge that they possess. There is a growing recognition of IKS in cost-effective and sustainable development by African governments and international development agencies (Muyambo *et al*., 2017). To reduce the impact of natural disasters in resource-limited communities, there is a need to review indigenous management strategies employed by resource-limited communities (Menghistu *et al*., 2018). Predictive, mitigative and adaptive strategies should be collectively used to ensure water security. These strategies have been documented in many African countries.

2.7.1 Harvesting of rainwater and pond construction

Rainwater harvesting may be used in conjunction with the construction of ponds after modification of dwalas. It is used to prolong periods of water availability. In the Eastern Cape, Mahlangu and Gurutsa (2014) reported that 76% of rural farmers use harvested rainwater to improve water supplies for livestock production. Most households in South Africa are not familiar with the construction of homestead ponds (Ipitsi in IsiXhosa) to conserve water for livestock (Mahlangu and Gurutsa, 2014).

2.7.2 Destocking, transhumance and changing herd and flock composition

As soon as signs of a drought are noticed, farmers reduce their herd size to reduce losses through the death of livestock. Jerie and Mataga (2011) revealed that some farmers in Mberengwa, Zimbabwe, destock by lending their livestock to relatives who live in water secure areas until the drought has passed. Another way of destocking is through livestock off-take by slaughtering or selling to reduce herd size (Le Houerou, 1996).

Transhumance is the seasonal nomadism of livestock to areas where pasture is available. Transhumance has been reported in Mberengwa, Zimbabwe; the Cape, South Africa; Ovambo farmers, Central Namibia; Lesotho

(Beinart, 2010; Jerie and Mataga, 2011; Newsham and Thomas, 2011; Rampai, 2017). Transhumance practices are scattered in Southern Africa but common in Central Africa (Motta *et al*., 2018). Transhumance however, is constrained by a shortage of space and issues of land ownership and animal health (Samuels *et al*., 2007).

Farmers also use resilient livestock breeds or species. Some farmers may adopt the rearing of indigenous breeds adapted to harsh conditions. For example, goats are better adapted to water insecurity than cattle. Furthermore, the Afrikaner or Dorper are better adapted to water shortages than the Merino (Le Houerou, 1996). Change in herd composition capacitates farmers to manage the effects of droughts.

2.7.3 Weather forecasting or ethno-meteorology

Weather forecasting is an early warning system used in smallholder livestock farming systems, although it is done with low accuracy (Madebwe *et al*., 2005; Mapfumo *et al*., 2015). Smallholder farmers also lack internet, connectivity, television coverage and have low literacy levels (Dutta, 2009; Jiri *et al*., 2016). Mapfumo *et al.,*(2015) revealed that most farmers in Zimbabwe rely on ethno-meteorology. One ethno-meteorology indicator used in predicting seasonal forecasts is plant behaviour. One such indicator is the abundant fruiting of the Mobola Plum tree [*Muhacha*, Shona; *Parinari curatellifolia*], indicating an impending drought. In the Okavango Delta of Botswana, 75% of farmers predicted seasonal forecasts through the fruiting of Brandy bush [Moretlhwa, Tswana; *Grewia flava*] before the rains. The subsequent year will be a drought (Kolawole *et al*., 2014). Bees moving in the same direction may mean a drought (Muyambo et al., 2017). The behaviour of different animal species can also be used to predict seasonal water security. In the Eastern Cape, South Africa, a horse that ‘playfully jumps’ indicates an abundance of rain.

2.7.4 Use of taboos in livestock water security

Cultural taboos are used to deter people from committing ecologically destructive acts and ensure moral responsibility in managing water sources. For example, killing a python among the Shona in Zimbabwe is taboo and is perceived to result in a drought (Chemhuru and Masaka, 2010). In so doing, community elders manage to preserve pythons while highlighting the importance of ensuring that drought does not occur. The taboos deter people from practising acts that contaminate water bodies. For example, the Shona believe that urinating in water bodies result in the individual contracting bilharzia (*chirwere che hozhwa*) (Chemhuru and Masaka, 2010). As such, the contraction of bilharzia is a deterrent to urination in water sources, thereby reducing the level of pollution in water bodies.

2.7.5 Prohibition of the killing of aquatic life

In some communities in Southern Africa, the killing of aquatic life is traditionally prohibited. The outcome of defying the order is that the water source dries up. An example is in Zaka District, Zimbabwe, where Risiro *et al.,*(2013) recorded community elders saying that one of the wells dried up because the local people killed the ancestral water snake. Aquatic life plays an ecological role in water management and security. They are an indicator of whether a water source is free from pollutants.

2.7.6 Sacred wells

In some areas of Southern Africa, there are sacred wells that are believed to have mermaids *[Njuzu*; Shona]. In these wells, the water is only fetched using water gourds since metallic objects, or blackened sooty pots are prohibited as it is thought to anger the resident mermaid (Risiro *et al*., 2013). Fetching water with a water gourd facilitates water conservation in that community. Community members only bring water that they need to use rather than excess. Metallic or blacked pots are forbidden from being used because they may contaminate the water, making it unclean for human consumption (Chemhuru and Masaka, 2010).

2.7.7 Rituals

Rainmaking ceremonies have been reported across Southern Africa. Muyambo *et al.,*(2017) revealed that in the Eastern Cape of South Africa, after the village elders predict a drought, they collectively do rituals in a sacred mountain where they use opaque beer to appease the ancestors. In Zimbabwe, one such mountain is the Inyangani Mountain, situated in the Eastern Highlands of Zimbabwe (Ngara and Mangizvo, 2013). In Zaka, where they perform rainmaking ceremonies [M*ukwerere*; Shona] are performed under a Mobola plum tree [*Muchakata*; Shona], Sycamore fig [*Muonde*; Shona: *Umkhiwa*; Ndebele: *Ficus sycomorus*] or June Farquhar [*Mukamba*; Shona: *Afzelia quanzensis*] (Risiro *et al*., 2013).

Rainmaking ceremonies in KwaZulu-Natal are a way of appeasing a heavenly princess [*Inkosazana;* Zulu] who brings soft soaking rains for productivity and fertility (Benard, 2003). Similarly, in Limpopo province, the Rain Queen Modjadji, the leader of Balobedu in the Limpopo province, was responsible for rainmaking rituals. In the Eastern Cape, diviners [*amagqirha*; Xhosa] are responsible for the rainmaking ceremonies (Mahlangu and Garutsa, 2014).

2.7.8 Change in the composition of the herd

In the face of water shortages, farmers dispose of old or mature animals to avoid incurring unnecessary losses and raise income. Only breeding animals and young ones that are not yet ready for sale are maintained. The challenge is to acquire resistant breeds when restocking, although they may be slow growing (Le Houerou, 1996). Unfortunately, national governments and other rural development agencies tend to promote imported breeds.

CHAPTER 3: INDIGENOUS METHODS FOR WATER SECURITY

3.1 INTRODUCTION

The global food crisis is greatly fuelled by water insecurity (Jägerskog et al., 2014). Water is a resource that fortifies social, economic, cultural and environmental activities. Lack of access to water results in significant losses in livelihoods and exacerbates poverty levels. Therefore, global efforts to eradicate poverty should include ensuring water security because of the strong link between poverty eradication and access to water (Sullivan et al., 2003; WHO, 2007).

Water security is the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production (Grey and Sadoff, 2007; Scott *et al*., 2013). Water security in rural and urban environments is contextually different. Urban communities consider water security in terms of sustainable access to adequate, lawful, affordable and pollution-free water (Aboelnga *et al*., 2019). On the other hand, resource-limited communities view water security as the supply of an adequate quantity of water that can sustain agriculture and domestic activities. Chris (2012) highlighted that water scarcity is the shortage of sufficient quantities and quality of water for human and environmental uses. The Water Poverty Index (WPI) is usually applied to these resource-limited communities. The WPI involves the lack of capacity to ensure access to water resources for domestic use, production and the environment (Sullivan *et al*., 2003). However, the issue of quality is of less importance where water resource is scarce. Low availability is one of the biggest challenges for resource-limited households. One of the causes of water insecurity in resource-limited communities is frequent droughts (Sheffield and Wood, 2011). In addition to poor infrastructure, climate change is exacerbating the challenge. The situation in Limpopo, Eastern Cape and some parts of rural KwaZulu-Natal is dire.

To address water insecurity and meet the Sustainable Development Goal (SDG) Number 6, policies and programmes that call for safe, sufficient and reliable water for all have been crafted. Despite the availability of these policies, water in South Africa is still yet to be distributed equitably. Resource-limited communities still experience serious water challenges (SAHRC, 2018). Even in urban centres, protests for improved access to safe water are increasing across South Africa (Morudu, 2017). Most municipalities also fail to provide safe and reliable water for both humans and livestock. In the Eastern Cape, for example, 90% of the population in the Khambashe community had no access to public pipeline water (Mahlangu and Garutsa, 2014).

Livestock is the backbone of rural communities contributing towards the provision of food, income, insurance against crop failure and socio-cultural purposes (Rust and Rust, 2013). Water constitutes 60- 70% of the bodyweight of livestock, and lack of it affects the animal more than feed deficiency (Faries *et al*., 1998). Despite the contribution of livestock to livelihoods, water shortages reduce livestock productivity, leading to loss of livelihoods. The 2015 drought, for example, reduced stocking rates due to forced slaughter and the death of livestock (AgriSA, 2016). During water shortages, preference is given to humans, although losses in livestock have subsequent ramifications on livelihoods. As a result, water shortages in resource-limited communities must be addressed simultaneously for both livestock and humans.

The consistent failures of governments and municipalities to ensure water security call for options to complement efforts for water provision to both humans and livestock. One of the frameworks that have been reported is the Drought Cycle Management (DCM) (ILRI, 2004). The framework embraces the resilience of communities to water insecurity, as an ongoing process where households are either in preparation, experiencing or recovering from the effects of water scarcity. The DCM framework further classifies the intensities of water insecurities in stages of the drought cycle as normal (water-secure stages before and on the onset of a drought), alert, emergency and recovery. The framework takes an integrated approach and recognises the need to incorporate disaster preparedness instead of taking a reactive approach to water security management. The use of the DCM framework, together with the inclusion of IK in ensuring water security, is holistic.

Indigenous knowledge is a set of skills that originate within a particular community through observations and experimentation in relation to a specific geographic region (Norton *et al*., 1998). It also refers to the long-standing traditions and practices of communities that are unique to a given culture or society for the sustenance and wellbeing of the community (Senanayake, 2006). African IK also comes from a spiritual perspective where supernatural beings influence elements of nature (Emeka and Ekeopara, 2010).

The IK approach to ensuring water security is sustainable, environmentally friendly, culturally and socially accepted, cost-effective, and community-centred. Resource-constrained communities use IK to predict an impending drought and cope through mitigation and adaption to ensure livelihoods and resilience while minimising vulnerability (Jiri *et al.*, 2016; Macnight-Ngwese *et al*., 2018; Siambombe *et al*., 2018). However, the lack of documentation of these techniques threatens the dilution and extinction of IK (Senanayake, 2006). The youths consider IK archaic, old-fashioned and “unscientific,” despite the centuries that have been used to validate these techniques.

Other regions have successfully managed to mitigate the effects of droughts by using IK either as a stand-alone or in conjunction with conventional methods (Madebwe *et al*., 2005; Mafongoya, 2017). It is essential to explore IK beliefs and attitudes on water security for household use. Livestock production in KwaZulu-Natal and Limpopo Provinces of South Africa are hugely affected by these water challenges. Therefore, the study's objective was to identify indigenous knowledge used in human and livestock water security in resource-limited communities.

3.2 MATERIALS AND METHODS

3.2.1 Study sites

The study was conducted in Umhlabuyalingana Local Municipality under uMkhanyakude District Municipality, KwaZulu-Natal and Musina Local Municipality under Vhembe District Municipality, Limpopo. Umhlabuyalingana is mainly rural and is situated on the northeastern side of KZN, bordering with Mozambique and the Indian Ocean. It has a subtropical climate with annual rainfall ranging from 600 to 700 mm, while the yearly average temperature is 21.5˚C. The district has the Pongola River, which runs on the western border of the municipality, Lake Sibiya and KuNhlange on the far eastern corner (Umhlabuyalingana Local Municipality, 2017). The vegetation is comprised of Maputaland Coastal Thicket with sclerophyllous plants, which are adapted to withstand dry conditions.

Musina Local Municipality is situated on the northern part of the Limpopo under the coordinates 22° 20 ′ 17″S 30° 02′ 30″E. The annual rainfall is 350 mm per annum, with no rainfall received in June. The highest rainfall is experienced in January (55 mm) (Musina Local Municipality, 2018). The maximum temperature is 45˚C, and evaporation rates are 2500 mm per annum (Musina Local Municipality, 2018). Musina Municipality lies within the catchment of Limpopo, Nwanedi and Nzhelele rivers, which are mostly used for irrigation purposes.

3.2.2 Selection of villages and participants

The villages from each district municipality were identified based on ownership of livestock, lack of access to perennial water supplies and presence of the elderly who are revered for ownership and usage of IK in water security. Participants were selected using the snowball sampling technique through the assistance of extension officers and community key informants who gave referrals to information-rich informants. In Umhlabuyalingana, participants came from Ndlondlweni, Mseleni, Kwa-Mabasa and KwaSonto villages. Domboni and Malale represented Musina Local Municipality. Data collection in Umhlabuyalingana Municipality was done at the end of September 2019. In Musina Municipality, data were collected at the beginning of October 2019. Trained enumerators were used in both municipalities.

3.2.3 Data collection

Data was collected using direct observations, face-to-face interviews, focus group discussions (FGDs), and transact walks. Data was collected in September and October 2019 during the hot-dry season.

3.2.3.1 Face-to-face interviews

Face-to-face interviews were used to access data from the elderly, tribal chiefs and religious leaders. These interviews were conducted in the vernacular, iZulu in Umhlabuyalingana Municipality and Tshivenda in Musina Municipality. The data were mainly on the indigenous knowledge methods used in water security. The participants were referred by the livestock association official and the tribal chiefs. Tape-recorders were used to capture the data to reduce errors in transcribing, and notes were done as a backup. Information gathered was translated into English, then transcribed, and thematic analysis was done afterwards. Eight interviews in each municipality were conducted. Each interview took an average of an hour. The participants in Musina included three tribal chiefs, one traditional healer, two livestock association representatives and three elders. In Umhlabuyalingana, the interviews included two tribal chiefs, two traditional healers, one livestock association representative and three elders.

3.2.3.2 Focus group discussions

Four focus group discussions in each province were constituted to gather information on the water security situation. The FGDs were conducted in vernacular languages in the respective provinces. The focus groups comprised youth males below 25 years, females below 25 years, adult males above 25 years, and females above 25 years each focus group comprised between eight and 15 participants. The focus groups for adults comprised livestock owners to capture data on both humans and livestock water security situations. The data gathered included the water security situation and perceptions about IK methods used in sustaining water security. Semi-structured guides were used in FGDs, to give room for probing and for the participants to express their knowledge and perceptions on water security issues in their communities. Translation, transcribing, and thematic analysis were done. Each FGD took between 30 and 60 minutes.

3.2.3.3 Direct observations

Direct observations were made during transect walks, and a digital camera was used to take photographs of available water resources and associated infrastructure. Transect walks were done to explore and observe water source supplies used in the villages.

3.2.4 Data analyses

Interviews were organised into themes using the Nvivo software.

3.3 RESULTS

3.3.1 Water sources

Households in Umhlabuyalingana and Musina relied on both natural and conventional water sources. The distribution of water sources in the villages studied is shown in Table 3.1. In Umhlabuyalingana, natural water sources included rivers like Umnandawu, Mtunzini and Welandlovu. In addition, springs were dug out along rivers and streams during extreme dry spells. Conventional water sources included Lake Sibhayi, which supplied tap water to the communities. Although the communal taps found in KwaSonto were reported to have not been functioning for more than six months, taps in the homesteads had water available. The FGD revealed that the water from the taps had a bad taste compared to water from the stream. Underground water sources reported included boreholes (*Ipitshi*. Zulu) manually operated or electrically powered to pump the water to the surface. Electrically powered boreholes are expensive, making it difficult to share the water with neighbours unless they pay for it. Water supply from the boreholes is reliable, as it never runs out. Therefore, this makes this type of water source more reliable than others are. There was no community borehole in either of the villages. Instead, a household installs one for itself. Furthermore, the communities get water from a water tanker that generates water from Mseleni Hospital, Lake Sibhayi and Manzengwenya plantation.

In Musina Municipality, water was obtained from rivers and streams. Underground water resources included wells and springs (*Magakani*: Thsivenda). *Magakani* are situated on top of hills or mountains. The conventional infrastructure used was boreholes and taps. These were provided and supposed to be maintained by the municipalities. There were two boreholes in Domboni village that supplied water to humans and another one to livestock. The borehole that provided water to livestock was not functional due to poor maintenance from the municipality. Cattle and goats drank water from the river, except in households that had private water sources. Newly calved cows were supplied with water. Unlike in KZN, Musina did not have dams or lakes in the vicinity.

Livestock in both the municipalities included cattle, goats and chickens. Livestock in Umhlabuyalingana and Musina Municipalities drank water from taps, boreholes and rivers. In Musina, rivers were used as an alternative to tap/ borehole water for livestock. In Umhlabuyalingana, rivers were the primary water source for cattle and goats. Livestock in Musina also drank water from the vicinity of *magakani*, sacred wells and community boreholes or taps where pools of water are created from intentional or unintentional spilling or leaking of taps/pipes.

Table 3.1: Water sources in villages of Umhlabuyalingana and Musina Local Municipality

Province	Village	Water source used
KwaZulu-Natal	Ndlondlweni	Private boreholes;
	Mseleni	Sibhayi Dam
		Mthunzini Stream
		Private taps
	KwaMabasa	Communal taps
		Mseleni River
	KwaSonto	Private taps
		Sibhayi Dam
		Welandlovu Stream
		Mnandawo Rivers
Limpopo	Domboni	Community boreholes
		Private boreholes
		Nwanedi River
		Individual wells
		Sacred well: Tshilingoma
		Magakhani
	Malale	Limpopo and Nwanedi Rivers
		Community taps
		Community boreholes

3.3.2 Distance travelled to water sources

Participants in both municipalities travelled for between 10 and 60 minutes to get to the nearest water source. For example, in Domboni Village, humans and livestock travelled for more than 15 km to access water at Nwanedi River when the water in primary water sources has dried up. When people arrive at the river shortly after the cattle are there, they must wait for the water to settle before collecting water for domestic use.

3.3.3 Conventional methods for water collection, storage, transportation and usage

The major water security challenges include water shortages (seasonal supplies), poor infrastructure and poor water quality (contamination). In both provinces, households use 20 or 25 ℓ plastic containers to collect water. In Umhlabuyalingana, however, narrow-necked containers were generally used, while in Musina, buckets mainly were used for collecting water. Similarities also existed in the containers used when a vehicle was used to ferry the water to the homesteads where 200 ℓ drums were used. Young children, who may not be able to carry the 25- ℓ containers, used five or two ℓ containers.

The amount of water collected per trip varied. The containers used for the collection were doubled up as water storage containers. However, some households had 260 ℓ or 2000 ℓ water tanks (popularly known as JoJo tanks), which they used for long-term water storage, as shown in Figure 3.1.

The FGDs revealed that girl children and women are responsible for ensuring water availability in the household. They spent a lot of time searching for water sources or queuing for water. The women in Musina municipality revealed that they go to fetch water twice a day, in the morning and evening, while girls indicated that they fetch water every day after school. On the contrary, the FGD for the boys in both municipalities revealed that everyone in the household fetched water. However, the water they collect is usually used for their personal use. Water collection from the river was done before going to school at 05h00, making them tired and lose concentration in school. Men were responsible for collecting large amounts of water used for building and agriculture. Vehicles were used to collect water from communal taps or sources further away from the homesteads (Figure 3.2). Most participants walked on foot to and from water sources in both municipalities and carried the containers on their heads. Wheelbarrows were also used to ferry between one and three 20 ℓ containers from source to homesteads. In Musina, in addition to wheelbarrows, animal-drawn scotch carts were used.

Figure 3.1: An electric pump used for drawing underground water into a water tank in Ndlondlweni, Umhlabuyalingana Local Municipality

Figure 3.2: A man collecting water using plastic containers for domestic purposes from a communal tap to be transported by a vehicle in Ndlondlweni Village, Umhlabuyalingana

The water usage per capita is represented in Table 3.2. The weekly water usage is between 40 and 50 ℓ per capita. Umhlabuyalingana had variable costs of hiring a vehicle to ferry water ranging from R105 to R400 per trip (Table 3.2). In all the villages that participated in the study in Musina Municipality, the price of hiring a vehicle was R120. However, water was sold by neighbours who have water pumps at R2 per 20 ℓ and R40 per day for drinking water of goats.

Table 3.2: Water usage and price of water

Local Municipality	Water Usage (ℓ/Person/Week)	Cost
Umhlabuyalingana	50	R105 to R400 hiring a vehicle per trip
Musina	40-50	R2 per 20 ℓ R120 hiring vehicle per trip R40 drinking water for goats (unspecified number) per day

3.3.4 Indigenous methods used in water security for humans and livestock

Indigenous methods of ensuring water security are currently not being widely practiced. Among the FGD for men in Umhlabuyalingana, communities presently use IK but are not free to reveal their 'secrets'. Christianity was blamed as one of the causes of indigenous methods being abandoned. The other blame was put on traditional leaders who turned their backs on their ancestors, thereby abolishing their traditional customs in preference to the conventional system.

'The ancestors are angry. No one goes to the cemetery to beseech the rain. These days, ancestors are considered to be demons because of Christianity from Western countries.'- Village Elder, Umhlabuyalingana
'Christianity is giving us problems…'- Traditional diviner, Musina

Indigenous knowledge methods were used to predict periods of water shortages, cope during droughts, recover from the effects of water scarcity and prepare for future periods. The IK holders concurred that the interventions used in ensuring water security could be classified as predictive, evasive, mitigative, reconstruction and adaptive. These categories were then adopted in this report.

3.3.4.1 Indigenous predictive measures of water shortages

Ethno-meteorology is used to predict an impending drought or wet season. Characteristics of ethno-meteorology used include astronomy, bio-indicators, rituals, and observation of weather trends. In the methods outlined in this section, a wet season or the presence of rain meant the community would be water secured.

Rituals

Interviews and FGDs in Musina Municipality indicated that few communities and households practised rituals. One of the traditional diviners interviewed indicated that the spirit mediums were able to ask ancestors whether there was an upcoming drought or not.

'Ancestors through their mediums are able to tell you whether a drought is coming'- Traditional diviner in Malale Village, Musina

The diviner highlighted that not every traditional healer can communicate to the ancestors on issues about droughts and water security. Only those who have a calling for water-related interventions can intercede for the community. For the assigned medium to be able to speak to the ancestors, a group of diviners and chiefs would assemble at a place called *Manenje,* where songs and traditional dances would be performed until the spirit of the ancestors possessed the assigned medium and speaks out on what is to come. Rituals provide water for both humans and livestock. When it rains, hydrological water sources are recharged, including those used for drinking water for livestock.

Astronomy

In Umhlabuyalingana, the stars and moon were used to predict whether rains were coming or not. The presence of many stars in the sky meant that there would be no rain. In addition, observing the 'signs' of the moon was also done. The moon lined up with yellowish red colour indicated that it would rain in approximately a month.

On the other hand, in Musina Municipality, traditional diviners revealed that the presence of a morning star (*Masase*. Tshivenda) signified a wet season. In addition, the key informant reported that when the moon is black, it indicates that there will be no drought, while a 'light' moon means a drought.

'If you the Masase around 5 am, know that we are blessed with water that season'- Traditional leader, Musina

Observing the stars and moons assisted farmers in preparing and planning for an impending weather condition. If the moon or stars show that a dry period is coming, farmers may prepare by stocking hay, storing water or moving their cattle from one point to another. This method is used to ensure water security for both humans and livestock.

Bio-indicators

Both municipalities reported the use of bio-indicators to predict a water-secure season. Bio-indicators assist in predicting a wet season, which benefits both humans and livestock. The coming of a rainy season is indicated by the flying-by of a flock of swallows (*Inkonjane.* Zulu; *Thambelamadi*. Tshivenda; *Psalidoprocne pristoptera*). The flock precedes a dark cloud, which brings rain to replenish water sources. In addition, the use of Ground Hornbills, (Dandila Tshivenda) as an indicator of a wet season was a common phenomenon among the key informants in Musina Municipality. On the other hand, tree phenology indicators used in Musina Municipality included the fruiting of the Shepard's tree (*Muthobi*; Tshivenda; *Boscia albitrunca*) and Bird plum (*Berchemia discolour*), which signify a wet season.

Observation of weather patterns

Prevailing weather was used in both municipalities to predict drought. Face-to-face interviews revealed that the presence of a 'heat wave' for three continuous days or more indicated the coming of rain. In Umhlabuyalingana, the wind blowing from the Indian Ocean indicated an impending rain.

Diviners in Musina Municipality indicated that in the olden days, two types of winds were used as indicators of a water-secure period, the 'Woman' coming from Mozambique and the 'Man' coming from Cape Town. The 'woman' brought rain while 'the man' indicated a dry season. However, if the 'man' and 'woman' meet, they produce thunderstorms because the 'man' will be establishing his position. In addition, dark coloured clouds that were close together indicated impending rain in Musina. Another key informant reported that partial clouds, which had colours like a 'guinea fowl,' indicated rain.

3.3.4.2 Indigenous evasive strategies of water shortages

Rituals, taboos and transhumance were the indigenous methods used to avoid drought impacts.

Rituals

In Umhlabuyalingana, when the crop-growing season approached, the elders (both men and women) used to do rituals at the cemetery designated for chiefs to plead with the ancestors to send the rain.

'*The elders would go to the graveyard early in the morning before 5 am and then between 4.30 pm and 5.30 pm. They would go with a Zulu beer (uMqombothi) and a goat which they would slaughter there'*- Village Elder

In Musina Municipality, a ritual was performed at the fruiting of the Marula tree (*Sclerocarya birrea*). It involved brewing Marula traditional beer and presenting it to the ancestors before community members consumed the fruits for the season. The beginning of the growing season involved brewing conventional beer made from finger millet (*Mufhoho*. *Tshivenda; Eleusine coracana*), which will be left at sacred mountains for a week for the black mamba (*Dzhambila*. Tshivenda) to drink. Examples of sacred mountains used included Ramabulana in Nzhelele, Raluvhimba in Makonde and Amatibe in Beitbridge, Zimbabwe. During the seven days, the women from the royal family (*Vhomakadzi*) wear traditional clothes (*Tsindi* and *Zvideka*). If the black mambas do not drink the beer, then it is a sign that there will be no rain, and subsequent corrective measures would be done, including further rituals to plead with the ancestors to bring the rain.

Taboos

Taboos were used to evade a drought by making people not to practice behaviour that would cause a drought to befall the land. Taboos ensure water security by keeping water clean for human consumption. Interviews in Umhlabuyalingana revealed that women were not allowed to cook or fetch water when menstruating. Furthermore, children were not supposed to conduct body viewing of a corpse and abortions were prohibited. Similarly, abortions in Musina Municipality were forbidden. At fruiting of the Marula, people were not supposed to consume them before rituals were done to thank the ancestors. Killing of pangolins and spilling their blood on the land was prohibited. Other taboos that caused droughts included killing river snakes (*Nowamulambo*. Tshivenda).

Transhumance

Permanent transhumance results in permanent relocation to areas that are water secure. Transhumance ensures water security, particularly for livestock. An elderly key informant in Umhlabuyalingana revealed that the AmaChunu people relocated to the area with their livestock due to drought. She further stated that transhumance, however, is no longer being practised. Another participant reiterated that they could not practice transhumance because the study site had little grass along rivers that cattle could feed on compared to Jozini and KwaNongoma. Contrary to the Umhlabuyalingana, a key informant in Musina Municipality reported that before the borders and animal control measures, cattle used to be moved north of the Limpopo River into Zimbabwe when there was a drought, which he referred to as environmental migration.

3.3.4.3 Indigenous mitigation strategies to water shortages

Mitigation strategies that help households to cope during periods of water shortages include rituals, use of sacred wells, springs, supplementing livestock with feeds of high-water content, changing livestock management systems and destocking.

Rituals

During periods of water shortages, rituals were conducted to appease the ancestors. Traditional diviners (*Sangoma*. Zulu) in Umhlabuyalingana used to consult to determine the cause of the drought, and after that, they would conduct rituals together with the king/tribal chief. They would go to a sacred mountain accompanied by selected men. A cow or goat would then be slaughtered and they would consume all the meat there. No meat was allowed to be taken home, and the rains would fall almost immediately. The rains would be enough to fill up the dams for humans and livestock to have water.

'If they went up the mountains in the morning before 5 am, then it would rain the next day. But if they went up around 4-5 pm, and slaughter a goat or cow, then the rains would come as soon as they were descending from the mountain.'- Village Elder and Traditional diviner

In Musina, as found in Umhlabuyalingana, rituals were done to consult on the cause of the drought from the ancestors. Rituals were done for the common purpose of ensuring water security for humans and livestock. In Malale, tshikona (man dance) or domba dances were done at the tribal chief's homestead. Thereafter, they would use snuff at the graveyard to ask for rain from the 'sleeping forefathers'. Alternatively, a group of spirit mediums could gather and play drums. Among them, one person would be possessed. A dark goat or cow would be given traditional beer to appease that spirit. If it refused, then the ancestors would have declined to intervene, putting an end to the drought.

Use of sacred wells

In Madimbo village, Musina Local Municipality, a sacred well was used during extreme droughts to provide water for the community. The high pressure water that came out from the ground was used for domestic purposes, while the one that flowed down the hill was used for livestock drinking. The custodian of the sacred well is the royal family, who gives permission for anyone to use the well. Without permission, it is perceived that a trespasser would be attacked by a snake or leopard, which guards the well. When community members visit the well, they are not allowed to wear red or black coloured clothes. Women are not allowed to visit the well during their menstrual periods.

Springs and wells

Both municipalities reported that during periods of extreme water scarcity, people would dig shallow holes along the bed and banks of rivers or streams where water would sprout out. The holes were dug using bare hands and sometimes hoes. The water was then used for domestic purposes and livestock. The FGD for girls in Umhlabuyalingana revealed that during periods of water scarcity, if livestock reached the shallow wells and springs before them, they would chase them away and wait for about 30 minutes for the water to settle before they could fetch it.

Supplementing livestock with feed containing high water content

In Musina Municipality, the leaves from Mopane (*Colophospermum mopane*) and Iron wood (*Musimbiri*. Tshivenda; *Olneya tesota*) trees were collected and fed to the livestock during droughts.

Change in the livestock management system
Both municipalities indicated that they changed the management system during droughts. During the wet season, when there is adequate water and pasture, the cattle are housed in kraals during the evening. However, during droughts, they are left to free range to search for feed and water. In Umhlabuyalingana, people would only check on their cattle once a week. They supplemented using lucerne (*Medicago sativa*) which they buy for R145 per bale from neighbouring commercial farms. One key informant in Malale revealed that his cattle stay at Nwanedi River, and he goes there to check on them daily.

Destocking
When the water situation intensifies, Umhlabuyalingana and Musina households sell their cattle and use the money to provide water for the remaining cattle.

'If water scarcity becomes severe, I sell my cattle. For example, if I have a herd with 20 cattle, I sell half and use the money to buy water to give the remaining cattle and also to recover my losses…' – Livestock Association Representative, Umhlabuyalingana Local Municipality

3.3.4.4 Indigenous reconstruction strategies

Neighbour relationships
To recover from the effects of water scarcity, the communities in both municipalities relied on neighbour relationships. Households shared their replacement bulls, rams and fertile eggs with neighbours. Water-related information that neighbours shared, included management of water and how to purify it.

Covering up of shallow wells
Households cover up the shallow wells, which were dug during the drought. Filling up shallow wells is an environmentally sound strategy that ensures water security by reducing injuries and death of livestock and humans.

Rituals
When rains eventually come in Musina, a ritual was done where beer brewed from finger millet was presented to mountain snakes to appease them so that they continue sending the rain.

3.3.4.5 Indigenous adaptive strategies to water shortages

Adaptation methods assist households in coping after the drought and preparing for future episodes. The adaptation methods used included rearing of tolerant livestock breeds and species.

Change of livestock breeds reared
In Umhlabuyalingana, Nguni cattle buffered households from losses incurred by crop failure during droughts. Households however, are faced with a dilemma of choosing livestock breeds based on economic potential rather than hardiness. One key respondent indicated that he owns Nguni cattle for their drought resistance trait, although he preferred Brahmans because of their market value.

Change of livestock species reared
Households in Musina rear goats as opposed to cattle. In Umhlabuyalingana, many homes do not have goats because they perceive them to be 'troublesome'.

3.4 DISCUSSION

Water insecurity was rampant in the study sites. Water was a scarce resource that required intense interventions among the communities. While most households relied on conventional interventions to curb water insecurities, a few still practice indigenous strategies. Indigenous strategies of ensuring water security were holistic. The methods employed were used to predict water shortages, avoid, mitigate, adapt and recover from droughts. While water is an essential resource for livestock and humans, its shortage mostly disadvantages livestock since humans are prioritised. Households relied on indigenous strategies even to explain the causes of droughts. Rukema and Simelane (2013) reiterated that when communities stop respecting their customs and following the Western or "modern" ways, they face water insecurity challenges due to angry ancestors. Similar findings were reported in the North-West Province, where droughts were associated with the ancestors' anger towards affected communities (Kaya and Koitsiwe, 2016). The wrath of the ancestors was caused by communities abolishing IK. Risiro et al.,(2013) proposed that abolishing IK results from the perception that they are charged with unproven, unrealistic, and naive ideas that cannot be adopted into policy.

Predictive strategies were used as preparatory mechanisms for upcoming natural disasters. Drought preparedness translates to community resilience to the effects of water insecurity. The behaviour of abiotic and biotic factors was also used by other communities in Southern Africa in Botswana (Kaya and Koitsiwe, 2016). Astronomy involves using beliefs and theories of the stars and the moon, which influence social norms and behaviour (Holbrook, 2016). Similar findings were reported in Botswana, where a circle around the moon indicates precipitation (Mogotsi *et al*., 2011). Astronomy was similarly reported in Botswana, Malawi and Swaziland, although star patterns and movement were used to forecast a dry period (Mugabe *et al*., 2010; Kalanda-Joshua *et al*., 2011; Mogotsi *et al*., 2011). Bio-indicators are defined as climate sensitive animals or plants that respond to changes in weather and display observable behaviour that can be used to predict weather (Hughes 2003). The appearance of specific bird species and tree phenology are the only bio-indicators captured. Bio-indicators reported elsewhere include the singing of crickets in Brazil (Costa Neto, 2006); the sprouting of *Vachellia* trees in Botswana (Mogotsi *et al*., 2011); the chirping of Burchell's Coucal birds (*Centropus burchelli*) in Swaziland (UNEP, 2008) and germination of the baobab tree in South Africa (Zuma-Netshiukhwi *et al*., 2013).

A heatwave is a high-temperature incident where temperature rises above the normal with 5˚C (Bandyopadhyay *et al*., 2016). Similar findings were reported in the Kalahari, Botswana, where high afternoon temperatures indicated the coming of rains (Mogotsi *et al*., 2011). High temperatures heat moist air creating convectional currents. As the air rises, it cools down, forming cumulonimbus clouds resulting in convectional rainfall. In Umhlabuyalingana, the observations were attributed to the dense wind from the Indian Ocean that is characterised by warmth and moisture since it originates from the equator and brings rain (Vilakazi *et al*., 2019).

In Musina, the assertions concerning the 'woman' and 'man' were reiterated by Jury (2016), who reported that the western bound warm-moist Mozambique currents from the Indian Ocean are responsible for rain which may be experienced in the Limpopo River Basin (LRB). Even though the LRB experiences the moist Mozambique currents, the resultant wet weather is intermittent. Dry conditions currently observed in the region result from the El Nino-Southern Oscillation (ENSO) brought about by the interactions between warm moist Indian and cold, dry Atlantic oceanic climates (Mosase and Ahiablame, 2018). Furthermore, the LRB experiences the low pressure Inter-Tropical Convergence Zone (ITCZ), which brings thunderstorms when it moves southerly (Mosase and Ahiablame, 2018); hence, the traditional diviner explained it as the meeting of the man and woman. Dark coloured clouds, which are close together in Musina, were concurrent with studies in Bergville, KwaZulu-Natal (Vilakazi *et al*., 2019).

Transhumance is the seasonal migration of livestock to areas that can support them (Abiola *et al*., 2005). Seasonal transhumance is temporary, and those who practice it will come back to their permanent homes, while permanent transhumance results in households not returning. In Zimbabwe, farmers migrated to areas with succulent pasture or perennial rivers, which supported livestock throughout the dry period (Chakoma *et al*., 2016; De Haan *et al*., 2016). However, the sustenance of this method is limited due to land ownership laws, livestock restriction laws, and the low carrying capacity of grazing lands. Transhumance is well defined in West Africa, where pastoralism is prominent (Alassan *et al*., 2017). In South Africa, transhumance has been reported in the Cape region (Beinart, 2007).

Water scarcity mitigation strategies are activities that assist in minimising the effects of water insecurity or droughts (Nyong *et al*., 2007). Rituals were practised in many African communities, although the proceedings, arbitrators, and materials differed from place to place. While the arbitrators in this study performed rituals in the mountain and went back home to wait for the rains, communities in Msinga, KwaZulu-Natal, would not return home until the ancestors ‘tell’ them to (Rukema and Simelane, 2013). In the current study, the site for rituals were mountains, the chief’s compound and graveyard, the rituals conducted in the Eastern Cape were arbitrated by men in sacred forests, rivers, caves or mountains to appease the ancestors so that they send rain (Mahlangu and Garutsa, 2014). These differences indicate the uniqueness of each community.

Sacred wells had a conservation purpose in water security (Muleya, 2014). Sacred wells were also reported in Zimbabwe and Lesotho (Rusiro et al., 2013; Muleya, 2014). They are naturally occurring, and the custodians, who ultimately claim ownership, are those that reside around or near them. Taboos are used as deterrence against misuse, and this ensures that the well acts as a reservoir, especially during droughts when the water is most needed. The belief that menstrual blood is impure and unclean was reported in many communities, including Nepal (Thapa *et al*., 2019). Hence, alienating menstruating women was an act meant to ‘preserve water’ from contamination. Taboos mainly were used to ensure human water security and not livestock. Some taboos, therefore, alienate livestock from using water sources, thereby reducing the availability of water for livestock.

Springs are natural outflows of water from an underground supply at a clearly defined point while wells are dug vertical holes to access groundwater (USDA, 2001). Springs and wells are important during periods of water scarcity as they allow access to nature’s stored water in the form of groundwater. Kelbe and Rawlins (2004) reported that 65% of South African households living in rural areas rely on groundwater sources like springs and wells. While boreholes require expensive mechanisation to reach groundwater, spring water and wells are easily accessible to both humans and livestock. However, springs and wells are mostly unprotected and can be a potential health hazard, especially from humans and livestock sharing water sources (Mothetha *et al*., 2013). The use of springs and wells should be augmented with water purification methods like sedimentation and boiling. Digging holes along the river can easily assist in the development of gullies. These can cause injury to livestock and humans, making it counterproductive to water security.

Livestock utilises water through drinking, feeds and metabolic water. Tree leaves contain substantial nutritional value and water that the animal can use. Tree leaves as feed supplements during droughts have been reported, such as *Vachellia* species, *Moringa oleifera* and *Adansonia digitata* (baobab) (Chimvuramahwe *et al*., 2011; Mukumbo *et al*., 2014; Gegeyew *et al*., 2015). Mopane trees and Ironwood have a deep root system that necessitates access to underground water and mineral salts during periods of water scarcity, thereby maintaining a high nutritive value and water content (Topps, 1992). Similarly, plant material supplement was practised in Zimbabwe, although crop residues were used (Matope *et al*., 2013).

The findings that farmers destock through selling when water scarcity deepens concur with Eastern Cape studies (Musemwa *et al*., 2010). Resource-limited households are more likely to sell live animals during water shortages. The probability of selling in resource-limited households increases with decreased body condition, which is the case during droughts (Musemwa *et al*., 2010). Destocking reduces the pressure of managing a large herd where the water resource is not permitting. Intensifying water shortage incidences reduce livestock body condition, reducing their value. Asset disposal as a mitigation strategy allows farmers to raise capital that can be channelled to improve the water supply for the remaining livestock. Destocking also reduces pressure and competition for water resources. However, destocking during the height of water security challenges replenishes the breeding stock, reducing reconstructive efforts after the drought. Destocking should be done as a last resort after efforts of increasing water supply have failed (Campbell *et al*., 2000; Moyo *et al*., 2013).

In addition, destocking can also be done in phases by selling small livestock first because of the high costs of replacing cattle.

Neighbour associations play a vital role in ensuring water security in resource-limited communities. When the situation gets dire, neighbours share their water resources water security information, and during recovery, they share replacement stock (Dean *et al*., 2016). Neighbour associations, therefore, augment the role of social capital in ensuring water security and livelihoods through IK.

Adaptation strategies enable households to adjust to the impacts of droughts (Nyong *et al*., 2007). The findings revealed that stock selection was rarely driven by drought resistance. Instead, farmers selected stock was based on profitability. Contrary to these findings, stock selection in Zimbabwe was based on resistance to drought (Matope *et al*., 2013). Indigenous breeds can adapt better to water shortages than imported breeds.

The perception in Umhlabuyalingana that goats are ‘troublesome’ may be driven by social influences that regard cattle highly compared to small livestock (Rukema and Simelane, 2013). Goats are more resilient to water shortages than cattle. Stocking drought-resilient livestock assists in the resilience of communities during periods of water scarcity and highlights the livestock’s function as a buffer in case of crop failure.

CHAPTER 4: POSSESSION AND USE OF INDIGENOUS KNOWLEDGE TO ENSURE WATER SECURITY AMONG RESOURCE-LIMITED HOUSEHOLDS

4.1 INTRODUCTION

Climate change is one of the most significant contributors to water challenges causing rainfall variability and uncertainty (Rust and Rust, 2013). Unreliable rainfall causes poverty and hunger by reducing yields and quality of agricultural output. In addition, water shortages reduce available water for domestic use, maintaining good hygiene to combat disease outbreaks like coronavirus (e.g. COVID 19) and also reduce livestock productivity. Resource-limited communities are among the most affected due to possession of limited resources to buffer the impacts of water shortages and weather extremes, climate change and variabiity, thereby increasing their vulnerability.

Livestock markedly contributes to the livelihoods of rural communities. During periods of extreme weather, livestock buffer for crop failures may create pressure and competition for water between livestock and humans. Other socio-economic benefits of livestock include the provision of food and draught power. Most African rural communities rely on natural water sources. Therefore, prolonged dry periods and variable rainfall will result in adverse water shortages (Chadwick *et al*., 1998). There is, therefore, a need for interventions that increase community resilience.

Conventional water security interventions alone overlook and disregard the contribution of social structures and communality of sharing resources (Chadwick *et al*., 1998). One such intervention is the use of IK, which relies on locally engineered skills passed across generations. Indigenous knowledge increases the resilience of rural communities to water shortages while social participation cultivates ownership and responsibility of the water resource among its end users. While technologically savvy countries practice modern technologies to solve water shortages, resource-limited communities have little capacity to use this route fully hence the need to search for sustainable alternatives.

Chapter 3 identified IK methods used and classified them according to their function in water security as predictive, evasive, mitigative, adaptive and reconstructive. Households in Umhlabuyalingana and Musina Local Municipalities relied on neighbour-based social capital as a reconstruction method after a period of water scarcity.

Application of IK to ensure water security in South Africa is limited by a lack of documentation coupled with the negative perception of being archaic, old fashioned and unreliable. Colonialism and imperialism also intentionally removed IK from the mainstream formal educational curricula, hindering IK's inclusion in development (Zegeye and Vambe, 2006). However, the often centralised conventional technologies have failed to provide sustainable solutions to water insecurity challenges facing South Africa. Attitudes of the youths need to be determined to develop sustainable and affordable technologies and systems. There is a need to assess attitudes and perceptions of communities towards IK to design and map sustainable IK models (Ansah and Siaw, 2017).

Furthermore, the status of the use of IK in South Africa needs to be ascertained due to the insurgence of industrialisation and modernisation. Perceptions and extent of the use of IK in water security may indicate the willingness and ability of communities to incorporate IK as a water management tool. The overall perception of IK may be based on their accuracy, reliability and convenience. In resource-limited communities, accuracy is conceptually how much the predicted event differs from the actual. Reliability is the trust households have in indigenous methods to produce favourable results (Mohajan, 2017). Convenience concerning IK is the ease of applying a technique. The influence of demographic factors on IK use should be assessed to ensure that efforts towards ensuring water security are not misdirected towards the wrong target groups (Mamba, 2016).

Therefore, the objective of the current study was to determine the possession and extent of use of IK in resource-limited rural communities of KwaZulu-Natal and Limpopo Province, South Africa. It was hypothesised that the acceptability of IK to ensure water security is low.

4.2 METHODOLOGY

4.2.1 Study site

The project was conducted in two geographical sites, namely Umhlabuyalingana Local Municipality, KwaZulu-Natal and Musina Local Municipality in Limpopo. Details on the description of the sites were provided in Chapter 3.

4.2.2 Household selection and data collection

The sites were selected based on their frequent experiences of water challenges for both humans and livestock with the assistance of local leadership and the Department of Agriculture and Rural Development. Experiences of other WRC projects based at the University of Venda were also used to select villages. Households that participated in the study were from Ndlondlweni, Mseleni, KwaMabasa and KwaSonto communities in Umhlabuyalingana Local Municipality and Domboni and Malale, Musina Local Municipality. The data were collected between August and October 2019.

One hundred and fifty-four respondents in Umhlabuyalingana and 130 in Musina were randomly selected to participate in the study. Participation in the project was done willingly. Data collection was done through the assistance of four trained enumerators who local community leaders identified to increase the reliability of data collected in each municipality. The questionnaires were presented in the vernacular language, Zulu in Umhlabuyalingana and Tshivenda in Musina.

Structured questionnaires developed from data gathered through interviews of key informants and focus group discussions were administered to determine the extent of indigenous methods used. The questionnaire captured household demography, level of education, sources of water supply, mitigation and adaptation strategies used to ensure water security for humans and livestock. Respondents below the age of 40 were classified as young adults, middle-aged adults as those between 40 and 59 and old adults were above 60 years (Wen-Bing Horng *et al.*, 2001). Professionals were those that had knowledge-based contemporary occupations with skills that were acquired from formal training or education (Evettes, 2003). The questionnaire was administered to determine the extent of use of the indigenous methods. In addition, the questionnaire captured the perceptions of the use of IK in resource-limited households. The demographic distribution of the data was characterised as shown in Table 4.1.

4.2.3 Statistical analyses

Chi-squared tests were used to test the association between demographics and the use of IK (SAS 9.4, 2018). Ordinal logistic regression was done using PROC LOGISTICS of SAS 9.4, and odds ratios were used to predict the likelihood of being knowledgeable in IK methods, using IK and perceiving IK methods as reliable.

Table 4.1: Demographic distribution percentage of respondents in Umhlabuyalingana and Musina Local Municipalities

Variable	Category	Umhlabuyalingana	Musina
Gender	Male	71	37
	Female	29	63
Age group (years)	≤ 25	8	7
	26-59	40	75
	>60	52	18
Highest level of education	Less than 7 years of formal education	43	53
	Secondary level	50	27
	Tertiary level	7	20
Formal livestock training	Yes	30	21
	No	70	79
Occupation	Professional	15	20
	Informal	67	47
	Other	18	23

4.3 RESULTS

4.3.1 Factors influencing the perception of IK use

The associations between demographic information and perception on the use of IK are shown in Table 4.2. In Umhlabuyalingana, the accuracy of IK methods was influenced ($P<0.05$) by age group, level of education and occupation. In contrast, the reliability of IK methods was affected ($P<0.05$) by age group, animal husbandry training and occupation. The application of the IK methods was influenced ($P<0.05$) by age group, while occupation affected the perception of the convenience of these methods. In Musina, factors that influenced ($P<0.05$) the perception of accuracy of IK methods were occupation and age group. Level of education affected ($P<0.05$) reliability. Gender was not associated with the accuracy of IK methods ($P>0.05$) in both municipalities. There were no influences ($P>0.05$) of the site on IK use.

4.3.2 Predictions of IK use

Tables 4.3, 4.4, 4.5 and 4.6 show the odds ratio estimates of different demographic predictors of using IK in ensuring water security. The likelihood of the young adults applying IK and perceiving it as reliable was significant in Umhlabuyalingana. Surprisingly, young adults were five times more likely to use IK and consider it reliable compared to the elderly. Traditional healers were also five times more likely to be knowledgeable in IK methods of ensuring water security than the unemployed ($P<0.05$). The likelihood of educated households in Musina knowing indigenous ways of ensuring water security was 13 times higher than uneducated households. Professionals were five times more likely to rely on IK than the unemployed were ($P<0.05$).

4.3.3 Frequency of use of IK

Table 4.7 shows the proportion of households who frequently use IK to ensure water security. Unemployed respondents (70%) preferred using IK often ($P<0.05$). In Umhlabuyalingana, frequent use of IK in water security was popular (80%) among the unemployed ($P<0.05$). In Musina, significant effects were observed among education level, livestock husbandry training, and occupation. Close to half of those who had above secondary level education (46%) frequently used IK compared to 78% of those without formal livestock husbandry training on a regular basis ($P<0.05$).

4.3.4 Perceptions on IK strategies for predicting water security

Communities predict water security using animal and plant weather bio-indicators, astronomy, rituals and weather observations ($P<0.05$). Significant differences were found in indigenous methods of predicting water insecurities in both municipalities (Figure 4.1). The use of weather patterns was prevalent (49%) in Umhlabuyalingana. The popular prediction method (55%) in Musina was bio-indicators. The flying-by of swallows and ground hornbills foretells that the oncoming season would be wet, having reliable rainfall. Fruiting Shepard’s tree and Bird plum also depict a wet, water-secure season.

Table 4.2: Association among demographic information and perceptions on use of IK in Umhlabuyalingana and Musina Local Municipalities

	Umhlabuyalingana				Musina			
	Reliability	Accuracy	Application	Convenience	Reliability	Accuracy	Application	Convenience
Age group	*	*	**	NS	NS	*	*	NS
Gender	NS	NS	NS	NS	NS	NS	NS	NS
Level of education	NS	**	NS	NS	**	NS	NS	NS
Animal husbandry training	**	NS	NS	NS	NS	NS	NS	NS
Occupation	*	*	NS	*	NS	**	**	NS

*P<0.05; **P<0.001; NS: Not significant (P>0.05)

Table 4.3: Odds ratios, Lower (LCI) and Upper (HCI) Confidence Intervals of IK use to ensure water security

Predictors	Knowledgeable						Application						Reliability					
	Umhlabuyalingana			Musina			Umhlabuyalingana			Musina			Umhlabuyalingana			Musina		
	Odds ratio	LCI	HCI	Odds ratio	LCI	HCI	Odds ratio	LCI	HCI	Odds ratio	LCI	HCI	Odds ratio	LCI	HCI	Odds ratio	LCI	HCI
Age																		
(E vs YA)	0.83	0.27	2.55	1.85	0.47	7.19	**0.18***	0.05	0.63	2.04	0.38	10.83	**0.17***	0.04	0.71	0.76	0.25	2.36
(MA vs YA)	0.80	0.22	2.90	2.15	0.82	7.76	0.33	0.07	1.43	1.93	0.54	6.56	0.97	0.26	3.58	0.93	0.35	2.46
Gender																		
(F vs M)	2.32	0.95	5.63	1.66	0.55	4.99	2.02	0.82	4.98	1.79	0.59	5.44	0.42	0.12	1.52	0.54	0.22	1.32
Education status																		
(Edu vs Unedu)	0.75	0.28	2.01	**13.47***	1.52	119.13	0.71	0.28	1.82	0.75	0.17	3.292	0.72	0.19	2.66	1.13	0.37	3.45
Occupation																		
(TH vs U)	**5.58***	1.17	26.55	**6.39***	1.11	36.88	1.74	0.36	8.48	>999.99	<0.001	>999.99	5.01	0.78	32.17	4.15	0.90	18.98
(P vs U)	0.72	0.27	1.92	2.42	0.87	6.74	0.62	0.23	1.69	0.77	0.26	2.23	0.74	0.22	2.42	**2.75***	1.16	6.51

Table 4.4: Odds ratios, Lower (LCI) and Upper (HCI) Confidence Intervals for possessing indigenous knowledge

Predictors	Knowledgeable					
	Umhlabuyalingana			Musina		
	Odds ratio	LCI	HCI	Odds ratio	LCI	HCI
Age						
(E vs YA)	0.83	0.27	2.55	1.85	0.47	7.19
(MA vs YA)	0.80	0.22	2.90	2.15	0.82	7.76
Gender						
(F vs M)	2.32	0.95	5.63	1.66	0.55	4.99
Education status						
(Edu vs Unedu)	0.75	0.28	2.01	**13.47***	1.52	119.13
Occupation						
(TH vs U)	**5.58***	1.17	26.55	**6.39***	1.11	36.88
(P vs U)	0.72	0.27	1.92	2.42	0.87	6.74

***P<0.05**; E- Elderly; YA- Young Adults; MA-Middle aged; F- Female; M- Male; TH- Traditional healer; U- Unemployed; P- Professional; Edu- Educated; Unedu- Uneducated

Table 4.5: Odds ratios, Lower (LCI) and Upper (HCI) Confidence Intervals for application of indigenous knowledge to ensure water security

Predictors	Application					
	Umhlabuyalingana			Musina		
	Odds ratio	LCI	HCI	Odds ratio	LCI	HCI
Age						
(E vs YA)	**0.18***	0.05	0.63	2.04	0.38	10.83
(MA vs YA)	0.33	0.07	1.43	1.93	0.54	6.56
Gender						
(F vs M)	2.02	0.82	4.98	1.79	0.59	5.44
Education status						
(Edu vs Unedu)	0.71	0.28	1.82	0.75	0.17	3.292
Occupation						
(TH vs U)	1.74	0.36	8.48	>999.99	<0.001	>999.99
(P vs U)	0.62	0.23	1.69	0.77	0.26	2.23

***P<0.05**; E- Elderly; YA- Young Adults; MA-Middle aged; F- Female; M- Male; TH- Traditional healer; U- Unemployed; P- Professional; Edu- Educated; Unedu- Uneducated

Table 4.6: Odds ratios, Lower (LCI) and Upper (HCI) Confidence Intervals for reliability of IK use to ensure water security

Predictors	Reliability					
	Umhlabuyalingana			Musina		
	Odds ratio	LCI	HCI	Odds ratio	LCI	HCI
Age						
(E vs YA)	**0.17***	0.04	0.71	0.76	0.25	2.36
(MA vs YA)	0.97	0.26	3.58	0.93	0.35	2.46
Gender						
(F vs M)	0.42	0.12	1.52	0.54	0.22	1.32
Education status						
(Edu vs Unedu)	0.72	0.19	2.66	1.13	0.37	3.45
Occupation						
(TH vs U)	5.01	0.78	32.17	4.15	0.90	18.98
(P vs U)	0.74	0.22	2.42	**2.75***	1.16	6.51

***P<0.05**; E- Elderly; YA- Young Adults; MA-Middle aged; F- Female; M- Male; TH- Traditional healer; U-Unemployed; P- Professional; Edu- Educated; Unedu- Uneducated

Table 4.7: Frequency of indigenous knowledge use

		Umhlabuyalingana		**Musina**	
		(%) Proportion frequently using IK	P values	(%)	Significance
Gender	Male	70	NS	37	NS
	Female	30		63	
Age group (Years)	≤ 25 - 40	17	NS	58	NS
	41-59	18		25	
	>60	65		17	
Level of education	Uneducated	42	NS	19	*
	Primary	7		35	
	≥ Secondary level	51		46	
Livestock husbandry training	Yes	29	NS	22	*
	No	71		78	
Occupation	Professional	12	*	20	*
	Traditional healers	8		10	
	Unemployed	80		70	

NS: Not significant (P>0.05); * P<0.05

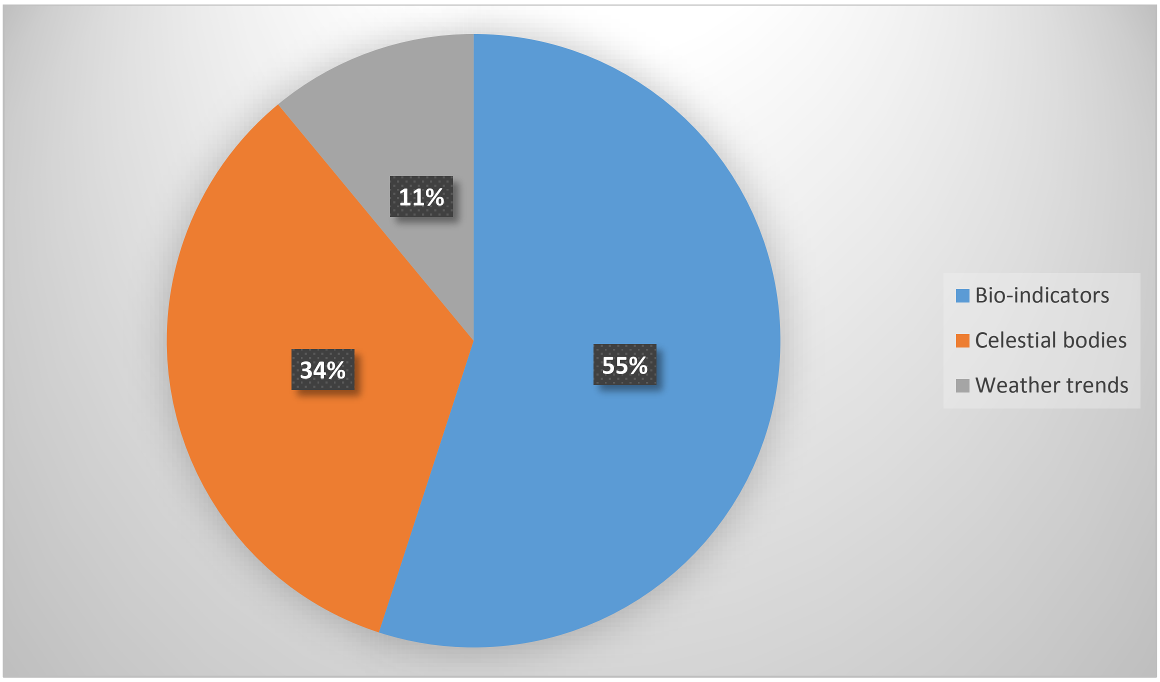

Figure 4.1: Use of IK to predict water security

4.3.5 Perceptions on IK strategies to avoiding droughts

The indigenous methods of evading droughts (detailed in Chapter 3) include temporary transhumance and the use of rituals. Significant differences ($P<0.05$) on perception were found on gender, age-group, livestock training and occupation when using transhumance (57%) in Umhlabuyalingana. Similarly, Musina had significant differences ($P<0.05$) on the use of transhumance (50%) across different age groups, gender, level of education, livestock husbandry training and occupation. Additionally, there was a significant influence ($P<0.05$) of age groups on the use of rituals (29%) as a method of evading water shortages.

4.3.6 Perceptions on IK strategies for coping during drought

Indigenous knowledge methods used to cope during water shortages included rituals, destocking, digging deep and shallow wells, changing the management system to abolish night kraaling, and providing water to livestock in water troughs. Mitigative strategies employed in Umhlabuyalingana and Musina Local Municipalities are illustrated in Figure 4.2. In Umhlabuyalingana, all the demographic factors tested affected ($P<0.05$) perception on reducing stocking rates and the digging of wells. Education and occupation affected ($P<0.05$) the perception on abolishing night kraaling and provision of water in water troughs.

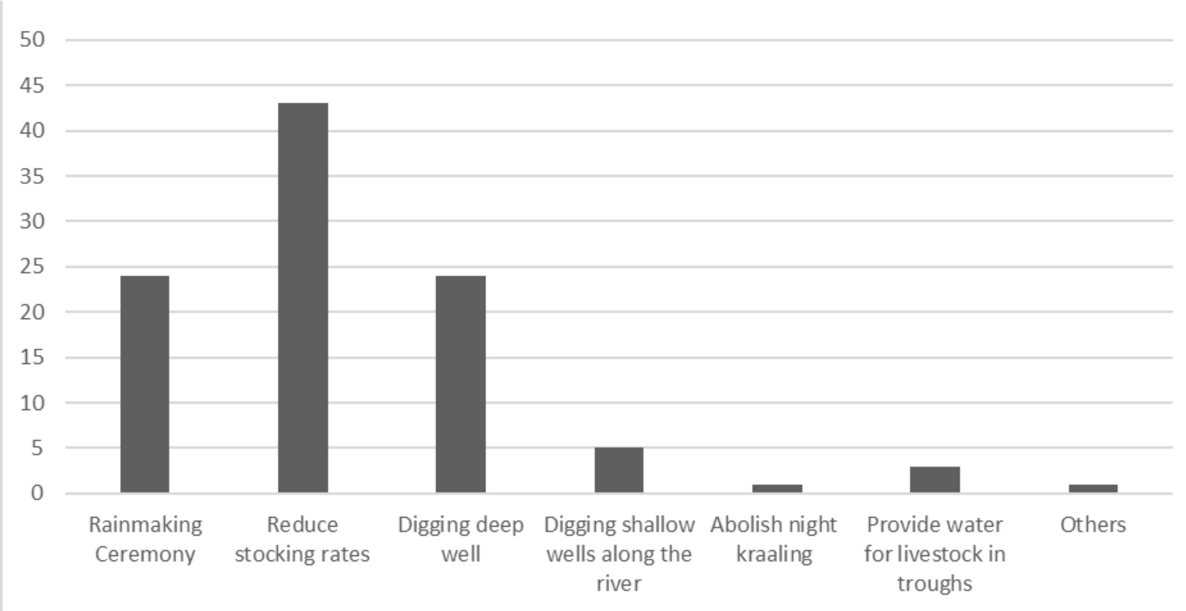

Figure 4.2: Indigenous knowledge methods used to cope during water shortages

The popular mitigating method was destocking (34%) which was affected ($P<0.05$) by occupation and livestock husbandry training. Abolishing night kraaling and rainmaking ceremonies were fairly popular (15%), and the perception was influenced ($P<0.05$) by occupation.

In Musina, significant influences were reported for destocking and digging of deep wells at the onset of droughts. Rainmaking was fairly prevalent (24%) and was influenced ($P<0.05$) by occupation as well as digging deep wells, which was affected ($P<0.05$) by all demographic characteristics. Type of occupation further affected ($P<0.05$) use of rainmaking ceremonies. Households commonly reduced stocking rates as a method of mitigating droughts.

During periods of water shortages, households sustained their livestock by using natural forage, crop residues or supplements (Figure 4.3). In relation to livestock water security, households in Umhlabuyalingana preferred feeding their livestock on natural forage (44%), and their decision was influenced by gender ($P<0.01$), occupation ($P<0.01$), level of education ($P<0.01$) and livestock husbandry training ($P<0.05$). Males (82%) strongly preferred ($P<0.01$) natural forage as well as those who have gone beyond secondary school in their education (55%). In addition, preference of natural forage during water shortages was chosen by the unemployed (97%) and those without formal training in livestock husbandry.

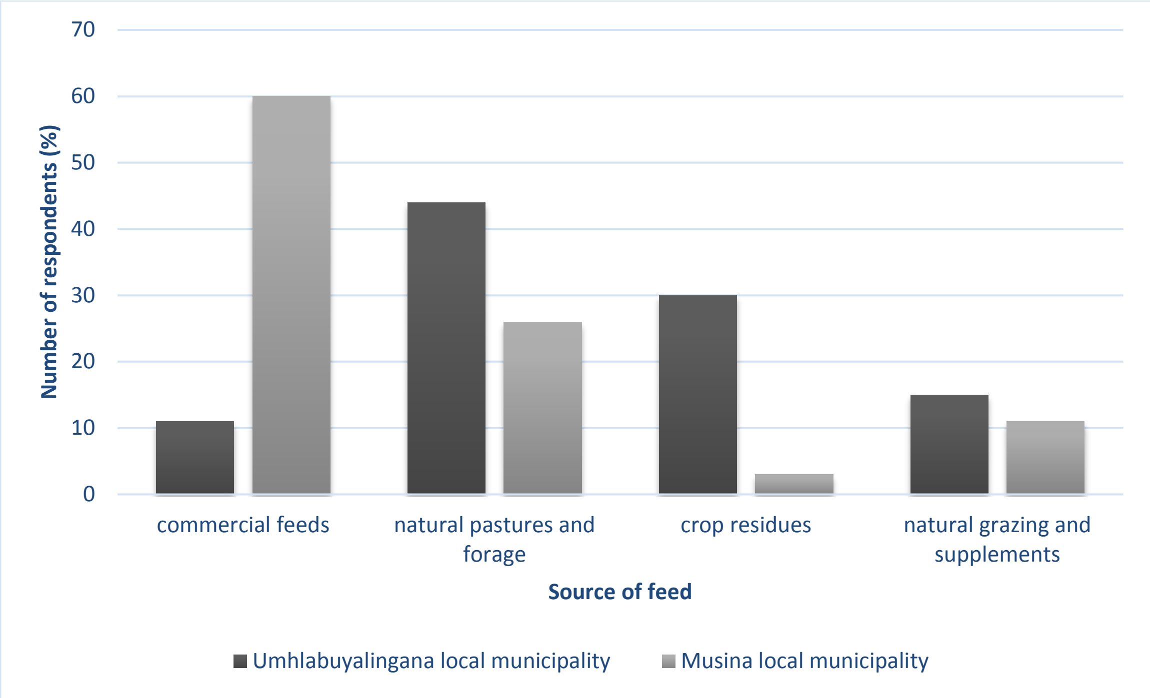

Figure 4.3: Type of feed used for livestock during water shortages

4.3.7 Perceptions on IK methods to adapt to water insecurity

Indigenous methods used to adapt to water shortages are illustrated in Figures 4.4 and 4.5. To prepare for future droughts, in Umhlabuyalingana, rearing Nguni breeds was prevalent (84%), and the decision was highly affected (P<0.01) by demographics. On the other hand, the most frequent adaptive strategy in Musina was rearing goats (84%) and was influenced (P<0.05) by demographics, especially livestock training and occupation (P<0.001).

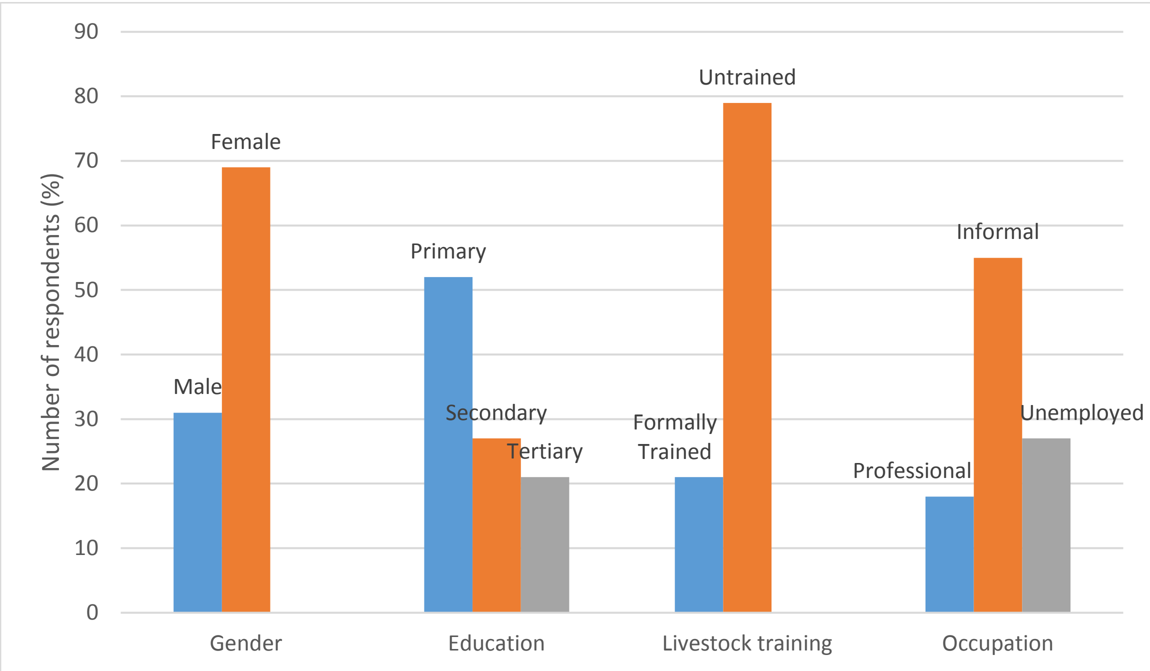

Figure 4.4: Preference for rearing goats as an adaptation strategy

4.3.8 Perceptions on IK methods used to recover from the effects of water insecurity

Communities reconstruct themselves by refilling shallow wells, buying new stock and training the younger generation ($P<0.05$). Demographics affected ($P<0.05$) choice of reconstruction methods in Umhlabuyalingana. Males, above the age of 56 years, younger than 40 years the uneducated, those without livestock husbandry training and the unemployed predominantly used to refill shallow wells, bought new stock and trained more youthful generations.

In Musina, refilling of shallow wells along the river (71%) was done at the beginning of the rainy season and the decision was affected ($P<0.05$) by livestock husbandry training and occupation. Those without livestock husbandry training (84%) and the unemployed (72%) preferred using this method. Households in Musina bought replacement stock (89%) but this was influenced by gender, age group, level of education, livestock husbandry training and occupation. Females (64%), who were aged below 40 years (60%), those who attained secondary education without livestock husbandry training (81%), and the unemployed (72%) preferred buying the new stock at the end of a drought. Training of younger generation (7%) was affected ($P<0.05$) by age group, level of education and the unemployment status. The age group below 40 years (88%), those with secondary education (75%) and the unemployed (87%) preferred training the younger generation.

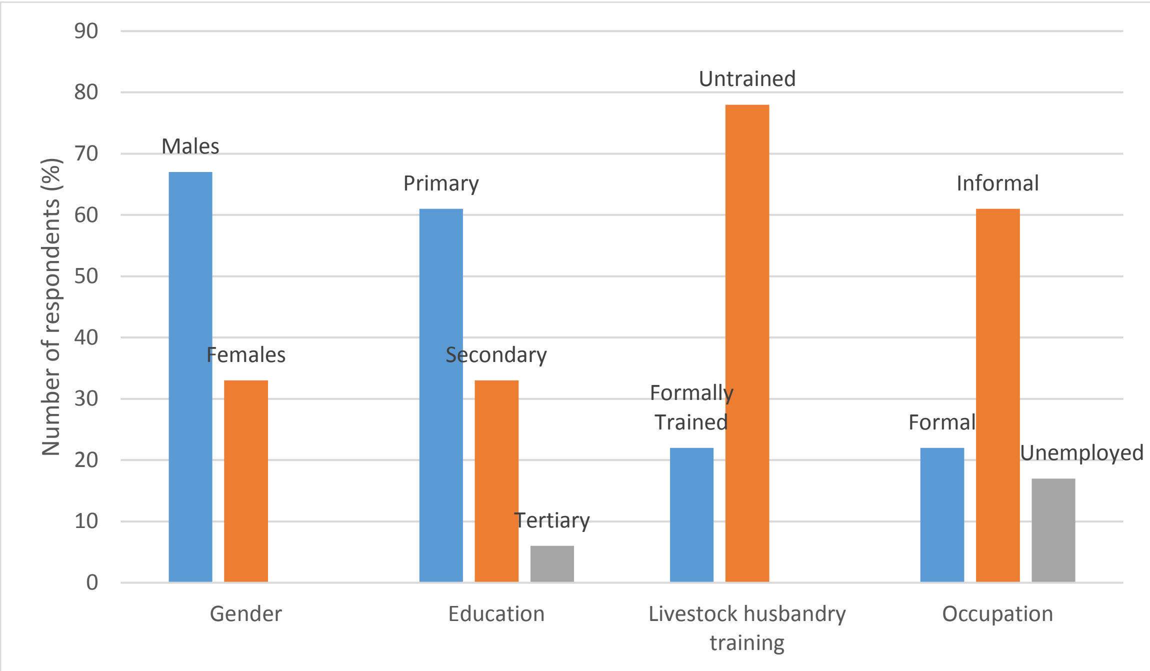

Figure 4.5: Preferences of rearing indigenous breeds as an adaptation strategy

4.4 DISCUSSION

The observed strong association between age group, level of education and occupation on reliability and accuracy of IK highlight the relevance of IK among resource-limited communities (Chikodzi *et al*., 2014). Like accuracy and reliability, age is directly associated with the experience. Therefore, perceptions of reliability and accuracy are expected to be higher in the elderly than the young due to having more water security experience than their counterparts have. In the case of the ability to apply IK, it is expected that the young generation is not able to apply as opposed to the older generation. There is an ongoing transmission process of IK from the old to the young (Paniagua-Zambrana, 2014). Hence, the young receive the knowledge from their elders and then improve their IK skills through practice and experience.

Despite the potential to enhance IK, formal education can result in drastic social changes due to its over-reliance on conventional science (Magni, 2017). Mamba (2016) similarly reported that the level of education influenced perception on IK use. Most rural communities are faced with adverse socio-economic conditions, which may be a limiting factor in formal school attendance. Lack of basic education may contribute to the erosion of IK. The ability to read and write will promote documentation and integration of IK and hence assist in its preservation. Participation in policy formulation and compliance to policy can also be enabled by literacy (Mathibela et al., 2015). Therefore, it can be expected that education level reduces the perception of IKs accuracy.

Animal husbandry training has an effect on the management of livestock during droughts, thereby influencing the decision on the best course of action during periods of water insecurity. Animal husbandry training curricula are based on conventional techniques of managing livestock. As a result, this may affect how households decide to ensure water security during periods of water shortages with a bias towards conventional methods. This is against the background that indigenous technical knowledge has been reported to be reliable and effective (Amitendu *et al*., 2004).

Occupation affected convenience, reliability and accuracy of IK methods showing that professionals, traditional healers and the unemployed have varying priorities in ease of applying an IK. Professionals are usually responsible for offering skills and services to ensure the livelihoods of communities. However, their training is usually based on conventional systems, which negatively influences their perception of the accuracy of IK as they put their trust in what they were schooled to be accurate and reliable (Magni, 2017). Traditional diviners, however, are IK practitioners and rely on it for their day-to-day operations. The unemployed have no financial footing to sustain conventional interventions. Therefore, it is expected that traditional diviners have a positive attitude towards IK, and the unemployed rely on IK hence considering it accurate, reliable and convenient.

Gender did not affect IK use, and similar findings were reported by Paniagua-Zambrana (2014). Everyone has a role in water security, regardless, and any adverse change will affect both genders equally. Shortage of water is not selective, and hence alternative measures are taken by both genders to ensure that they are adequately supplied.

Perceptions on IK use were not influenced by the site denoting that Umhlabuyalingana and Musina Local Municipalities had no significant cultural differences. Apart from these communities being located in sub-Saharan Africa, the culture and languages stem from Bantu culture, with archaeological evidence pointing to a common descendent (Russell *et al*., 2014). Therefore, this common aspect may influence similarities in their culture and how they respond to water insecurities.

Traditionally, elders are the custodians of IK and pass it on to their children. Elders in Msinga were knowledgeable in indigenous methods and were willing to pass on the information to the youth regardless of the youth responding by undermining traditions (Rukema and Simelane, 2013). Our findings revealed that the youths are beginning to show great interest in IK. As such, the perception that young people are not interested in issues to do with tradition can be challenged. The results further disqualify 'the old' as default experts of the IK application. The high likelihood of young adults in Umhlabuyalingana using IK to ensure water security may indicate their positive attitude and receptiveness to issues of IK. Young adults represent the future and are physically and mentally strong enough to participate in water security programmes.

Traditional diviners can be hands-on even in spiritual interventions to ensure water security. They act as advisors, intercessors between divine beings and the community and practice IK as a way of life while benefiting economically (Mathibela *et al*., 2015). Hence, they possess more knowledge than unemployed community members who can rely on traditional diviners for guidance. Because of their vast knowledge, traditional diviners can be engaged and encouraged to engineer IK programmes that ensure water security in communities.

The finding that educated households were more likely to be knowledgeable than uneducated households suggests that education sensitises communities to information. Contrary to the current results, Matope *et al.,*(2020) reported that education increases the ability to implement Western technologies, implying that it replaces the significance of IK. The current findings strengthen the role of social and cultural approaches to water security, which can potentially override or augment conventional efforts. The results that employed professionals were likely to consider IK reliable show their positive attitude towards IK. Successful IK programmes were implemented based on this perception by professionals in Mexico, where developmental programs were established and promoted in their respective communities (Magni, 2017).

The prevalence of IK use was common among the unemployed in both municipalities. The financial constraints among the unemployed disqualify them from using expensive conventional methods, such as drilling boreholes and purchasing water, such that they rely on IK methods, which are cheaper. Contrary to many studies, the educated and those who received training in livestock husbandry used IK widely. This implies that despite the influence of a conventional education system, households acknowledge the contribution of IK to ensure water security in the face of adverse water shortages.

In Musina Local municipality, IK users relied on bio-indicators compared to astronomy and observing weather patterns (Makwara, 2013; Mahoo *et al*., 2015). Plants and animals can sense variations in the environment and respond by showing physiological and behavioural changes, which can be used to forecast the absence or availability of water (Radeny *et al*., 2019). Birds sense an increase in air pressure, forcing them to display behavioural changes. Swallows, in particular, have sensitive ears that detect changes in air pressure. High air pressure associated with rain allows birds to fly with ease, and hence they move from a low-pressure area to a high-pressure area (Robillard *et al*., 2013). High-pressure tropical systems originating from the South-West Indian Ocean are responsible for 10% of the rains in the Limpopo River Basin, where Musina Municipality falls (Malherbe *et al*., 2012). This makes use of birds in ethno meteorology highly significant in ensuring water security in Musina.

Coping with water insecurity through avoidance is an emotion-based strategy that involves isolating oneself from a cause of stress and reducing the risk of loss (Scott *et al.,*2010). The most prominent method common in both municipalities is temporary transhumance, highlighting the importance of livestock in the livelihoods of resource-limited communities. Temporary transhumance is an economically sound strategy that seeks to preserve livestock's body condition and reduce losses due to incidences of mortalities associated with water shortages. Again, the strong attachment of farmers to their livestock may compel them to relocate them to areas where water is available temporarily. Successful incidences of temporary transhumance were reported in Zimbabwe (De Haan *et al*., 2016). However, the sustainability of this method may be limited by land ownership and livestock restriction laws. In the Western Cape, practising transhumance was historically prevalent but is currently shrinking due to these laws (Beinart, 2007). The success of temporary transhumance as an effective method of ensuring water security for livestock can be done with assistance from other stakeholders like the police, veterinary department and traditional leaders who should closely monitor livestock movements to reduce incidences of theft and transmission of livestock diseases.

The popularity of rituals in Musina reflected the local communities being deeply rooted in spiritualism. The belief that droughts and similar disasters result from angering spiritual entities, in this case, ancestors, is a common phenomenon in many African communities (Chemhuru and Masaka, 2010). As such, rituals are performed to quench the anger through pleading and asking for the interference of ancestors by sending the rain. Rituals are a cross-cutting practice used to predict, evade and mitigate periods of water scarcity. The procedures of conducting rituals are unique to any community and linked to the ancestors of a community who dictate what should be done and when (Chemhuru and Masaka, 2010).

Reduction of stocking rates was popular, followed by rituals. The popularity of destocking shows that households take reactive responses to water shortages. Destocking does not improve the water security situation but buffers the household against economic losses as droughts intensify. Many governments have also recommended destocking as a mitigative strategy for example, northern Kenya (Morton and Barton, 2002), Zimbabwe (Ndlovu, 2019) and Swaziland (Kamara *et al*., 2019). In Lesotho, households that destocked later in the drought incurred economic losses through the death of livestock or having to sell when value had depreciated (Kamara *et al*., 2019). The decision to destock was affected by education and livestock husbandry training. These factors conscientise households on the appropriate time to destock and allows them to make economically intelligent decisions in the face of adverse water shortages. Destocking in Umhlabuyalingana was affected by gender. Males are generally responsible for making household economic decisions with large livestock (Devkota *et al*., 1999). There are gender inequalities in education where males are more educated than women, affecting household decision-making (Devkota *et al*., 1999). Furthermore, females are likely to be emotionally attached to their livestock (Njuki *et al*., 2013) and, therefore, can decide against destocking as a mitigation strategy.

Households kraal their livestock for the sole reason of safeguarding them from theft and attacks by predators. Free-ranging is the primary management system in resource-limited communities. During periods of water security, pasture and water are freely available; hence, cattle have enough to eat and drink during the day. During periods of water insecurity, however, part of the water requirements of livestock are catered for by forage. Households, therefore, abolish night kraaling to allow them to meet the nutrient and water requirements by foraging during the night (Smith *et al*., 2006). Households capitalise on the fact that restriction affects the grazing pattern of cattle (Gekara *et al*., 2005). Similar findings to Umhlabuyalingana were reported in the Eastern Cape by Moyo *et al.,*(2012), who confirmed that night kraaling increases cattle grazing activity to compensate for time spent while enclosed. Abolishing night kraaling also allows cattle to reduce water loss from the body during the hot daytime by resting (Moyo *et al*., 2012).

Digging wells is done to make use of groundwater reserves during droughts. Groundwater can act as an emergency water source to scope during droughts (Mussa *et al*., 2015). Most resource-limited communities use hand-dug communal or private wells as water sources when the water security situation becomes dire. Traditional communal wells come with their challenges, including pressure on these water sources leading to long queues, increased time on the water source, conflicts and competition of the resource with humans and livestock. Digging wells privately allows communities to distribute the underground water resource and ensure access to all. As the water scarcity situation increases, the depth of the wells will have to be adjusted as the water table lowers.

For sustainability, keeping a positive groundwater budget should be encouraged as it determines the rate of groundwater depletion. As such, the use of wells as drinking water sources for livestock needs to be reviewed. Collectively, subsistence and smallholder farmers in South Africa own a herd size of 5.6 million cattle (Ndoro *et al*., 2015). Water consumption of cattle is 8 litres per kg of dry matter consumed at 32˚C environmental temperature (Shlink *et al*., 2010). If wells are the only option, such as during droughts, this can be translated into 44.8 Mega litres of groundwater per kg of dry matter consumed. This can potentially cause a strain on the groundwater resource.

Adaptation through stock composition can be made by changing the reared breeds or species. As reported in both municipalities, rearing indigenous livestock breeds and species is a commonly used adaptation strategy in water security. Indigenous breeds are hardy and resistant to hot temperatures and water scarcity associated with droughts. The Nguni are one of the breeds that are native to South Africa. The Nguni cattle has a small to medium body size, tolerance to hot temperatures, and high walking ability, enabling them to travel long distances in search of water (Bester *et al*., 2003). Similar results to Musina were reported in the Karoo, where the household reared Boer goats changed to Angora (Ncube and Lagardien, 2015). Indigenous livestock has gone through natural selection, which enhanced them to adapt to the Southern African environment through tolerance to heat and feed and water shortages (Mwai *et al*., 2015). The implication of rearing indigenous livestock is that resource-limited households become resilient to the losses associated with water shortages and droughts.

Reconstruction methods employed were used to recover from the effects of water shortages and either ensure environmental sustainability, improve livelihoods, continuity of IK to younger generations and build resilience to future droughts. The decision to refill shallow wells as a recovery method was predominant. Males are primarily involved in manual jobs, for example, digging deep wells and filling shallow wells with the earth, while females focus on domestic chores like cooking and washing (Sandy, 2008). The age group above 55 years also preferred using this method showing their high regard for environmental conservation and sustainability. People without basic education, livestock training, and the unemployed also used this method to naturally indicate social responsibility in rural communities. This strength can be capitalised in developmental programs.

Buying replacement stock was reasonably popular. Males in Umhlabuyalingana were responsible for this decision. This shows the dominance of males in household financial decisions (Devkota *et al*., 1999). In Musina, contrasting results to Umhlabuyalingana found that females buy replacement stock more than males. This may indicate more female-headed households than its counterpart, which makes females to do tasks that men usually do (Cheteni *et al*., 2019). Unlike asking neighbours for breeding stock, buying allows households to choose animals with superior qualities that they can include as their stock. As such, the uneducated, without livestock training and unemployed, preferred buying. The age group above 55 years is experienced in livestock production. Hence, they can choose new stock better than the younger generations. In Musina, the findings contrasted with Umhlabuyalingana, where those below the age of 40 and who have secondary or tertiary level education preferred buying. The educated may be well versed in issues that lead to disease transmission, heterosis and conflicts in livestock production.

Training of the younger generation was significantly used in both municipalities. Males widely preferred to train the younger generation. The cultural role of men is to ensure that their culture is passed on to their children for the continuation of their legacy, and this can explain why they are actively involved in training the younger generation. In Umhlabuyalingana, the elderly above the age of 55 years preferred training. This is consistent with Paniagua-Zambrana (2014), who reported that the elderly are custodians of IK and are responsible for passing it to the young. In Musina, however, training was done by the young, indicating a discourse in continuity and transmission of IK. In Umhlabuyalingana, the unemployed and those without livestock training preferred training. Meanwhile, those with education levels above secondary school widely used training to promote resilience to future droughts in both municipalities.

CHAPTER 5: INDIGENOUS KNOWLEDGE SYSTEMS FOR LIVESTOCK MANAGEMENT DURING DROUGHTS

5.1 INTRODUCTION

Livestock production is the primary source of livelihoods in communal areas contributing towards nutrient security (meat, eggs and milk), economic (income generation, countercyclical buffering), cultural (sacrifices during rituals) and clothing (hides and wool). The roles of livestock warrant the conservation of the livestock herds in communal areas to sustain households. Despite their contribution to livelihoods, livestock numbers in South Africa are gradually decreasing, with cattle estimated to have been 12 505 000 in November 2019 from 12 825 592 in May 2018 (National Livestock Statistics, 2020). The decline in the national herd can be attributed to natural disasters associated with climate change, such as floods, recurring droughts and general water shortages.

Livestock production in communal production systems has been under threat with the increased occurrence and intensity of droughts. Livestock numbers decline during a drought due to mortality associated with dehydration, starvation and diseases due to a weakened immune system (Blench and Marriage, 1999; Ndlovu, 2019). Vetter *et al.,*(2020) reported a 43% livestock mortality in KwaZulu-Natal alone and a 15% decline in South Africa's national herd during the 2015/16 drought. Apart from water scarcity due to droughts, general water shortages have been reported to be a significant constraint of livestock production in most parts of Southern Africa (Rembold *et al*., 2016). Hence, water availability challenges in Southern Africa are not an isolated incidence but are continuing.

In the face of climate change in Sub-Saharan Africa (SSA), temperatures are projected to increase by 2°C by the year 2100 (Serdeczny *et al*., 2017). South Africa has already shown an increase in the mean annual temperatures by 1.5 times the global average of 0.65˚C in the last 50 years (Ziervogel *et al.,*2014). Yearly precipitation in Southern Africa is predicted to decline by 20% (Conway *et al*., 2015). The general temperature increases, high frequencies of droughts, and rainfall variability are likely to intensify water stress and high levels of aridity in SSA (Otte et al., 2019), which impacts livestock production.

During droughts and water shortages, livestock experience water, feed and health stresses compounding to mortalities and loss of livelihoods. The dynamic state of communal livestock production systems as communities adapt to climate change creates a knowledge gap that warrants an investigation. There is limited literature on the survival of communal herds during periods of water shortages and droughts, making the characterisation of smallholder livestock production complex (Swemmer *et al*., 2018; Vetter *et al*., 2020). Complexities are exacerbated by integrating conventional and indigenous management techniques, employed due to low education status, low income and strong faith in local methods (Paniagua-Zambrana *et al*., 2014). There is a need to determine how farmers have adapted to ensure livestock survival during droughts.

Indigenous knowledge systems of livestock management are relevant in mitigating droughts and water shortages due to their accessibility and affordability. Understanding farmer and livestock adaptation to water shortages assist in mapping future interventions that are socially and culturally acceptable and relevant. Critiquing IKS used, assists in creating gaps towards its acceptance into mainstream livestock management systems. Over 2.5 million households in South Africa directly keep and depend on livestock production (Lehohla, 2016).

The study's objective was to critique the IKS used to sustain livestock during periods of water shortages and droughts. The main research questions were:

- What are the indigenous methods used in water, nutrition and health management of cattle during periods of water shortages and droughts?
- What are the strengths and limitations of IKS used in cattle management during water shortages and droughts?

5.2 MATERIALS AND METHODS

5.2.1 Study site

The study was conducted in Musina and Umhlabuyalingana Local Municipalities in Limpopo and KwaZulu-Natal, respectively. The description of the study sites was detailed in Chapter 3 of Project K5/2920.

5.2.2 Data collection

5.2.2.1 Interviews

Data collection was conducted with the assistance of officials from the Department of Agriculture and Rural Development and the local leaders who assisted in identifying eight farmers who own livestock, particularly cattle, in each municipality. Four trained enumerators from the local community in each municipality assisted in data collection.

Data were collected qualitatively through face-to-face interviews. The interviews were conducted in Tshivenda and Zulu, the local languages in Musina and Umhlabuyalingana, respectively. An interview guide was used as a template for the questions to ensure that no information was left out in the interview process. Otherwise, the enumerators used probing to capture inferred feelings as well. The interviews were recorded using digital tape recorders to prevent data losses in case of a technical malfunction. Notes were taken during the interviews. Data collected included indigenous health management methods, feed and water management, cow-calf management and breeding management.

5.2.2.2 Direct observations

Direct observations were used to monitor selected livestock to determine the distance travelled to the nearest watering points, frequency of drinking, time spent drinking, grazing and resting. A digital camera was used to take photographs of any relevant study details.

5.2.3 Data and statistical analyses

Interviews were organised into themes using the Nvivo software.

5.3 RESULTS

5.3.1 Water management

Indigenous methods of ensuring cattle water supply during droughts exploited perennial rivers and sacred wells.

5.3.1.1 Use of perennial rivers

The IK informants revealed that seasonal migration of cattle was common where cattle temporarily camped close to perennial rivers such as the Limpopo and Pongola. Recently, livestock movements have been restricted; hence, when the water situation gets dire, the movements were now localised. In KwaSonto Village, key informants indicated that their cattle utilised water from Umnandawu River and Domboni, Nwanedi River. Cattle travelled for more than 5 km to access these rivers from KwaSonto village to Umnandawu River and 10 km from Domboni Village to Nwanedi River.

A key informant revealed that cattle camps were pitched north of the Limpopo River on the Zimbabwean side prior to the movement control laws. Currently, localised camps were made along the Nwanedi River, where water was easily accessible.

'My cattle camp there in Nwanedi. I do not want my cattle to travel long distances to access water because it stresses them. I go there to count them and check for any diseases among them after every three days.'-
Livestock farmer, Malale, Musina

In Umhlabuyalingana, cattle camp close to rivers and they are checked by the farmers once every week.

5.3.1.2 Use of the sacred well

In Domboni village, Musina, one of the traditional leaders disclosed that the sacred well (*Tshilingoma*) was used when droughts intensified, and all available water sources had dried up.

'*Tshilingoma is our ancestors' way of ensuring that our people and their livestock have water when they have been befallen by a drought*' – Traditional leader, Domboni Village

The sacred well was situated in the mountains, and only authorised individuals could access the well. The royal family and users granted permission to use the well were expected to observe rules, including refraining from wearing bright colours for fear of angering the snake and leopard that man the well. Livestock utilised the spillage water that flows to the bottom of the mountains from the well.

5.3.1.3 Exclusive free ranging

A village elder in Domboni Village disclosed that their forefathers used to own large herds of cattle, and because there was a lot of space, the cattle were left to fend for themselves. In the current context, key informants in both municipalities disclosed that exclusive free ranging was done primarily to allow the cattle to fend for themselves. One key informant had two cattle breeds in his herd, the Nguni and the Brahman. By the middle of the drought, the Brahmans travelled 10 km to Nwanedi River to consume the vegetation along the river, while the Nguni utilised trees in the mountains behind Domboni village. The informant revealed that his Brahmans are sensitive, so he left them at the river for two to three days to reduce the stress of walking long distances.

5.3.1.4 Use of tree species

Key informants revealed that using herbaceous material to supplement feed for lactating cows, pregnant cows, calves, and sick animals was common.

'*We use the leaves of particular trees to make our vulnerable cattle strong*'- Key informant, Musina

Figure 5.1 shows the tree species that are utilised. Tree species used included the baobab tree (*Adansonia digitata*), Lebombo ironwood (*Androstachys johnsonii* or *Musimbiri* in Tshivenda), red bushwillow (*Combretum apiculatum* or *Musingidzi* in Tshivenda), wild olive (*Olea africana* or *Mutwari* in Tshivenda), white raisins (*Grewia bicolor* or *Mutabva* in Tshivenda), *Mutobi* (Tshivenda) and turpentine tree (*Colophospermum mopane* or *Mopane* in Tshivenda). Lebombo ironwood was mainly given to animals in poor body condition. Hay was also provided to the above classes of cattle as supplements.

5.3.2 Health management

One of the biggest challenges to cattle health during water scarcity is parasitic load. Faecal and body condition assessments were used for parasite diagnosis.

5.3.2.1 Faecal inspections

Faecal inspections were done in both municipalities. The indicators of parasite infestations included consistency and the physical appearance of the dung.

White raisins (*Mutabva*)

Red bushwillow (*Musingidzi*)

Lebombo ironwood (*Musimbiri*)

Mutobi

Figure 5.1: Herbaceous trees consumed by cattle during extreme water shortages

Faecal consistency

In both Musina and Umhlabuyalingana, key informants unanimously reported that the consistency of the dung is an indicator of parasitic infestation. Loose dung, which soiled the hind legs of the cattle, indicated helminths infestation. Loose dung was perceived to show high levels of infestation with adult worms. In addition, loose dung with solid parts that mimic goats was considered associated with helminths infestation.

Presence of a 'plastic' casing

Figure 5.2 shows different faecal samples with a 'plastic' casing, indicating helminths in cattle. In Musina, parasitic infestations were diagnosed by checking for a transparent, plastic-like covering inside the dung or outside. If the 'plastic' is covering the outside, the dung looks shiny; hence, shiny dung is perceived to be associated with helminth infestation. The same goes for the 'plastic' being intrinsically embedded within the dung.

Figure 5.2: Different cattle faecal samples with a 'plastic' indicating presence of helminths. The top right sample is shiny also indicating presence of helminths

5.3.2.2 Control of gastrointestinal parasites

Helminth infested animals are given Aloe (*Tshikopa* in Tshivenda, *Inhlaba* in iZulu) leaf crushed and mixed with water, ground *Mtutula* roots mixed with water and ground leadwood (*Combretum imberbe* or *Mudzwiri* in Tshivenda) roots mixed with water. In Umhlabuyalingana, helminths infestation was controlled using roots of eland's bean (*Elephantorrhiza elephantina* or *Intolwane* in Zulu) which were prepared by grinding and mixing with boiled water.

5.3.2.3 Pregnancy diagnoses

Pregnancy diagnosis and monitoring are critical management strategies employed to ensure foetal and cow health. Key informants revealed that pregnancy could be diagnosed 2 months after conception, and the first sign is that the tail will hang at the side of the vulva illustrated in Figure 5.3. As the pregnancy progresses, the belly and the udder increase, as denoted in Figure 5.4.

Figure 5.3: The tail hanging on the side of the vulva as a sign of pregnancy in cows

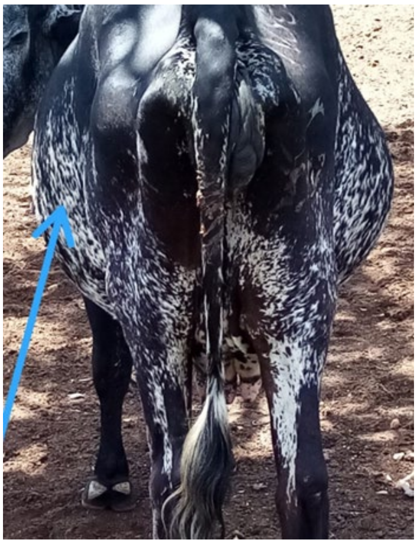

Figure 5.4: A pregnant cow with a bulged abdomen indicating an advanced pregnancy

Key informants in both municipalities agreed that the next critical stage after pregnancy diagnosis was parturition.

5.3.2.4 Signs of parturition

The signs of parturition were noticed a few days before. The vulva produced mucous discharge, seen under the tail at this stage. This sign indicated that the cow would calve within a week. A day or two before calving, the cow walked ahead of the cattle and isolated itself from the rest of the herd. In addition, the area near the tail end became hollow. At this point, close monitoring was done to ensure that the cow had safe parturition.

"*The back of the cow will be enlarged. Mucus will be discharged from the back. The way it walks away from the other cattle will tell you that it is less than a week away*"- Key informant, Umhlabuyalingana

"*When it is time, the cow will walk in front of the rest of the herd because it doesn't want the other cattle to see it in distress while giving birth. In fact, it is rare to give birth in a kraal where the other cattle are*"- Key informant, Musina

5.3.3 Selection of breeding cows and bulls

The herds were mostly made up of Nguni, Afrikaaner and Brahman mixes. Key informants revealed that the farmers practice selection of traits of economic importance. Key informants considered important traits were split between productive and drought-tolerant characteristics. One cattle farmer indicated that productive traits are important to him despite the droughts since he rears his cattle to resell.

'Even if there are a lot of droughts in the area, I prefer large-sized cattle such as Brahmans because I want to sell them and get profits. One Brahman sells for R15 000 while a Nguni will give me less than R10 000. This year alone, I lost 8 of my Brahmans to drought, but I will still choose them for their body size regardless'- Informant, Domboni

In Umhlabuyalingana, a key informant revealed that he preferred Brahmans for their market value, although he knew they do not perform well during droughts or water shortages. In contrast, some key informants in Musina were mindful of the need for promoting drought-tolerant traits and one key informant mentioned that it is one of the major ways of combating drought. The important traits to him were tolerance to drought, doing ability (the capacity to maintain body weight in the middle of a drought) and disease tolerance. When it comes to buying new cow stock, two informants indicated that the availability of money often limits them to select for traits they want from the onset.

'My choice in selecting for traits is limited when I am buying new stock. I do not ask much. I just buy whatever animal is on offer that is equivalent to my money'- Informant, Domboni

The bull selection was done to determine which bulls to castrate or cull through selling or slaughtering. Bull traits desirable to livestock farmers were large body size, fertility, temperament and mounting ability. Body size was noticed very early among calves, where the bull with a large body size grows bigger than its age mates do. Fertility traits, including mounting ability, are determined by observing the bulls among cows. A key informant revealed the following;

'If the cows in the same herd as the bull are followed by other bulls from other herds, then we know our bull is not doing its job. Even when the bull is still a calf, you can tell whether it can mount from the way it plays with the cows. A calf which is active and practices mounting the cows will be able to mount when the time comes' – Informant, Domboni

'*I want a bull that is well disciplined that is not always running around*'- Informant, Umhlabuyalingana

The preferred coat colour among the key informants was brown instead of black. When asked about the ease of selecting desirable traits in their cattle herds, farmers indicated that it was not easy because of herd interaction while the cattle were searching for food and water. Another limitation was the capital when buying new stock, such that they believe what they can afford regardless of its traits.

One key informant also stated that farmers could manipulate the sex of cattle. He said that after a cow has given birth, the sex of the next calf can be manipulated by using the afterbirth. Once the afterbirth is out, it is overturned utilising a shovel to land with the side which was on top.

In Musina, big body size was frequently cited when selecting cows, followed by calving and mothering abilities. In terms of breed, one informant indicated that they prefer the Nguni cows because they can successfully give birth even to a Brahman calf.

5.3.4 DISCUSSION

Perennial rivers or streams can successfully sustain cattle during dry periods, although their utilisation is associated with cattle travelling long distances to access the rivers resulting in walking stress. Walking increases the nutrient and water requirements to fuel the high metabolic rate needed in movement and locomotion (Maurya *et al*., 2012). The findings in the two municipalities were concurrent with those in Zimbabwe (Chakoma *et al*., 2016), West Africa (Alassan *et al*., 2017) and locally in the Cape region (Beinart, 2007), where cattle were moved to camps along perennial rivers. The continuous water flow in perennial rivers or streams can support livestock throughout dry periods. In the end, however, environmental issues may hinder the sustainability of this method. Direct cattle access to rivers negatively affects river morphology microbial contamination and promotes sedimentation (O'Callaghan *et al*., 2019). While rivers and streams may be the only water source for cattle during droughts, sustainable use may be ensured by reducing the time that cattle spend at the rivers (O'Callaghan *et al*., 2019). This can be implemented by discouraging cattle camps along rivers or streams.

Sacred wells were naturally occurring water reservoirs reported in Zimbabwe and Lesotho (Rusiro *et al*., 2013; Muleya, 2014). These wells are used to conserve water during periods of water shortages. They are successfully used as emergency reservoirs through deterrence in the form of taboos. The custodians, who ultimately claim ownership, are those that reside around or near them. The concept of solitary custodians allows the use of the well to be controlled and accounted for, hence reducing mismanagement.

Exclusive free ranging is a form of extensive farming where, due to the lack of inputs, farmers rely entirely on the environment and the adaptive ability of cattle for herd survival. For this reason, indigenous breeds, such as the Nguni, can utilise poor quality forage in rough terrain (Rhoads *et al.,*2013). The method is applicable in communities with large community land spaces instead of private land where trespassing issues may result in conflict. When exclusive free ranging is implemented well with close monitoring mechanisms, cattle can adjust their behaviour to adapt to stressful conditions, including the impacts of water shortages (Ratnakaran *et al*., 2017). Rhoads *et al.,*(2013) reported that cattle under heat-stressed conditions reduce their feed intake. The farmer provides feed and water to conserve energy since it is an energy-consuming activity.

On the other hand, cattle under an exclusive extensive system channel most of their energy to search for feed and water resources. The main weakness of this method is the lack of accountability by the farmer on whether the livestock can meet their daily nutritional requirement. If the cattle are not monitored closely, the method further exposes cattle to ingestion of foreign objects such as plastics and thieves and predators, which may increase mortality.

Tree species used for supplementation during droughts have the dual purpose of providing nutritional supplementation and medicinal effect. The Lebombo ironwood, for example, is an evergreen species that offers herbage material during periods of droughts when most of the trees have dried up (Bakali *et al*., 2017). In addition, the Lebombo ironwood is used for ethnoveterinary purposes on cattle to increase the body condition of sick animals, calves or pregnant or lactating cows (Bakali *et al*., 2017. Baobab tree leaves, for instance, are widely available even during droughts and have both anti-inflammatory properties and high nutritional content. Therefore, the anti-inflammatory properties may be responsible for reducing gastrointestinal ulcerations and discomfort associated with helminths. Baobab leaves contain 13-15% protein, 60-70% carbohydrate and 16% ash (De Caluwé *et al*., 2010). The dry matter content of mature leaves is 11% dry matter, where 21-49% is neutral detergent fibre (NDF), and 16-41% is acid detergent fibre (ADF).

However, the NDF content is lower in young leaves, making the young leaves more palatable (Feedipedia, 2013). The young baobab leaves especially are a source of Vitamin C (Sidibe *et al*., 1996) which assists in reducing heat stress. The synergetic effect of active and nutritional compounds of some tree species qualifies them to be used for ethnobotanical purposes in livestock production. Therefore, supplementation with herbage material can be successfully applied in resource-limited areas, especially where the herd constitutes Bos Indicus breeds that can utilise it. The successful application of supplementation with herbage material should be approached with caution, especially where overexploitation of the tree species can threaten sustainability. Environmental conservationists should work together with communities to develop programs that promote the active planting of these indigenous trees instead of relying on natural seed dispersion and germination. The advantage of planting indigenous trees is that they are genetically adapted to the local environment and will not need to be cultivated or watered.

Gastrointestinal parasites damage the digestive tract, cause discomfort, and increase susceptibility to other diseases. During drought, however, helminth infestation adds more challenges to an already nutritionally and water-stressed animal, reducing its chances of survival. In under-resourced areas, indigenous methods of internal parasite detection are necessary so that farmers can take the necessary steps to minimise the burden. Indigenous practices have identified loose faecal consistency as a sign of helminth infestation, and this is consistent with *Haemonchus sp.* is associated with scouring (Underwood *et al*., 2015). Scouring occurs after parasites' burrowing action has damaged the intestinal lining, reducing water absorption from the digested into the body (Underwood *et al*., 2015). Intestinal mucus discharge is a host response to a parasitic infestation in an attempt to expel the parasite out of the gastrointestinal system (Sharpe *et al*., 2018). Mucus forms a protective barrier to prevent the helminths from burrowing into the intestinal wall and provides a slippery environment that expels the parasites out through the faecal matter (Sharpe *et al*., 2018). Hence, indigenous methods have identified the presence of mucus, which they termed 'plastic' in the faecal matter. Indigenous knowledge methods of diagnosing parasites are effective, although they are limited in determining the type of helminth species present and its load. In addition, limitations are also found in the lack of dosage in the medicinal plants used, threatening the safety and side effects of the medicines used. This warrants further studies to be done in this regard.

Timely and accurate diagnostics are essential in livestock management as a preventative measure and a foundation for relevant interventions during water shortages. As a result, during droughts where livestock losses are high, farmers must be able to detect key elements, which may stress animals if left unchecked. Pregnancy diagnosis assists farmers in reducing cow stressors through the provision of appropriate diets and attention. It improves calving rates and prevents losses through abortions or cow mortality. Mokanthla *et al.,*(2004) reported that one of the causes of low calving rates in communal livestock production systems is abortions. Indigenous diagnostic methods detailed in this study are non-evasive compared to transrectal palpation, which may cause discomfort or damage the growing embryo if not conducted with due care. Conventional diagnostic methods or hiring a veterinary doctor is costly for most communal farmers. Hence, using indigenous diagnostic methods can be equally effective.

The signs of parturition for calving in this study are consistent with the ones detailed by Safdar and Kor (2014). The behavioural sign that the cow isolates herself is a form of nesting behaviour that prepares her to concentrate on the coming of the calf. Mucus discharge is associated with reduced levels of progesterone, which dilates the cervix in preparation for parturition (Safdar and Kor, 2014). The signs detailed by indigenous means do not indicate the exact delivery time but can be used to estimate when delivery can be expected to prevent difficulties in birth and retained placenta.

The belief that the 'first' milk should be milked and given to the calf to make it strong is consistent with conventional methods. Colostrum contains vast amounts of maternal antibodies for passive immunity, growth factors and nutrients for the calf (Gomez and Chamorro, 2017). Indigenous knowledge detailed in this study assisted in identifying the interface between uptake of colostrum and general health of the calf that goes into adulthood. Milking and feeding the calf with the colostrum by the farmer in the first few hours preceding its birth promotes the high uptake of colostrum by the calf, failure which Gomez and Chamorro (2017) referred to as 'failure in the transfer of passive immunity (FTPI).

On the other hand, the preparation process of the colostrum may potentially defeat the purpose of colostrum feeding, which is to transfer passive immunity. When boiling, applying hot temperatures to colostrum may denature critical proteins, particularly immunoglobulins (Godden *et al*., 2006). Application of hot temperatures during boiling kills bacteria, although one of the uses of colostrum is to assist in the early establishment of gut microflora (Gomez and Chamorro, 2017). As a result, farmers must be sensitive to overheating the colostrum, as it can be counterproductive to livestock production.

Scasta et al.,(2006) reported that communal farmers unintentionally select cattle that do not perform optimally during drought. The selection of cattle for their large body weight may work against maintaining the livestock resource base in communal areas in the current situations where droughts are frequent and more intense. Although large body size, such as in the case of Brahmans, yield more profits, when the incidences of high-intensity droughts and heat stresses are prevalent, they will not perform since *Bos Taurus* have low metabolic rates perspiration rates and have different coat characteristics as compared to *Bos Indicus* (Scasta *et al*., 2006). *Bos Indicus* can utilise browse and fibrous forages compared to *Bos Taurus* (Mwai *et al*., 2015). As a result, *Bos Indicus* breeds, such as the Nguni, have genetic resources that could potentially assist in maintaining the herd size in communal areas during droughts. In the same respect, coat colour can affect drought tolerance in cattle. The preferred brown colour and its lighter versions, such as fawn, reflect heat compared to black, with higher solar absorption (Scasta *et al*., 2006).

Selection is done directly when choosing cattle to cull or castrate. When it comes to selecting cattle for mating, the extensive nature of the livestock production systems in communal areas limit the control farmers have on the selection process. Herds mix when the cattle are searching for forage and water. This result is concurrent with Scasta *et al.,*(2006) and Mthi *et al.,*(2020), who revealed that communal farmers practice controlled breeding and that inter-herd interactions are difficult to control in systems with no fencing or paddocking.

The informants acknowledged the significance of selection in building a drought-resilient herd, although the characteristics they mentioned were not exhaustive of drought tolerance traits. The same findings were determined in Eastern Cape, where most farmers preferred productive traits, particularly body size and growth (Mthi *et al*., 2020). However, their reasons for selecting productive traits as traits of economic importance may result in losses due to droughts. In addition, households may be practising selection, even though their focus is on productive traits, which they perceive to be correlated to high profits. There is a need for developing programs and strategies to conscientise farmers on the role of selecting genetic stock for drought tolerance and the successive interface between selection, drought adaptation and rural development.

CHAPTER 6: WORKSHOP PROCEEDINGS

6.1 INTRODUCTION

Water security challenges have affected humans and livestock alike, resulting in loss of livelihoods. While existing policies safeguard human water security, especially during states of emergencies, livestock survival during droughts should be prioritised due to their contribution to livelihoods. Indigenous knowledge is valuable in ensuring water security among communities, especially during droughts that have become erratic and severe. Indigenous knowledge systems provide an inclusive solution to the effects of droughts for both humans and livestock.

The effects of drought remain even after the incidence itself is gone. Low conception and calving rates and high mortality rates during a drought year will reduce the herd performance and size the following year. In some instances, farmers fail to recover, especially cattle with a low proliferation rate and are expensive to acquire compared to small livestock. This reduces the resilience of communities and makes them vulnerable to upcoming droughts. Indigenous knowledge ensures community resilience through an ongoing system including prediction, evasion, mitigation, adaptation and recovery strategies. Understanding IKS of water security allows them to be incorporated into water management frameworks to develop cost-effective, relevant and sustainable strategies. The project objectives were, therefore, to determine the;

- indigenous knowledge strategies of ensuring water security in resource-limited communities
- possession and extent of use of indigenous knowledge to ensure water security among resource-limited households and
- indigenous knowledge strategies used to sustain livestock during periods of water shortages and droughts.

The participatory rural appraisal was utilised to meet the objectives. Mixed methods were used through face-to-face interviews, focus group discussions and questionnaires. With the assistance of communities in Musina and Umhlabuyalingana Local Municipalities, Limpopo and KwaZulu-Natal, respectively, the utilisation of IK strategies in sustaining water security for humans and livestock in drought-prone areas, was better understood. Both communities were among those that were declared as disaster zones during the El Nino induced 2015/16 drought (AgriSA, 2016) and is affected by seasonal droughts during the cold, dry and hot, dry seasons running from May to November. The data from both municipalities were analysed and presented to the respective communities through a feedback workshop.

6.1.1 Objectives of the workshop

The feedback workshop allowed the communities to comment on the findings and acknowledge, correct, or add to the presented outcomes. The objectives of the workshops, therefore, were to;

- Present findings on IK used to sustain human and livestock water security in resource-limited communities
- Obtain input on the findings from workshop participants; and
- Develop recommendations through the participation of stakeholders.

6.2 STRUCTURE OF THE WORKSHOP

The feed-in, feed-out workshop for each community was conducted over one-day. The presentations were structured into two sessions. The first sessions covered IK strategies used to ensure water security and their extent of use. The presentation was partitioned according to strategies used for drought prediction, mitigation, adaption and recovery. The session was closed by discussions where participants freely acknowledged, challenged or added to the results. The second session focused on indigenous strategies used in livestock management during droughts. The strategies were divided into those that ensured health, cow-calf management and livestock selection. The session ended with group discussions, which gave a chance for the participants to contribute to the knowledge presented.

6.3 PARTICIPANTS

The number of participants on Day 1 dedicated to Malale village was 35, and Day 2 (Domboni village) was 30. The invited participants were representatives of traditional leaders, municipality officials, village elders, youths, men, women, Department of Agriculture officials, Department of Water officials and members of local livestock association members.

6.4 WORKSHOP MATERIALS

Each participant was given a copy of the program (Appendix A), COVID-19 awareness pamphlet and a handbook (Appendix B). The above documents were available in both English and Tshivenda. To ensure that COVID-19 regulations were met, a temperature scanner, sanitisers and COVID awareness charts were available. There was a flip chart and markers in case there were further illustrations required. Social distancing and wearing of masks was practiced through the workshops.

6.5 PROCEEDINGS OF THE WORKSHOPS

6.5.1 Registration of guests

The workshop began with the registration of guests. All COVID-19 regulations were observed, including taking temperature readings, sanitising, wearing masks, and social distancing. The program was directed by Mr S.E. Mushavhanamadi from the Department of Agriculture and Rural Development, Limpopo.

6.5.2 Welcome and introductions

On Day 1 and 2, the workshop was conducted at Malale Municipality Hall, central for both Malale and Domboni communities. For both days, the workshop commenced with a prayer by Mr Ndou and delegates were welcomed on days 1 and 2. Introductions were facilitated by Mr Kwinda, the Livestock Association Chairperson of Malale village. In the openings, Mr Kwinda acknowledged the presence of the traditional leadership, the representatives from the Department of Agriculture, Municipality, village elders and farmers. Introductions for Day 2 were conducted by Mr Mafunise, the Livestock Association representative for Domboni village, who also observed all protocols.

6.5.3 Opening remarks

Dr Manjoro of the University of Venda introduced the project. She highlighted the background and project objectives. She highlighted the rising incidences and severity of droughts and their drastic effects on human and livestock water security. Dr Manjoro reiterated the need to find interventions to reduce the impacts of droughts. She introduced the concept of IKS as an intervention method, which was proven effective through years of experimentation, including trial and error. The project objectives were highlighted, followed by the methodology used in data collection. She further went on to state the aim of the feedback exercise and its importance in relation to ensuring the accuracy of reported information.

Dr Manjoro introduced the project by highlighting the water security challenges and their impacts on livelihoods. She emphasised that water security challenges have affected humans and livestock alike, resulting in loss of livelihoods. While existing policies safeguard human water security, especially during states of emergencies, livestock survival during droughts should be prioritised due to their contribution to livelihoods. She stated the contributions of livestock as sources of eggs, milk, meat, hides, animal draught power, household income, and socio-cultural functions within most African communities. Due to the numerous contributions of livestock, Dr Manjoro reiterated the critical need to develop strategies that reduce livestock losses during droughts. During droughts, the vulnerability of women and children to hunger, food and nutrition insecurity is exacerbated. The cost of food is increased.

In addition to causing losses during the drought, Dr Manjoro mentioned that the effects of drought remain even after the incidence itself is gone. In livestock, low conception and calving rates and high mortality rates during a drought year reduce herd performance and size the year that follows. In some instances, farmers fail to revive their herds and go deeper into poverty, especially cattle with a low proliferation rate and are expensive to acquire compared to small livestock. This reduces the resilience of communities and makes them vulnerable to upcoming droughts.

Due to the devastating impacts of droughts, which have become frequent, on vulnerable groups, Dr Manjoro suggested that indigenous knowledge (IK) is a valuable intervention in ensuring water security among communities. Indigenous knowledge systems provide an inclusive solution to the effects of droughts for both humans and livestock. She echoed that IKS relied on experiences and tested knowledge that households and IK holders have experienced or learnt from the earlier generations. Indigenous knowledge ensures community resilience through an ongoing system including prediction, evasion, mitigation, adaptation and recovery strategies. The IKS of water security should be incorporated into water management frameworks to develop cost-effective, relevant and sustainable strategies. To develop recommendations for ensuring water security using indigenous knowledge, the objectives of the project were to:

- determine indigenous knowledge strategies of ensuring water security in resource-limited communities;
- assess possession and extent of use of indigenous knowledge to ensure water security among resource-limited households; and
- determine indigenous knowledge strategies used to sustain livestock during periods of water shortages and droughts.

Dr Manjoro also described the approaches, methods, and study sites used to collect data, particularly participatory rural appraisal (PRA). Mixed methods were used through face-to-face interviews, focus group discussions, and structured questionnaires. With the assistance of communities in Musina and Umhlabuyalingana Local Municipalities, Limpopo and KwaZulu-Natal, respectively, the utilisation of IK strategies in sustaining water security for humans and livestock in drought-prone areas, was investigated. Both communities were among those that were declared as disaster zones during the El Nino induced 2015/16 drought and is affected by seasonal droughts during the cold, dry and hot, dry seasons running from May to November. Dr Manjoro also acknowledged the commitment that students attached to the project (Ms Evelyn Kamba, Ms Kamva Getyengana and Mr Ndivhoniswani Nephawe) demonstrated their interest in working with the communities.

Dr Manjoro highlighted that the purpose of the workshops were to provide feedback to the communities to give the communities opportunities to validate the findings. The workshops also ensured that the communities had a sense of ownership of the results. Their inputs were captured to enrich the final report submitted to the Water Research Commission, which funded the project. Such inputs could be incorporated into policy discussions that include IKS in ensuring water security for both humans and livestock.

Dr Manjoro further described and acknowledged the composition of participants. Five participants from each of the following social groups in each village were invited: village elders, youths, women and men. Two traditional leaders from each community and representatives from the municipality, Department of Water, Department of Agriculture and livestock association were invited. The representatives from the Department of Water could not be available for the workshop due to prior engagements.

6.5.4 Session 1: Indigenous knowledge methods of ensuring water security

Ms Evelyn Kamba presented the first session in English with the assistance of an interpreter in Tshivenda. She used visual aids such as a colour printed handbook (Appendix B), available in both English and Tshivenda. A flip chart and markers were used for illustrations of points.

The different strategies in each category were explained in detail, and at the end of each category, the participants were allowed to ask for clarifications from the presenter. First, Ms Kamba presented the extent of using indigenous methods to ensure water security. These included the factors influencing the perception of accuracy (occupation and age group) and indigenous methods' reliability (level of education). Likelihood estimates were also presented and explained.

Ms Kamba then presented the methods used in predicting drought or rainy seasons. Three categories were identified: celestial bodies, particularly observing the moon and stars; biological indicators through observing the behaviour of birds and trees and weather patterns, particularly trends in temperature, the direction of the wind and cloud type. Regarding the extent of using indigenous methods to predict water security, using biological indicators was most popular.

The methods of avoiding droughts and the impacts were classified as rituals, taboos and transhumance. A detailed description of the methods was given with the help of the handbook. The strong influence of age on the decision to use rituals was highlighted, with the older demographic group preferring using rituals in comparison with transhumance and taboos. The most preferred category in the two villages was transhumance, although it was a difficult strategy to practice due to animal movement and migration laws.

Strategies used for coping during droughts were rituals, a sacred well, supplementary livestock feeding, change in the livestock management system and destocking. Ms Kamba reiterated the extent of use of these methods, indicating that destocking was the most popular coping strategy followed by rituals. She went further to identify the factors influencing the choice of coping strategies.

The impacts of droughts go beyond the drought itself; hence the IK findings of strategies used to recover were categorised as socialisation, land conservation and rituals. The presenter emphasised that seven in every ten farmers preferred refilling shallow wells and highlighted the factors that influenced the choice of recovery strategies.

Ms Kamba further presented findings on the strategies used to prepare for future droughts followed by the extent of use of the different methods. The most preferred strategy was the rearing of goats. She indicated that rearing goats was traditionally considered a way of buffering communities from losses due to water insecurities. They consume less than cattle and use low-quality forage, enabling them to survive during water insecurities. In addition, the low water consumption of goats also reduced competition for water with humans. Livestock training and occupation influenced the choice of rear goats to curb water insecurity problems. The session was concluded by explaining the Indigenous Knowledge Water Security Framework (IKWSF), which was coined from the findings and hybridised from the Drought Cycle Management (DCM).

6.5.4.1 Discussion on IK methods of ensuring water security and its extent of use

In the feed-in session, the participants (Day 1 and 2) agreed that the IK strategies used to ensure water security were well captured. In addition, they affirmed that the knowledge holders were traditional leaders, including healers and elders. However, they expressed their surprise at the findings that the educated were also knowledge holders and that the young generation had a positive attitude towards IK. The discussion also revealed that the community had previously taken indigenous strategies as stand-alone methods of ensuring water security, but because of the diagram and the other contents of Session 1, they were under the realisation that the knowledge that they have is a self-sustaining system, which covers all aspects of drought management.

6.5.5 Session 2: IKS of livestock management during droughts

The session was introduced by stating the importance of livestock and the impacts of droughts on livestock. Ms Kamba then gave suggestions on ways of ensuring livestock survival during droughts. The four suggestions were used to structure the presentation thereafter. The sections thereof were the provision of drinking water, good livestock health, cow-calf management and livestock selection.

Perennial rivers such as Nwanedi and Limpopo Rivers were the primary water source to provide drinking water for livestock during droughts. Results indicating how cattle distribute their time during droughts (time budgeting) were presented. Time budgeting referred to the daytime allocation of time for different activities such as walking, standing, drinking, resting and grazing. Cattle from Domboni village, which relied on free ranging, spent most of their time walking in search of feed and water, while those in Malale, which camped at the riverbanks, spent most of their time feeding. This shows that cattle expend a lot of energy searching for the feed when feed is in short supply compared to energy-saving activities that ensure productivity.

Ms Kamba introduced methods of ensuring good livestock health by highlighting the incidences of gut worms in cattle reared under communal systems. The indigenous diagnostic methods were then described with the assistance of photographs. The interpretation of the signs of intestinal worm burdens or infestations into worm burdens and respective treatments were described.

Other findings from studies on intestinal worms in the villages presented included the susceptibility of cattle as droughts intensify. When drought intensifies, the effect of whether an animal is male or female, coat colour, water source and whether you are supplementing or not does not matter; what matters is the age and how many times the cow has given birth. Adult cattle and cows, which had never calved, were susceptible to high worm burdens.

Findings on cow-calf management covered critical practices such as pregnancy diagnosis, signs of parturition and postnatal management. Pregnancy was diagnosed two months after conception through the tail that hangs at the side of the vulva. A pregnancy that had progressed was diagnosed by an enlarged belly and udder. Pictures were used to illustrate the signs of pregnancy. Before calving, a farmer was able to notice signs such as mucous discharge around the vulva and the cow isolated itself from the rest of the herd. Postnatal management included checking for retained placenta and ensuring that the calf had taken the first milk.

Livestock selection for animals that were tolerant to droughts was presented thereafter. The findings from interviews revealed that even though farmers were aware of the impacts of droughts on livestock, they still preferred characteristics such as large body size, which predisposed livestock to droughts. Ms Kamba highlighted the need for farmers to be conscientised of the role of selection in increasing the drought adaptive capacity and to build resilient herds.

6.5.5.1 Discussion on livestock management during droughts

Both groups (Day 1 and 2) of participants agreed that the presented material was accurate. There were contributions on Day 1 regarding parturition where they added that currently, liquid soap is used as a lubricant to assist cows with dystocia. They said that postnatal care of retained placenta involved using *Cissus quadrangularis* (*Malongakanye*. Tshivenda), which is crushed and mixed with drinking water. The plant caused uterine contractions, which expel the retained placenta.

6.6 WAY FORWARD

In the plenary sessions on Day 1 and 2, the participants expressed their excitement about the compilation of the IK strategies of the Tshivenda culture. They expressed their gratitude to the researchers that allowed the data collection process to be inclusive from start to end. Upon seeing the compilation of IK strategies available in their community, the youths indicated that this project opened their eyes to the realisation that IK has everything they need to be water secure. Participants acclaimed a need to disseminate the information and that the traditional authorities, municipality, Department of Education, Department of Water and Department of Agriculture should include IKS in their programs. Government officials and community leaders agreed that conventional systems have played a role in the loss of IK. Hence, in a bid to mainstream IK, these departments should also play a part. The participants emphasised the need to develop programs to capacitate the community on IK and water security. They indicated that community members should take an active approach in ensuring water security, and the findings of this study could structure the programs that could be implemented.

Through the project, community members have realised that every demographic group has a role in curbing water insecurity using IKS. They expressed the need to educate, conscientise and encourage different social groups about the role of IK, as a way of weaning communities from relying on external assistance during disasters such as droughts. Some of the elders and traditional leadership voiced their concerns about ownership of information. They were concerned that free access would eventually lead to the loss of identity of the Tshivenda IKS; hence, there is a need for intellectual property rights to be exercised regarding IK. They highlighted the need to protect the information so that it can be identified as belonging to the Tshivenda culture.

The participants recommended that since neighbour relations have a significant role in drought mitigation, they can be used to mobilise community members to dig wells. Participants suggested that some of them should be trained by elders who know how to do it. Then after that, community members can group to dig the wells. One of the challenges noted was lack of expertise in determining the position where the water table is high.

Most farmers were ignorant about the significance of selection in increasing the adaptive capacity of cattle. Although most farmers know that larger, exotic breeds cannot perform during droughts, they still choose them when purchasing stock for their market value. The workshop enlightened them, and they recommended that the Department of Agriculture and the Livestock Association develop programs to conscientise farmers on the importance of selecting animals for their drought tolerance.

The participants acknowledged that they learnt from the presentation that the water requirements for goats are lower than for cattle, and hence rearing goats can work in their favour when water is in short supply. The elders in Domboni indicated that they can predict impending droughts through indigenous methods, but they did not have a platform to share them with community members before this project. They suggested that community programs should be created that allow elders to predict water insecurities and alert other community members so that they can prepare for the droughts.

Concerns that arose in the workshop involved the sustainability of tree species as resources for the community. Participants were concerned that the tree species may not be available for future use due to the pressure of use. They recommended that the traditional authority and municipality join hands to develop programs that encourage the planting of indigenous trees.

CHAPTER 7: CONCLUSIONS & RECOMMENDATIONS

7.1 CONCLUSIONS

The capacity of resource-limited communities to secure water for domestic use and their livestock is threatened by the increased frequency and incidences of droughts. Droughts reduce water availability and quality. It increases water salinity and turbidity, deeming it undrinkable. On the other hand, municipalities concentrate on urban communities, neglecting resource-limited communities by not servicing them with water supply infrastructure. Water security challenges cause food insecurity, decrease the health status of households, reduce household income and reduce the quality of life. Water insecurity results in livestock fatalities and reduced quality of livestock products. Since livestock provides protein and generation of income, the performance of this sector is integral to livelihoods.

A holistic approach should be used to develop strategies that improve water security in resource-limited communities. The use of IK can curb water insecurity challenges during or after droughts either as a stand-alone solution or as an integration with conventional water management systems.

The status of water security in both municipalities could not support both humans and livestock. Conventional water supply methods were insufficient to provide water for communities because of dilapidated infrastructure, poor municipal support, expensive access to water and poor water quality. Indigenous knowledge is helpful in the prediction, evasion and mitigation, reconstruction and adaptation to water challenges. Such IK methods include rituals, taboos, astrology, bio-indicators, sacred wells, springs, supplementing animal feed with high water content leaves, and changing livestock management methods. Rituals were multifunctional in ensuring water security by predicting, evading, mitigating and reconstructing. Most methods used recharged hydrological water sources, which both humans and livestock subsequently used. During water shortages, livestock is provided with forages containing high water content, and they get water from springs, wells and spillage from the sacred well. Relationships with neighbours played a role in strategies to recover from the effects of water scarcity through information dissipation and sharing of water sources and breeding stock.

The IK can be capitalised on and used in water security development programmes. Factors that influenced the use of IK were age (ability to apply, reliability, accuracy), level of education (accuracy and reliability), animal husbandry training (reliability), occupation (accuracy, ability to apply, reliability and convenience). Farmers below the age of 40 years in Umhlabuyalingana had positive attitudes towards using IK to ensure water security as opposed to elders, while traditional diviners and the educated were potential sources of IK. In Umhlabuyalingana, frequent use of IK was prevalent among the unemployed. In Musina, the level of education, livestock husbandry training and occupation affected frequent use of IK in water security.

Ensuring livestock survival during droughts was conducted by controlling parasites and diseases and selecting adaptable traits to droughts. Cattle are largely not penned during droughts. Cattle also spent most of their time searching for feeds. Detection of gastrointestinal parasites was done through faecal examination. Parasitic infestation is indicated by mucus in the faecal matter, mixed consistency of faecal matter and loose matter. Pregnancy diagnosis was done by observing the position of the tail and the bulge of the abdomen. The earliest pregnancy diagnosis can only be done two months after conception with an indication of a tail hanging at the side of the vulva. Signs of parturition were noticed within a week of delivery, and these included mucus discharge and isolation behaviour of the cow. Parturition can also be assisted if there is a difficulty. Postpartum care included boiling the first milk and feeding it to the newborn calf to strengthen it. Traits of economic importance to survive droughts included drought tolerance in both bulls and heifers. Mothering ability, fertility and coat colour are also important.

During droughts, cattle walk up to 15 km to get water. Long distances travel causes stress.

7.2 RECOMMENDATIONS

- There is a need to document IKS in other areas further since it provides holistic, sustainable, and self-containing solutions to water shortages. During the feed-in, feed-out workshop, the youths expressed their astonishment after seeing the compilation of the different indigenous methods, which led to the realisation that all the skills and knowledge needed to curb water scarcity are locally available.

- There is a need for collective engagement of the community, government and the research fraternity in acknowledging the contribution of IKS in drought management. Collaborative research between universities and communities should be strengthened. This can be achieved by changing the attitude towards IKS for all stakeholders. To ensure a change of attitude, centres of excellence in research institutes can be established to focus on the advancement of IKS. Communities can be encouraged to participate in research by incentivising them. Key informants can be considered for authorship in research papers. Funding can be mobilised for community-based research.

- There is a need to disseminate the information within the surrounding communities, which share similar water challenges. This can be done by creating information hubs in communities that harbour IKS and water security information in support with access benefit sharing, however, observing intellectual property rights of the knowledge holders.

- There is a need for different stakeholders, including government departments, to work together with communities in mainstreaming IKS programs. Government departments should consider including IKS in their programs, such as the curriculum in schools or training programs initiated by the Department of Agriculture.

- There is a need to protect intellectual property and to protect local knowledge. Access and benefit-sharing agreements (ABA) should be made between research institutions and communities through the Nagoya protocol. The ABA from this research can be published on the ABA clearinghouse following the recommendations by the Nagoya Protocol, which calls for transparency on traditional resources.

- There is a need to capitalise on local skills, knowledge, and community collaborations to access groundwater reservoirs. Community members can organise themselves to dig wells during droughts collectively.

- There is a need to increase the adaptive capacity of farmers. There is a need for educating and training farmers on the importance of selection in drought management. The Department of Agriculture and the Livestock Association can develop programs to conscientise farmers on the importance of selecting animals for their drought tolerance. Further research needs to be done which capitalise on IKS to improve the drought adaptive capacity of livestock.

- Cattle have high market and socio-cultural value than goats. In the face of frequent droughts, it is essential to increase goat production due to their ability to withstand droughts. The hardiness and low water requirements of goats should be exploited to encourage the rearing of goats instead of cattle. Avenues to market goats and their products, particularly meat and milk, should be created so that farmers can benefit economically the same way they benefit from cattle.
- There is a need for integrating indigenous weather forecasts with modern communication tools as part of early warning systems. There is a need to disseminate weather forecasts among all community members timeously. It is recommended that a platform can be created to alert community members whenever the elders have predicted a drought, the same way that the South Africa Weather Services send forewarning to other communities, especially urban areas, through radios and televisions.

Platforms such as short message services (SMS) can be used to alert community members whenever indigenous signs of dry or wet conditions are seen. That way, indigenous methods can successfully be used as early warning systems.

- Sustainable use of available resources is required. There is a need to develop programmes that encourage the planting of indigenous trees during water secure periods. Cattle use *browse* as a source of feed, and leaves are constantly being used to supplement or medicate vulnerable animals. It is recommended that traditional leaders and government departments work towards encouraging communities to plant these tree species in preparation for droughts.

- There is a need to consider water pollution issues, especially where cattle can camp along the Nwanedi River during droughts. Camping cattle along riverbanks, as in the case of most herds from Malale, reduces the distance travelled to water sources but raises issues of high faecal contamination. Researchers should assess the level of contamination, the communities that can be affected and the potential effects downstream.

- The study has revealed that IK ensures security during periods of water shortages. The IK also ensures the sustainable exploitation and replacement of water for humans and livestock. It is recommended that an intervention framework (Figure 7.1) be utilised in grassroots communities to apply IK to ensure water security. The framework incorporates the strengths of the different demographic groups and the IK strategies' classifications according to the Drought Cycle Management (ILRI, 2004; Pantuliano and Wekesa, 2008) to birth the Indigenous Knowledge Water Security framework (IKWSF).

  The IKWSF is made up of four components which make up the alert (prediction strategies), emergency (evasion and mitigation strategies), recovery (reconstruction strategies) and water secure (adaptation strategies) phases. Therefore, the findings from the interviews, focus group discussions, and structured questionnaires embedded in these four components. The fifth component is located centrally and allocates responsibilities of different demographic groups when implementing the framework based on their strengths. The findings were also used to allocate responsibilities in the fifth component.

  The establishment of IK programmes could be well received because of positive attitudes among the young and the availability of knowledge banks within traditional diviners and the educated. Based on their vast knowledge, traditional healers and the educated should be positioned as key drivers in formulating sustainable IK models. Positive attitudes of young adults and professionals can be utilised to capacitate them further and build on their knowledge by positioning them as key implementers of IK models of ensuring sustainable water security. Through the IKWSF, different demographic groups can participate in ensuring water security in their communities.

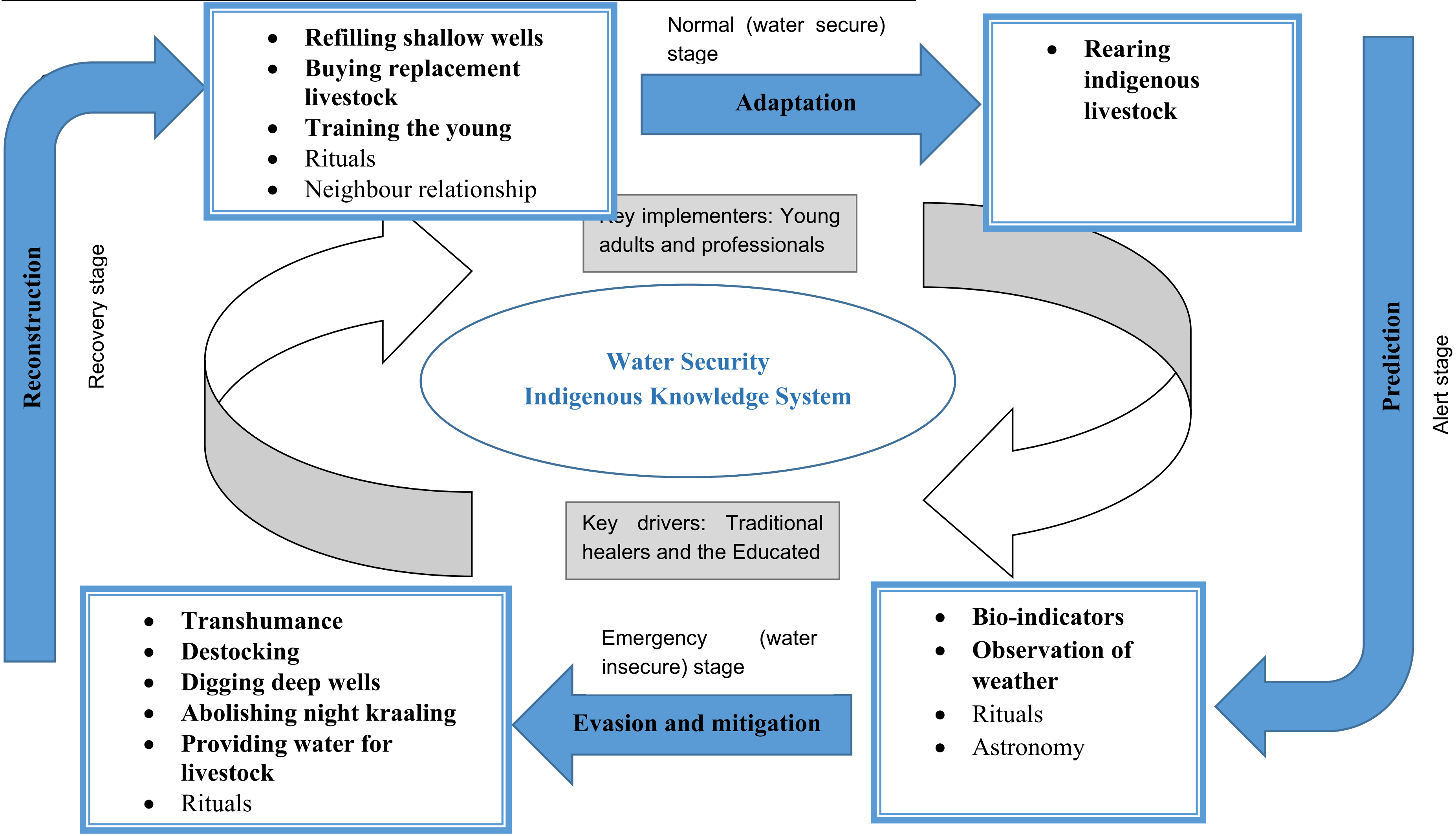

Figure 7.1: Indigenous Knowledge Water Security Framework

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APPENDIX A: WORKSHOP CONTENT FOR DAY 1 AND 2

		DAY 1	DAY 2
PROGRAMME	Programme Director	Department of Agriculture	
09.00-09.30	Registration	Ndivho	
	Opening by prayer	Volunteer	
09.30-09.40	Welcome and introductions	Farmers Association	Farmers Association
09.40-09.50	Introducing the project	Dr M. Manjoro	
09:50-11.15	**Session 1: Indigenous knowledge methods of water security and their extent of use**	Ms E.T. Kamba	
	Feedback:		
	Exercise 1: Strengths? Weakness? Additions?		
11.15-11.20	BREAK		
11.20- 11.50	**Session 2**: **Indigenous knowledge systems of livestock management during droughts**	Ms E. T. Kamba	
	Exercise 2: Strengths? Weaknesses? Additions?		
12.30-13.00	Discussions and Way forward	Ndivho Nephawe	
Closing Session	Word of support (Local Municipality)	Municipality representative	
	Word by a traditional leader	Chief Nemalale	Mr Malise
	Vote of thanks and Announcements	(Farmer)	(Farmers Rep)
	Closing prayer	Volunteer	
	LUNCH		

APPENDIX B: WORKSHOP HANDBOOK (ENGLISH VERSION)

WATER RESEARCH COMMISSION

Utilisation of indigenous knowledge in sustaining water security for humans and livestock in resource-limited communities in KwaZulu-Natal and Limpopo

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

University of Venda
Creating Future Leaders

Feedback Workshop
Musina Local Municipality
24 and 25 May 2021

IKS METHODS ON WATER SECURITY

Table 1: Water sources for humans and livestock in Community 1 and Community 2, Musina Local Municipality

Province	Village	Water source used
Limpopo	Community 1	Community boreholes Private boreholes Nwanedi River Individual wells Sacred well: Tshilingoma *Magakhani*
	Community 2	Limpopo and Nwanedi Rivers Community taps Community boreholes

SESSION 1 - INDIGENOUS METHODS USED IN ENSURING WATER SECURITY

Table 2: Methods of predicting droughts or rainy seasons

Category of method	**Water security indicator**	**Description of water security indicator and interpretation**	**Interpretation concerning water security**
Celestial bodies	Moon	Presence of a 'black' moon	Drought
	Stars	Presence of a morning star (*Masase*. Tshivenda)	Dry conditions
Bio-indicators	Behaviour of birds	Flying-by of a flock of swallows *(Thambelamadi*)	Rainy season
		Flying in of Ground Hornbills (*Dandila)*	Rainy season
	Trees	Fruiting of Shepard's tree (*Muthobi)*	Wet season
		Bird plum (*Nyii*. Shona)	Wet season
Weather patterns	Temperature	Presence of a heatwave	Coming of rain
	Direction of the wind	The wind coming from Mozambique is called the 'Woman'	Brought rain
		The wind coming from Cape Town direction called the 'Man'	Dry season
		The 'man' and 'woman' meet	Thunderstorms
	Cloud type	Dark clouds that are clustered together	Brought rain

Table 3: Methods of avoiding droughts or the effects of droughts

Category of method	**Water security indicator**	**Description of water security indicator and interpretation**	**Interpretation concerning water security**
Rituals	Fruiting of the Marula tree	A ritual involving brewing of Marula traditional beer and presenting it to the ancestors before community members consumed the fruits for the season.	Avoids the anger of the ancestors who will bring rain, if they are happy
	The beginning of the growing season	They were brewing traditional beer (*Mufhoho),* which is left at sacred mountains (Ramaburana in Nzhelele, Raluvhimba in Makonde and Amatibe in Beitbridge) for a week, for the black mamba (*Dzhambila*) to drink. During the seven days, the women from the royal family (*Vhomakadzi*) wear (*Tsindi* and *Zvideka*).	If the black mambas do not drink the beer, then it is a sign that there will be no rain, and subsequent corrective measures would be done, including further rituals to plead with the ancestors to bring the rain.
Taboos	Abortions	Bring droughts	
	Marula fruits	People were not allowed to eat Marula fruits before rituals	Eating Marula fruits before rituals brought droughts
	Pangolins	Killing pangolins	Brought droughts
	River snakes (*Nowamulambo*)	Killing Nowamulambo	Brought droughts
Transhumance	Temporarily moving cattle	Before the borders and animal control measures, cattle used to be moved north of the Limpopo River into Zimbabwe.	Avoiding effects of droughts in Musina

Table 4: Methods of coping during droughts

Category of method	**Water security indicator**	**Description of water security indicator and interpretation**	**Interpretation concerning water security**
Rituals	Consult the ancestors	*Tshikona* or *domba* dances were done at the tribal chief's homestead. Thereafter, they would use snuff at the graveyard to ask for rain from the 'sleeping forefathers'.	If the ancestors were happy, they would bring the rain
		A group of spirit mediums gather and play the drums. Among them, one person would be possessed. To appease that spirit, a dark goat or cow would be given traditional beer,	If the goat refused, then the ancestors would have declined to intervene by ending the drought.
Sacred well	Tshilingoma	A sacred well was used during periods of extreme drought to provide water for the community	Provided water during droughts
Supplementing animal feed	Use of tree leaves	The leaves from Mopane and Iron wood (*Musimbiri*) trees were collected and fed to the livestock during periods of droughts.	Provided nutrition to livestock
Change in the livestock management system	Exclusive free ranging	Farmers stop kraaling their cattle at night. Some cattle stay at Nwanedi River, where they get water and feed. Some stay in the mountains	Cattle will search for their own feed and water
Reduce the number of livestock in a herd	Destocking	Farmers sell their livestock	Reduce competition for feed and water for the remaining animals

Table 5: Methods used to recover from droughts

Category of method	**Water security indicator**	**Description of water security indicator and interpretation**	**Interpretation concerning water security**
Socialisation	Relationships with neighbours	Neighbours share their replacement stock like bulls and rams, fertile eggs, water-related information, including how to manage water.	Sharing strengthen the community to return to where they were before the drought
Land conservation	Covering up of shallow wells	Filling up shallow wells with earth	Reduces injuries of humans and livestock so that they will be safe to access water
Rituals	Appeasing the ancestors	Beer brewed from finger millet was presented to mountain snakes	To appease the ancestors so that they continue to send the rain.

Table 6: Methods of preparing for future droughts

Category of method	**Water security indicator**	**Description of water security indicator and interpretation**	**Interpretation concerning water security**
Changing herd composition	Rearing drought-tolerant species	Keeping goats	Goats are better adapted to drought than cattle
	Rearing drought-tolerant breeds	Indigenous breeds, e.g Tshivenda/Nguni cattle	Indigenous breeds can survive during droughts
Education	Training	Training young generation on water conservation methods	Ensure sustainable use of water

SESSION 2 - INDIGENOUS KNOWLEDGE SYSTEMS OF LIVESTOCK MANAGEMENT DURING DROUGHTS

A. Importance of livestock
   1. Provide food (meat, milk and eggs)
   2. Can be sold to get money to pay for other goods and services, e.g. school fees, buy feed, etc.
   3. Cultural purposes (Rituals, lobola)
   4. Sign of social status

B. Impact of droughts on livestock
   1. Livestock become thin and weak
   2. Livestock die due to lack of water and feed
   3. Livestock diseases and parasites increase
   4. Cows fail to become pregnant, increased abortions or die when calving
   5. Calves die

C. To ensure the survival of livestock during drought, farmers need to
   1. Provide drinking water
   2. Ensure good livestock health
   3. Ensure good management of cows and calves
   4. Ensure that their livestock herds are made up of animals that are tolerant to droughts

Methods of providing livestock drinking water

Table 7: Methods of providing livestock drinking water in Musina Local Municipality

Method	Description
Use of perennial rivers	Nwanedi, Limpopo Rivers
Use of the sacred well	*Tshilingoma*
Exclusive free ranging	Cattle can live in areas where they can get feed and water, such as near rivers or in the mountains so that they do not travel long distances
Cattle use trees to forage	Baobab tree, Lebombo ironwood (*Musimbiri*), red bushwillow (r *Musingidzi*), wild olive (*Mutwari*), white raisins (*Mutabva*), *Mutobi* (Tshivenda) and turpentine tree (*Mopane*).

Methods of ensuring good health in cattle

- One of the biggest challenges is the presence of intestinal worms in cattle
- Indigenous methods can be used for diagnosis, treatment and for the herd to be made up of cattle that can fight intestinal worms

Diagnosis of intestinal worms

- Check the appearance of the dung

Figure 2: Different cattle faecal samples with a 'plastic' indicating presence of helminthes. The top right sample is shiny also indicating presence of helminths

Table 8: How to detect worm burdens and treatment

Indicator	Level of infestation	Treatment
Normal dung	None	-
Dung has mixed consistency of solid particles and liquid	Low	Check closely the performance of the herd
'Plastics' intricately embedded into the faecal heap	Moderate	Administering medicinal plants
Dung is of loose consistency, which can soil the hind legs	High levels of adult worms	Isolation of sick animals; combining medicinal plants to treat until signs of high worm loads disappear.

Ensuring good management of cows and calves

1. **Pregnancy diagnosis**

Pregnancy can be diagnosed 2 months after conception, and the first sign is that the tail will hang at the side of the vulva	
As pregnancy progresses, the belly and the udder size increase	

Figure 3: Signs of pregnancy

2. Signs of parturition (Giving birth)
   - Vulva produces mucous discharge, which can be seen under the tail.
   - A day or two prior to calving, the cow walks ahead of the rest of the cattle and isolates itself from the rest of the herd.
   - The area close to the tail end became hollow
   - Close monitoring is done to ensure that the cow had safe parturition.

3. Parturition (Calving)
   - The cow sits on all four legs allowing half of the calf's body to come out, beginning with the head.
   - After a while, it will stand up, and the rest of the calf comes out.
   - If it keeps lying down, it may be an indication that it may be having difficulties calving; hence assistance is needed immediately.
   - The farmer covers their forearms with soap for lubrication, and they put their hands into the cow's birth canal up to the womb, where they feel the position of the head.
   - If there is a breech, they apply more soap onto the calf inside and turn the head.

4. Postnatal management (Caring for the cow and the calf)
    - After parturition, the cow will be allowed to lick its calf for bonding.
    - If the calf is weak, it is carried to the kraal, where it suckles.
    - Milk the cow and leaves the milk to settle.
    - Decant the clear liquid in the milk and boils it, and then feeds it to the calf so that it can be strong throughout its lifetime.

5. Ensure that their livestock herds are made up of animals that are tolerant to droughts
    - Herds are mostly made up of Nguni, Afrikaaner and Brahman mixes
    - Some farmers prefer large cattle such as Brahman, which bring in more money when they sell, although when they die when drought is severe
    - Bull characteristics that were desirable to farmers were large body size, fertility, temperament and mounting ability
    - Farmers like cows with medium body size, good calving ability and mothering ability.
    - The preferred coat colour was brown
    - The results show that many farmers do not consider characteristics that allow their cattle to survive during droughts as important