UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

The use of Indigenous Knowledge Systems to Predict Extreme Weather Events: Exploring the Case of Tropical Cyclone Eloise

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Declaration

I declare that this research report is my own work, unless otherwise acknowledged. This research is submitted in fulfilment of a master's degree in the Faculty of Sciences at the University of the Witwatersrand. This work has not been submitted in part or in full towards any other degree.

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Abstract

A tropical cyclone is defined as a storm that develops over tropical oceans and is primarily fueled by heat transfer from the ocean. Tropical cyclones are intensifying and the regions of cyclogenesis and of storm lifetime maximum intensity are expanding poleward. This is exposing more areas to tropical storm impacts. This study investigated the use of indigenous knowledge systems (IKS) in Jozini, KwaZulu-Natal (KZN) to forecast tropical cyclone landfall and impacts, with a focus on Tropical Cyclone Eloise. Through in-depth semi-structured interviews conducted with residents of Jozini, this study investigated the extent to which people who were affected by Tropical Cyclone Eloise were able to forecast the storm and take precautionary measures. The study explores the IKS indicators used by residents of Jozini, and the perceived reliability of these indicators relative to South African Weather Service (SAWS) forecasts. The results indicate that community members in Jozini, KZN use various biological, meteorological and cultural indicators to forecast weather, as well as for their day-to-day activities. These include domestic animals (cats); wild animals (birds and ants); meteorological indicators (cloud cover, temperature and wind speed); and reactions from humans (specifically young children and elders who had a surgical procedure). The results reveal that people from Jozini community still use and rely on their indigenous knowledge (IK), even though they also note that their indigenous species are becoming extinct due to climate change and environmental degradation, making it difficult for them to rely on their IKS. As a result, they have to make use of the science based meteorological data provided for them, even though for some, it is hard to understand while others find it unreliable. In the case of Tropical Cyclone Eloise, participants did not forecast it using their IKS, therefore it was not effective in terms of forecasting the cyclone. However, they were able to use their IKS to understand the severity of the storm and take precautionary measures like putting heavy materials on top of their houses. The recommendation of this study would be conducting a

similar study in Mozambique where Tropical Cyclone Eloise first made landfall, to get more IKS based information from people that experienced the tropical cyclone from the onset.

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List of Acronyms

AWIPS: Advanced Weather Information Processing Systems

IK: Indigenous Knowledge

IKS: Indigenous Knowledge Systems

JTWC: Joint Typhoon Warning Center

KZN: KwaZulu-Natal

NHC: National Hurricane Centre

POPIA: Protection of Personal Information Act

SAWS: South African Weather Services

STATSSA: Statistics South Africa

TV: Television

CHAPTER ONE

INTRODUCTION

1.1 Background

Accurate climate and weather prediction models are necessary to create confidence in projections of future climate over many decades and forecasts for days to seasons (Maloney et al., 2019; Alley et al., 2019). The weather forecasting models used by meteorologist include tools such as Doppler radar, satellite data, supercomputers, automated surface observation networks, radiosondes and Advanced Weather Information Processing System (AWIPS) (Gneiting and Rafter, 2005; Hofman et al., 2017). Maloney et al. (2019) assert that these models must be physically validated for multiple weather and climate processes. These tools are used for different purposes in weather forecasting such as observing severe storms, monitoring earth from space and collecting observational data that scientists analyse, to regularly monitor weather conditions on the earth's surface and collect data about sky conditions, surface visibility, precipitation, temperature and wind (Gneiting and Rafter, 2005 Soden et al., 2018). To turn this information into forecasts, they use AWIPS (Alley et al., 2019). AWIPS are computer-processing systems that combine data from all the aforementioned tools into a graphical interface that forecasters use to analyse data, prepare, and issue forecasts and warnings (Gneiting and Rafter, 2005; Voosen, 2019). This helps the forecasters prepare and issue more accurate and timely forecasts and warnings (Alley et al., 2019). Hoffman et al. (2017) argue however, that significant and frequently prevalent biases continue to plague these models, limiting their capacity to offer accurate forecasts of the weather and the future climate.

The inability to generate accurate scientific forecasts may be a limiting factor undermining its use in some rural communities across Africa, particularly in communities where the use of IKS is prevalent because according to Ajibade and Shokemi (2003), these forecasting techniques are not easily understood by some communities across Africa, particularly in rural areas where IKS is still used and relied upon for weather forecasting and planning (Grey, 2019; Ouedraogo et al., 2022). Some rural areas of Sub-Saharan African nations rely on IK and traditional coping mechanisms to forecast the weather and climate, but in recent years, increasingly unpredictable weather patterns have made it difficult to rely on IKS (Kalanda-Joshua et al., 2011; Naab et al., 2019). Every day, meteorological agencies produce weather forecasts and release them to the public via media and other channels of communication such as Television (TV), radio and newspapers (Naab et al., 2019). However, this information is often not communicated in a way that can be understood by everyone (Naab et al., 2019).

A range of factors affect the ability of indigenous communities to make use and trust of meteorological data (Ebhuoma and Simatele, 2019). These include the utilization of scientific language that make it challenging for people to interpret forecasts, their inability to comprehend the meteorologists' language, and their lack of access to full forecast information (Shah et al., 2012). Because of this, it might be challenging for indigenous people to adopt weather forecast advices (Ebhuoma and Leonard, 2020). Despite accurate scientific forecasts and prompt communication, there have been instances where vulnerable populations were caught off guard by catastrophic weather conditions because of the language and channels of communication (Ebhuoma and Leonard, 2020). For many indigenous communities IKS remains a more widely used and, in some cases more reliable approach in forecasting the weather. Johnson (1992) describes IKS as a body of knowledge

that involves the transmission of cultural continuity from one generation to the next through social attitudes, beliefs, principles, and customs of behaviour and practice that are based on historical experience. Nkomwa et al. (2014) defines IKS as traditional knowledge that is passed down among indigenous groups from one generation to the next.

IKS are significant in the context of weather and climate because they have demonstrated potential to support creation of locally relevant, weather forecasts (Mbah et al., 2021; Mazzocchi, 2020; Masoga and Shokane 2019). IK has mainly been used in the understanding of weather patterns through the use of natural indicators such as changes in the behaviour of local plants and animals (Nkomwa et al., 2014). Local communities across the world, especially in developing countries have been able to use IK to recognise the changes in their climate and local environment (Johnson, 1992; Nkomwa et al., 2014; Naab et al., 2019). Like vulnerability to climate change, IKS varies spatially, providing locally relevant adaptation strategies to impacts of climate change (Nkomwa et al., 2014). Particularly now, when climate change is causing extreme weather events like tropical cyclones, incorporating IK into climate change interventions and policies can result in the development of effective adaptation strategies that are inclusive, pertinent at local levels, and sustainable (Chanza et al., 2022). Utilizing all available data is crucial for creating adaptation strategies (Nkomwa et al., 2014). A lot of IKS-based research focuses more on droughts than storms caused by severe climatic events (Hosen et al., 2020; Mbah et al., 2021; Dintwa et al., 2022). Tropical cyclones are weather systems that bring severe climatic events including storms, strong winds and extreme rainfall leading to flooding but get less focus in IK application (Paul and Routray, 2013). Indigenous coastal communities can forecast the onset of tropical cyclones using their IK gained through everyday life on the coast (Paul and Routray, 2013). This indigenous

approach of forecasting cyclones is based on a variety of variables, including weather, water, and unique animal behaviour (Paul and Routray, 2013). Lin and Emanuel (2016) define tropical cyclone as a cyclone that originate over tropical oceans and is driven principally by heat transfer from the ocean. Tropical cyclones usually develop over ocean water that has surface temperature of >26° C, and move towards higher latitudes (Kossin, 2018)). They are of concern in southern Africa because the region is located in a coastal area surrounded by Indian Ocean, from which tropical cyclones occur (Malherbe et al., 2014). Tropical cyclones have caused environmental and economic damage in Mozambique, Botswana, Zimbabwe and South Africa (Malherbe et al. (2014); Molongwane et al., 2020; Charrua et al., 2021; Chivhenge, 2021). These storms are the focus of this study, with a particular focus on Tropical Cyclone Eloise. Tropical Cyclone Eloise made landfall on the 23rd of January 2021 in Beira, Mozambique and the storm affected parts of South Africa on the 24th of January 2021 (Mrizka, 2021). Tropical Cyclone Eloise caused major damages in South Africa, specifically in Limpopo, Mpumalanga and KwaZulu-Natal (Office for the Coordination of Humanitarian Affairs, 2021).

1.2 Rationale

Although recent years have cast doubt on climate models' capacity to identify local implications of climate change, they are excellent at delivering global information on the subject (Vilakazi et al., 2019). Due to their extensive reliance on natural resources for existence, local farmers in South Africa are particularly affected by the effects of climate change, which presents a problem (Elum et al., 2017). In Kwa-Zulu Natal, it was found by Vilakazi et al. (2019) that local farmers encounter difficulties obtaining accurate meteorological information. Local farmers from rural areas where there is little access to

climate information have relied more on their ancestors' traditional knowledge to forecast climatic occurrences, which is where the value of IKS comes into play (Enock, 2013).

IKS weather forecasting techniques in Zimbabwe, Masvingo province and in Msinga, KZN province in South Africa were found to be more accurate at the local level than scientific climate models, and they are perceived to support farmer-planning efforts (Enock, 2013; Vilakazi et al., 2019). For accurate and inclusive weather forecasting, it is crucial to comprehend how IKS is used in forecasting and making plans for extreme weather events like tropical cyclones (Ngondondo et al., 2021). No published studies have explored the effectiveness and use of IKS in predicting tropical cyclones to facilitate the adoption of precautionary measures among households in the region. This is important because future weather projections in southern Africa have been showing that there will be an increase in the frequency of extreme weather events (Malherbe et al., 2013; Intergovernmental Panel on Climate Change; 2021). This support the need of applying IK in weather forecasting, which can help in ensuring that all warning systems and adaptation strategies are understood by everyone. This information can be used in decision making concerning the issues of climate change (Lennard and Hegerl, 2015). The reason behind focusing on areas that have been affected by Tropical Cyclone Eloise is because it is the most recent tropical cyclone to adversely affect the regions in KZN.

1.3 Research question

- To what extent do people in Jozini community use IKS in predicting extreme climate events, and what indicators do they use?

- What indigenous indicators enabled Jozini community members to effectively predict and prepare for Tropical Cyclone Eloise?
- Did the Jozini community rely more on IKS or South African Weather Services (SAWS) to prepare for Tropical Cyclone Eloise?
- What is the perceived effectiveness of IKS and SAWS warnings in the context of tropical cyclones

1.4 Aim and Objectives

The aim of the study was to investigate the extent to which residents of Jozini community used IKS to predict Tropical Cyclone Eloise and take precautionary measures.

This aim will be achieved through the following objectives:

- Determining the extent to which Jozini community uses IKS in forecasting the weather, and extreme weather events at daily, seasonal and inter-annual scales through assessing their reliability on IKS on daily basis.
- Understanding the IKS used in predicting Tropical Cyclone Eloise and how it helped them to embark on precautionary measures.
- Determining the extent to which households in Jozini community relied on IKS compared to South African Weather Service (SAWS) to prepare for Tropical Cyclone Eloise.
- Determining the perceived effectiveness of both IKS and SAWS in accurately predicting Tropical Cyclone Eloise

1.5 Structure of the Research Report

This research report comprises six chapters, including the introduction chapter. Chapter two reviews global and local literature on extreme weather events and their implications on food production and human health. It also discusses tropical cyclones and the debates on the tropical cyclone forecasting models. It further provides background on IKS in the context of forecasting weather events. Chapters three presents the study area and methodology used to conduct this study. This includes the recruitment of the research participants, data collection and analyses, as well as ethical considerations, researcher's positionality and limitations of the study. Chapter four presents the results obtained from this study. This includes the use of IKS and challenges associated to using IKS. It also highlights traditional indicators used for forecasting tropical cyclones and the reliability of IKS in comparison to the reliability of scientific weather services. Indigenous ways of protection against tropical cyclones and evacuation plans are also presented. Chapter five discusses the results of the study and compare them to IKS and tropical cyclones literature. In chapter six, the extent to which objectives of the study were achieved are discussed. Additionally, the contribution of this research to climate science research and recommendations for future research are highlighted.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Researchers in the field of climate and sustainability science are increasingly advocating for the use of both IK and western science to better understand climate change and its consequences (Klein et al., 2014; Diver, 2017; Mercer et al., 2010). IKS, according to Mavhura et al. (2013), are a critical component in building disaster resilience. This is because IKS may be exported and adapted to different areas, they stimulate community engagement and empowerment, increase intervention adaption to local circumstances, and go beyond traditional environmental education (Mavhura et al., 2013). Dube and Nhamo (2021) argue that a lot of IKS based research has been studied in the context of droughts and heavy rainfall, but not much has been done on tropical cyclones and IKS.

This literature review explores the literature to date on extreme weather events and their impacts on humans and the natural environment. Furthermore, tropical cyclones as the focus of this research are highlighted together with debates around their forecasting. Lastly, the chapter also reviews the literature on IKS, together with their importance in climate change and the need to incorporate the knowledge with scientific knowledge to build more sustainable, inclusive, and resilient societies.

2.2 Extreme weather events

Unexpected, unusual, severe, or unseasonal weather conditions are considered extreme climate events (Lubchenco and Karl, 2012), they extend beyond the range and historical

distribution of weather conditions (Powell and Reinhard, 2016). Climate change is likely increasing the frequency and intensity of extreme weather events, and extreme weather has major complications on humans and ecosystems alike (Stott, 2016). In developing countries, extreme weather events can cause a spiral of debt, and an increase in capacity to cope with these events can reduce the scope of the damage on both an economic and social level (Mirza, 2003, Thornton et al., 2014; Field and Barros, 2014).

Many elements influence the capability of various indigenous communities to tolerate and recover from severe experiences of climate extremes, but one of the most important is the ability to track adjustments in the regularity and amount of severe weather conditions (Dube and Nhamo, 2021). The overarching problems are to improve the interconnection of observing systems, detect extreme weather more reliably, and ensure continuity of observations (Lubchenco and Karl, 2012).

Extreme climate conditions including events such as heat waves, torrential rainfall, and droughts are expected to become more frequent in most parts of the planet (Ledger and Milner 2015; Donat et al., 2020; You and Wang, 2021). This will be especially harmful to households in underdeveloped nations, where a huge portion of the population depends on natural resources for survival and governments frequently lack the financial and technological skills to tackle rising climate risks (Groppo and Kraenert, 2017). The frequency and intensity of daily temperature extremes have increased as a result of human induced climate change, as has the broad intensification of daily precipitation extremes (Ummenhofer and Meehl, 2017). The increase in daily temperatures also increased the likelihood of certain extreme weather and climate events, such as floods, droughts, and heat waves (Stocker, 2014). To improve the reliability of the conclusions made for such weather events, Stott (2016) argues

that improved climate models, observational data sets, and theoretical knowledge would be required. Extreme weather phenomena such as floods, droughts, tropical cyclones, hailstorms, thunderstorms, heat and cold waves have increased in socio-economic impact because of population growth and migration to urban areas, which has resulted in greater susceptibility (De et al., 2005).

Developing countries have been striving to improve their adaptive capacities to climate change in order to be less vulnerable to climate change (Eriksen et al., 2021; Pörtner et al., 2022). It is further stated that developing the ability to control catastrophic weather occurrences can reduce the extent of economic, social, and human harm and eventually investments in terms of borrowing money from lending institutions (Mirza, 2003). Consequently, in developing nations, these must be considered while planning for long-term sustainable development (Davis-Reddy et al., 2017). Extreme weather events have put a tremendous amount of strain on developing economies, destroyed infrastructure, and increased the vulnerability of the poor (Otto et al., 2015).

Mirza (2003) reports that in early February 2000, exceptionally heavy rains occurred over Mozambique, and caused severe flooding. It is argued that these floods left a trail of devastation (Cairncross and Alvarinho, 2013). Affected industries included agriculture, infrastructure, including roads, trains, bridges, and water control embankments, as well as water intake, treatment facilities, and supply systems (Mirza, 2003). The Mozambique floods left over 700 people dead and half a million homeless (Christie and Hanlon, 2001). Mozambique is particularly vulnerable to floods in a number of notable ways. For instance, socioeconomic conditions such as poverty and lack of development make the country more vulnerable. Rural areas also tend to be more affected than urban areas due to their heavy

reliance on agriculture. Finally, there are insufficient human and material resources to deal with the massive disaster-like floods that occurred in 2000 (Cairncross and Alvarinho, 2013). Madagascar and Mozambique are more susceptible to tropical cyclone disasters than places with effective disaster risk reduction and coping strategy programs because they are developing nations with relatively poor disaster warning, readiness, and coping methods (Ash and Matyas, 2012).

In the South African context, In April 2019, the coastal province in the east of South Africa, KZN, experienced floods which led to 71 deaths, more than 1400 people displaced and an estimated damage of about USD71 million (Letsatsi and Kruger, 2022). These impacts were felt in the very recent past despite the availability of weather information disseminated through mobile apps, television and radio stations, and social media (Bopape et al., 2021). By making use of archival climate data and primary data from key informants and field observations, Dube et al. (2022) asserts that it emerged that there is a statistically significant increase in the frequency of flooding and consequent human and economic losses from such in the coastal cities of the Western Cape Province. Flooding in urban areas of the Western Cape is a factor of human and natural factors ranging from extreme rainfall, usually caused by persistent cut off-lows, mid-latitude cyclones, cold fronts and intense storms (Balica et al., 2012). Such floods become compounded by poor drainage caused by vegetative overgrowth on waterways and land pollution that can be traced to poor drainage maintenance. Clogging of waterways and drainage systems enhances the risk of flooding (Dube et al., 2020).

2.3 Tropical Cyclones

A tropical cyclone, in technical terms, is a rapidly rotating storm that forms over tropical oceans and is primarily driven by heat transfer from the ocean (Emanuel, 2003). Tropical cyclones are classified based on their highest wind speed, which is primarily used to provide helpful warnings (Anthes, 2016). Tropical cyclones were mostly detected by reports from coastal stations, islands, and ships at sea before World War II (Emanuel, 2003). Many storms are likely to have gone undetected throughout this time, and many more were only seen once or twice (Emanuel, 2003). This was especially true for tropical cyclones that never made landfall and in less-travelled sections of water. Recent southern African tropical cyclones have had disastrous results due to their poor disaster warning systems and coping strategies (Fitchett and Grab, 2014; Gupta et al., 2019; Letsatsi and Kriger, 2022).

Numerous studies have demonstrated that the severity of the impact of tropical cyclones, such as storm surge, wave damage, and inland flooding, is dependent on both the radial extent of strong winds and the maximum wind value (Fitzpatrick, 2014; Done et al., 2015; Davis, 2018). When the first image of a tropical storm was transmitted from a polar orbiting satellite in 1960, it was considered a huge improvement (Cardone and Cox, 2009). By the 1970s, satellite surveillance were able to detect nearly all tropical cyclones, with the possible exception of some of the elusive so-called midget storms (Emanuel, 2003). Any tropical cyclone with a distinct eye may be located by satellite, and pattern-recognition methods and infrared radiance measures are employed to estimate storm intensity based on satellite data (Kolstad, 2021). Although there is considerable debate about the accuracy of satellite-based wind estimates, they are now the foundation for the majority of such estimations, with the exception of some Atlantic storms that are still assessed by aircraft (Hashemi et al., 2016). Future projections of tropical cyclone activity face the challenge of developing both a reliable

projection of changes in the various factors influencing tropical cyclones, both local and remote, as well as a method of simulating the impact of these climate changes on tropical cyclone metrics like storm frequency, intensity, and track distribution (Davis, 2018).

2.4 Impacts of tropical cyclones on rural livelihoods

Extreme weather conditions, including heavy rains and floods as a result of tropical cyclones, have a huge influence on public health, especially in underdeveloped nations, and the consequences are deep around the world (Epstein, 1999). The global environment, agriculture, and the availability of low-cost, high-quality food for humans may all be impacted by current environmental and climate change that induce extreme weather events (Codjoe and Atiglo, 2020). Individual farmers and consumers are expected to be impacted by regional and worldwide climatic changes. The agriculture sector must identify what is at risk in both developing and developed nations and make proper plans for the likelihood of change (Bouwer, 2019). Despite notable advances in technology and agricultural yield potential, the environment continues to play a significant role in determining how crops develop because sun radiation, temperature, and precipitation are the fundamental determinants of crop development (Ebi et al., 2021).

Due to the effects on the built, social, and institutional infrastructures that support health and health care, as well as the changes in service demand brought on by the effects of extreme weather such as tropical cyclones on human health, extreme weather events have an impact on how well health services work (Groppo and Kraenert, 2017). In addition, to improve health and health care resilience to extreme weather, organizations in the care sector, communities, and individuals must modify their practices (Curtis, et al., 2017). Flooded

health facilities, interruptions to electricity and water supply, patient record protection as well as access, ambulance service disturbances, and continuity of outreach and community care are all suggested as physical infrastructure implications (Menne et al., 2013). The destruction of infrastructure is often associated with the occurrence and impacts of tropical cyclones. Extreme weather phenomena such as snowstorms, tropical cyclones, and major rainstorms have not only wreaked havoc on property and urban infrastructure systems, but they can also have a significant impact on human activity (Groppo and Kraenert, 2017).

The implications of extreme weather events on food production and infrastructure are also directly linked to the impacts that tropical cyclones have because Tropical Cyclone Ami caused significant loss of agricultural production in Fiji in 2003 (Barnett, 2011). Tropical cyclone Eline that made landfall in February 2000 did as much, if not more, damage because it affected Mozambique and parts of Zimbabwe and South Africa (Reason and Keibel, 2004). Tropical cyclone Eline affected all sectors from agriculture to infrastructure and human health. It left a large number of people homeless, and others lost their lives (Mirza, 2003). It has been argued that climate hazards have been particularly severe in Mozambique's Central Region (Sofala Province), which borders the active cyclone area of the South Indian Ocean. The strongest tropical cyclone in the southern hemisphere, Cyclone Idai, struck the region in March 2019 with powerful winds, bringing severe flooding and a massive loss of life (Charrua et al., 2021).

Tropical cyclones are disastrous in nature and need to be tackled and managed using all means necessary for sustainable future (Anthes, 2016). Indigenous communities have different ways of dealing with and managing tropical cyclones (Ford et al., 2020). These needs to be studies and incorporated to the western knowledge to help reduce the impact of

tropical cyclones (Mercer et al., 2007; Ford et al., 2020). Poor communities in developing and underdeveloped countries are the most affected during extreme weather events (Rataj et al., 2016). The following two sections will be highlighting tropical cyclones, as they are the key extreme weather events focus of the research. General background about them and their western scientific tracking techniques will be discussed.

2.5 Tropical cyclones in the Southern African region

Research has been done for tropical cyclones in southern Africa in terms of their occurrence, forecasting and characteristics. Countries in the southern hemisphere are usually more exposed to the risks of tropical cyclones because of their lower adaptive capacity (Muthige et al., 2018). As a result, when the southern African countries are hit by a tropical storm, the damage is usually very severe and they take time to recover (Malherbe et al., 2014). In terms of the changing climate and global environmental change, Muthige et al. (2018) argues that the potential impacts of the primary global temperature objectives on tropical cyclones that make landfall over southern Africa have not been fully studied.

The number of tropical cyclones that make landfall across southern Africa, however, is anticipated to decline as a result of global warming (Mavume et al., 2009; Muthige et al., 2018). The southern African region may gain and sustain less harm from a decrease in the frequency of tropical cyclones (Muthige et al., 2018). However, while a reduction in flood-related losses is beneficial, general declines in tropical cyclones and tropical lows may also be linked to less rainfall across the Limpopo River basin and southern, central, and northern Mozambique, having a detrimental effect on dryland agriculture (Reason, 2007).

On average, the southwest Indian Ocean basin experiences nine tropical cyclones annually (Malherbe et al., 2013). Only 5% of all tropical cyclones that develop over the southwest Indian Ocean make landfall over southern Africa. (Reason and Keibel, 2004; Reason, 2007; Mavume et al., 2009; Fitchett and Grab, 2014). Additionally, Mozambique, Zimbabwe, and South Africa also experienced floods as a result of the tropical cyclones that made landfall along southern Africa's eastern coast (Reason, 2007; Bopape et al., 2021). For instance, in February 2000, Tropical Cyclone Eline caused catastrophic floods in Mozambique before traveling 2000 km across southern Africa towards the Atlantic Ocean (Mirza, 2003). The southwest Indian Ocean had never experienced a tropical cyclone with such a long lifespan (Reason and Keibel, 2004; Muthige et al., 2018). The Limpopo River basin receives significant rainfall from tropical cyclones that originate in the southwest Indian Ocean, and these cyclones are also linked to some of the basin's most important rainfall events (Malherbe et al., 2012). These systems both cause devastation, particularly near the coast, and provide much-needed rainfall over a significant portion of the interior (Mavume et al., 2009).

2.6 Debates on tropical cyclones forecast models

Tropical cyclones are considered as a threat to life and property, hence, understanding and forecasting the location, strength, and frequency of tropical cyclones is important for both society and science (Vecchi et al., 2014). While the accuracy of tropical cyclone track forecasts 24-72 hours before landfall has improved by approximately 50% in 1990-2008, Harnos and Nesbitt (2011) argue that there has been no improvement in intensity forecasts over the same period. Similarly, DeMaria et al. (2014) ague that over the last two decades, the mean absolute error of official tropical cyclone intensity estimates from the National Hurricane

Centre (NHC) and the Joint Typhoon Warning Centre (JTWC) shows little improvement. This result has been wrongfully exploited to suggest that the tropical cyclone intensity guidance models have made little or no improvement (Mukarami et al., 2012; DeMaria et al., 2014; Wehner et al., 2015). Falvey (2012) asserts that although operational track forecasts have improved considerably in the previous decade or two, verifications of operational intensity forecasts over the same time periods have showed little or no improvement. Forecasters have relied on tropical cyclone track estimates from a variety of global and regional numerical weather prediction models for guidance in recent years (Goerss, 2000).

Tropical cyclone forecasts give information to aid planning, with the forecasts' potential utility limited in part by their projected and realized skill, as well as the relevance of the quantity being forecasted to the decision structure in question (Anthes, 2016). A variety of approaches have been developed to predict the route and severity of individual tropical cyclones days in advance, and a wide range of sectors regularly make choices based on these 1–5 day forecast due to their demonstrated skill and regionally relevant information (Vecchi et al., 2014). Tropical cyclones have a variety of effects that vary from one region to another (Kam et al., 2013). It is unclear from the literature whether the tropical cyclone forecast models are effective tools for tropical cyclone warning and management. The next few sections will discuss the importance of IKS in management and prediction of weather events, and those include tropical cyclones.

Engelbrecht and Vogel (2021) ague that improving forecasting techniques is Important in terms of providing accurate and early warnings. On the other hand, Gwimbi (2021) argues that there is a need to review the mainstreaming of early warning systems because of the loss of life and destruction of property caused by Tropical Cyclone Idai in 2019 in southern Africa.

It is argued that forecasts for the track, intensity, and landfall leading time were difficult to anticipate a few days before landfall, and warning messages arrived late, causing confusion in the public's response to warning messaging (Gwimbi, 2021). Low public response was attributed to a lack of public danger awareness along with a lack of trust in the warning communication messages delivered. When assessing the occurrence and preparedness for Tropical Cyclone Idai, Kolstad (2021) found that the current prediction models like the ensemble-based European Center for Medium-range Weather Forecast (ECMRWF) only forecast for a few days ahead and this does not provide enough time for evacuation and other preparedness measures (Kolstad, 2021).

2.7 Background on Indigenous Knowledge Systems

Risiro et al. (2012) define IK as local knowledge that is unique to a culture and is learned by local people through a combination of experiences, informal experimentation, and a deep grasp of the culture's environment. This knowledge includes a society's technological, social, philosophical, and economic systems, as well as its educational and governmental structures (Abah et al., 2015). According to Vilakazi et al. (2019), IK refers to what local people know and do to survive, which has grown through trial and error and has shown adaptable to change. The knowledge linked with that symbiotic relationship is slowly eroding due to the interference of contemporary technology (Jiri et al., 2015). However, Gwezi et al. (2016) says that indigenous people around the world have maintained their own worldviews and knowledge systems for many years, despite enormous social upheavals caused by transformative forces outside their control (Gwezi et al., 2016; Hatfield and Hong, 2017). Indigenous communities, in particular, might have a rich cultural and spiritual interpretation

of observations of changes in abundance, distribution, phenology, or behavior of the natural environment (including plants and animals) that might not be present in western study (Hatfield et al., 2018). IKS are best understood as tangible, subjective, and contextual things that are inextricably linked to a person, their group, or their environment (Abah et al., 2014). Agriculture, food preservation, water collection and storage, and animal husbandry are some of the examples of community development processes that rely on IKS (Abah et al., 2014). This information is also the basis for native interpretation of meteorological and climatic events, navigation and orientation on land and water, and management of natural resources (Gwezi et al., 2016).

In indigenous communities, the knowledge and wisdom of elderly are passed down to younger generations through traditional songs, stories, legends, dreams, and traditions (Jiri et al., 2015). The knowledge is sometimes preserved in artefacts passed down through the generations and almost all of these systems rely on direct transmission of information from one person to another (Gwezi et al., 2016). Knowledge of locally occurring plant and animal species is relied on in rural Indigenous communities for usage as foods, medicines, fuel, construction materials, and other items (Khaya and Seleti, 2014). The Elders directly involve their children, especially those who are loyal, in using nature's gifts to share knowledge and wisdom with them. According to Chanza and Mafongoya (2017), indigenous people around the world have extensive understanding of their ecosystems, due to years of living close to nature (Chanza and Mafongoya, 2017). These people have a particular and often detailed understanding of the properties of plants and animals, the functioning of ecosystems, and the techniques for using and managing them as a result of living in and from complex ecosystems, which is passed down to the younger generation through traditional songs, stories, legends, dreams, and practices (Mbewe et al., 2019; Kenote, 2020).

Chanza and Mafongoya (2017) add that IK generation is built on realities that are contextualized regionally, environmentally, and seasonally. Traditional education is used to pass down this information from generation to generation, with elders teaching practical understanding of culture, the environment, and survival through demonstrations, ceremonies, stories, songs, and village gatherings (Risiro et al., 2012). Many of the essential values, beliefs, and practices associated with those worldviews have survived and are increasingly being acknowledged as relevant for today's generations as they were for previous generations. As the whole world strive for a more satisfying and sustainable way to live on this planet, the richness of IK entrenched in long-term occupation of a particular location offers insights that may benefit everyone, from educators to scientists (Gwezi et al., 2016). Many indigenous and non-indigenous people have recently begun to acknowledge the limitations of a mono-cultural education system, and new approaches to comprehending the relationship between Indigenous ways of knowing and those connected with Western civilization and formal education have begun to develop (Mbewe et al., 2019). In reaction to new circumstances, these knowledge systems are always adapting and altering (Barnhardt and Kawagley, 2005).

A study conducted in the Chimanimani district in Manicaland province of Zimbabwe has shown that IKS has been used by rural communities in this region to forecast weather and seasonal changes in their environments (Risiro et al., 2012). It was discovered that the community use atmospheric conditions and biological features to forecast weather over short and long period and temperature and wind patterns were considered as pointers to weather changes (Risiro et al., 2012). The behavior of animals and insects were less frequently mentioned as useful in determining weather condition, and human ailments such as surgical procedures were pointed out as the accurate indicators of impending weather changes (Risiro

et al., 2012; Ajayi and Mafongoya, 2017). Another important finding was that due to environmental change and degradation, certain plants and animal species have been lost (Jiri et al., 2015; Shoko and Shoko, 2013). Another study by Vilakazi et al. (2019) discovered that Bergville and Msinga communal farmers forecast weather using indigenous indicators such as wind and cloud patterns, animal and bird behavior, moon shape, and sun position. It is argued that these farmers have managed to withstand extreme weather events using their IKS (Vilakazi et al., 2019). After observing and forecasting the weather with indigenous indicators, they make decisions about when to plant, what crops to plant, water conservation techniques, and livestock rearing methods.

2.8 Indigenous knowledge systems and indicators used to forecast extreme weather events

Some communities strongly believe in IKS and make informed decisions based on this knowledge (Mbewe et al., 2019). To maintain agricultural productivity, communal farmers have devised indigenous techniques to deal with extremes of weather (Vilakazi et al., 2019). The indications for forecasting weather do not differ much between localities. They are categorized as meteorological (moon and sun), phenological (tree blossoming and fruiting, leaf burst, bird and bug movement and behavior), meteorological (temperature extremes and wind movements), and some bird species are used as short-term forecasting indicators (Cruz, 2007). Mbewe et al. (2019) argue that many communities in Zambia have utilized IKS as a vital knowledge base and survival tool for coping with catastrophic climatic events and other natural disasters. According to Vilakazi et al. (2019), to forecast weather, communal farmers in Bergville and Msinga in South Africa's KwaZulu-Natal Province employ indigenous signs

such as wind and cloud patterns, animal and bird behavior, insect's indicators, stars, moon shape, and sun position. Using IKS, it is argued that communal farmers of Msinga and Bergville in KwaZulu Natal have been able to survive adverse weather disasters (Vilakazi et al., 2019). Farmers' planning activities in indigenous communities are argued to be reinforced by indigenous weather predicting systems Enock (2013). Gwezi et al. (2016) assert that, in general, the elderly predict seasonal rain by monitoring natural trends, while cultural and traditional experts used divination, dreams, or visions to make predictions. Indigenous indicators have contributed significantly to sustainable development as they are understood better at local level and pose little to no threat to the natural environment (Vilakazi et al., 2019).

When indigenous people participate in the annual cycle of subsistence activities, Risiro et al. (2012) argue that indigenous people engage in a form of science. Indigenous communities have researched and learned much about the flora and fauna, and they have developed their own classification systems and versions of meteorology, physics, chemistry, earth science, astronomy, botany, pharmacology, and psychology (Barnhardt and Kawagley, 2005). This information is easily relatable to these populations, and it aids their comprehension of modern scientific concepts for environmental management, such as disaster prevention, preparedness, response, and mitigation (Mbewe et al., 2019). In terms of climatic events, floods can be forecast, for example, based on the height of bird nests near rivers and drought can be predicted by moth numbers (Vilakazi et al., 2019). Farmers can predict the start of the rainy season by observing the position of the sun and the call of a specific bird on trees near rivers. The presence of specific plant species indicates a low water table (Kamara, 2005).

2.8.1 Importance of incorporating indigenous knowledge into western scientific knowledge

According to Breidlid (2009), researchers and leaders in Africa and Asia, as well as in the West, have questioned and criticized western science and knowledge institutions. Development initiatives that focus on local views and methods are needed because they are more likely to be relevant to people's needs and result in long-term actions that are locally understood (Sillitoe, 1998). IK is also highly useful in primary health care, preventative medicine, psychosocial care, and the rule of procreation in the local community (Ngulube, 2016). It has also recently taken center stage in poverty alleviation through community savings and lending, clothing and tool production, and shelter construction and maintenance (Abah et al., 2014). IK was once seen to be irrelevant, unscientific, and out of date, but attempts have been made to integrate IKS into scientific knowledge because they have potential to aid in solving contemporary issues like poverty and natural disasters (Ngulube, 2016).

IKS is also used in local traditional agricultural activities (Mbewe et al., 2019). It also guarantees consistent vegetative cover and allows nutrient recycling through crop and weed leftovers (Mbewe et al., 2019). Modern agricultural experts are investigating these indigenous adaptive techniques to generate ecologically adaptive crops that will increase yields and food security. The utilization of modest technologies helps indigenous people better their livelihood (Ngulube, 2016). Many of indigenous communities are dedicated to discovering and developing technologies that enhance the lives of the disadvantaged members of society while also providing opportunities for small local businesses and farm owners (Apraku et al., 2021). Indigenous Africans, like indigenous people around the world, rely on plant and animal-based medicine to address their medical needs (Kom et al., 2022).

Scientific and IKS must be integrated in interdisciplinary projects dealing with the links between culture, environment, and development in areas such as biological diversity conservation, natural resource management, understanding of natural hazards, and mitigation of their impact. (Risiro et al., 2012). Most natural aspects in indigenous cultures, such as plants, animals, and landscapes, are said to have withstood environmental destruction because they are revered (Enock, 2013). The forest serves various purposes for several Indigenous communities: it protects them, offers medicinal plants and food, and serves as a habitat for flora and fauna conservation (Chikaire et al., 2012).

Given the above uses and importance of IKS in indigenous communities, it is clear that IKS play a huge role in daily lives of the people in indigenous communities. These knowledge systems are cost effective and better understood at local levels (Vilakazi et al., 2019). They do not pose threat to the environment and some of them indirectly help to conserve natural resources (Risiro et al., 2012). On the other side, western scientific techniques are not understood and not accessible by all and they are costly. Therefore, the integration of these would be a big step towards sustainability and building of inclusive and resilient societies (Ubisi et al., 2019).

2.9 Indigenous knowledge systems and tropical cyclone warnings and management

Paul and Routray (2013) assert that tropical cyclone forecasting has been improving over the years, but despite substantial improvement, it falls short in terms of clear communication of warning information to people at risk on a local level, as well as accuracy in predicting landfall timing and intensity factor. Engelbrecht and Vogel (2021) argue that even though there are advances in climate science warning systems, this improvement is not enough when it comes

to reducing the impacts of current and future extreme weather events. Tropical cyclone intensity has increased in some ocean basins as the global climate has warmed; however, other studies argue that the evidence is thin because this recent upward trend still falls within natural variability, and longer-term records do not reveal changes in underlying intensity (Nguyen et al., 2013, Vecchi et al., 2021). Paul and Routray (2013) found that in Bangladesh, coastal populations are regularly familiar with cyclones and aware of the potential risks. Ngongondo et al. (2021) also show that local communities in Malawi also rely on IKS using indicators such as plants, animals and atmospheric observations to predict tropical cyclones, although some of these indicators are threatened by environmental degradation.

Paul and Routray (2013) argue that people do not respond to cyclone warnings proactively because of several reasons such as the distrust and misinterpretation of warning information, poor understanding of cyclone warnings, and past experience of the failure of warnings. In addition, as a result of environmental change, it is becoming difficult for IK indicators to provide accurate or sufficient foreknowledge to respond to climate events such as tropical cyclones (Ngongondo et al., 2021). There is unreliability or distrust of weather forecast information, which encourages the use of IKS among coastal residents of Bangladesh (Paul and Routray, 2013). They can use their IK to foresee cyclones as they have gained IK through everyday life on the coast (Vilakazi, 2019). With the challenges around the use of IKS as well as lack of reliability of scientific weather techniques, the integration of contextualized IKS and scientific climate knowledge is encouraged to cover the gap (Nguyen et al., 2013).

According to Mavhura et al. (2013), the interest in IKS has been intensified in flood disasters due to the likely increase in flood events caused by anthropogenic climate change through heavy precipitation and sea level rise. This implies that literature has given more IKS related

focus to flood and storm disasters and management or adaptation (Owusu-Ansah and Mji, 2013). In addition, the majority of studies on the links between IKS and flooding have been conducted in Asia, with a small number of such studies conducted in Africa (Mavhura et al., 2013; Mkabela, 2005). Bringing IK more into focus and context is necessary to deepen the understanding of how people manage their own changing circumstances and can bring more appropriate information about the hazard event globally (Mavhura et al., 2013). Local communities in Africa have a well-developed IKS for environmental management and coping techniques, which has made them more adaptable to environmental change (Abah et al., 2014). These communities have long used IK to master and monitor climate and other natural systems, as well as construct early warning indications for their own benefit and that of future generations (Gwezi et al., 2016).

A study that explores the relationship between the use of IKS and tropical cyclones was conducted in Malawi. This research looked into the connections between IKS and climate science for flood forecasting in a flood-prone area hit by Tropical Cyclone Idai (Ngongondo et al., 2021). The study was done through collecting perceptions of flood trends and risks using household and key informant interviews as well as mixed gender focus group discussions in Chikwawa District. According to the findings by Ngongondo et al. (2021), communities highlighted dependable IKS (flora, fauna, and atmospheric observations) used for flooding forecasting before and during rainfall events. Nevertheless, it was also stated that often IK indicators are adversely affected by degradation of the environment and may not be suitable for forecasting rainfall patterns or intensity at substantial temporal and spatial scales such as floods from rainfall in upstream catchment areas (Ngondondo et al., 2021). According to the findings, IKS indicators may not provide enough foreknowledge to respond to climate events like tropical cyclones (Ngongondo et al., 2021). Forecasts can be made using scientific climate

knowledge at both small and large spatial and temporal scales (Ebhuoma and Simatele, 2019; Kolawole et al., 2014). As a result, combining contextualized IK with scientific climate knowledge can produce reliable flood forecasts in under-resourced settings (Ngongondo et al, 2021; Chisadza et al., 2020; Ngulube, 2016; Mafongoya et al., 2021).

2.9.1 IKS and 'Western' Forecasting

Farmers have traditionally relied on IK to understand weather and climate patterns and make crop and farming decisions (Breidlid, 2009). IKS are community-developed knowledge systems, as contrasted to modern science, which is commonly referred to as modern knowledge (Kalanda-Joshua et al., 2011). This knowledge consists of a categorization, a set of observable facts about the surrounding ecology, and a self-management framework that regulate resource utilization (Mbewe et al., 2019). This includes the ability to analyze situations and interpret the results, as well as practical problem-solving expertise and a broad understanding of a subject or issue (Johnson, 1992). IKS are used by African communities and the rest of the world for various purposes depending on the needs of the society in question (Enock, 2013). It is argued that if IKS is thoroughly researched, documented, and then incorporated into conventional forecasting systems, it may bring tangible importance and boosts in forecasting accuracy and reliability (Vilakazi et al., 2019).

Farmers in Malawi's Nessa Village use a variety of indicators to forecast weather and climate, all of which are centered on environmental and cultural beliefs. Animal, bird, and insect behavior are the most common indicators (Kalanda-Joshua et al., 2011). For example, when a bird locally known as *nanzeze* (Glareola nordmanni) is seen flying within the household surroundings, it indicates rain coming in less than a week (Kalanda-Joshua et al., 2011). The

croaking sound of frogs is believed to be an indicator of approaching rains and increased occurrence of termites in the gardens normally signals a prolonged dry spell (Kalanda-joshua et al., 2011). Vilakazi et al. (2019) mentions how local farmers in KZN have developed indigenous strategies to cope with extreme weather in order to sustain agricultural production. They also use indigenous indicators such as animal behavior, birds, and shape of the moon in predicting climate extremes and in conserving, both soil and water (Vilakazi et al., 2019).

For many years, indigenous people have relied on this knowledge. According to Jiri et al. (2015), access to scientific meteorological information at the local level remains a problem, which has caused rural farmers in South Africa to endure climatic variability by using IKS for coping and adaptation tactics. Despite the fact that IK has been the method used by rural farmers to make farming-related decisions, Kalanda-Joshua et al. (2011) and Jiri et al. (2015) contend that farmers' confidence in IK has decreased as a result of increased rainfall variability brought on by climate change in recent years. Thus, their capacity to adapt is diminished, making them more vulnerable to the consequences of climate variation and change. For individuals who understand the shortcomings of conventional climate projections but are unable to adopt scientific ones, this has posed a challenge (Kalanda-Joshua et al., 2011). This is based on a study that was conducted in Nessa village in Malawi, with the aim of establishing commonly used IK indicators in weather and climate forecasting (Kalanda-Joshua et al., 2011).

The findings are that people have realized that current scientific weather and climate predictions in Malawi were not that useful at village level because they do not incorporate IKS (Kalanda-Joshua et al., 2011). Researchers are calling for the local application of IK, which

can help build the resilience of populations exposed to extreme climatic events, in order to solve this issue (Hoppers, 2011). Jiri et al. (2015) and Mafongoya et al. (2021) also emphasize the need for the integration of IKS in science education and policy framework for more sustainable approach to climate change. According to Kalanda-Joshua et al. (2011), scientific weather forecasting has its downfall especially for indigenous people because they normally use regional climate as the lowest spatial scale and predicting different things for each region. They do not go as far as predicting for certain communities or villages specifically and this sometimes make their prediction unreliable at village level (Kalanda-Joshua et al., 2011). It is also argued that there is an evident lack of a credible communication procedure of the forecasts to local farmers (Naab et al., 2019). The scientific and technical nature of such forecasts further complicates their effectiveness among farmers (Kalanda-Joshua et al., 2011).

It is argued that both IKS and Western and scientific systems are similar in essence and organization (Risiro et al., 2012). Both are made up of complicated webs of premises and interpretations that have been put up by groups of scientists and agreed upon (Abah et al., 2014). Each knowledge system has its own set of strengths and weaknesses (Rautela and Karki, 2015). As a result, it is impossible to argue that one system is better suited to today's environmental and sustainability challenges than the other, because each system emphasizes different aspects of truth at the expense of others. While western science provides a greater understanding of context beyond the local level, the IKS provides depth of experience in a culturally specific local context (Jiri et al., 2015). This shows that far than being fundamentally incompatible, IKS and Western science are complementary or similar (Abah et al., 2014). Because both IKS and western science have strengths and faults, combining them would increase agricultural output and resilience to unfavorable conditions (Vilakazi et al., 2019).

2.10 Summary

The existing literature shows the importance of IKS in weather forecasting, especially in rural communities with small-scale farmers. IKS is important for indigenous communities because it is easily understood and passed on to the younger generations. Despite its usefulness, it has some downfalls especially given the fact that we are in the era of climate change and environmental degradation. It was mentioned on a number of articles that due to the changing climate and extinction of certain species, it is becoming difficult for indigenous communities to reliably use their IKS. Therefore, researchers are advocating for the collaboration of IKS and western forecasting techniques to better create resilient societies against extreme weather events. This research report will contribute to filling the gap on the understanding of western weather forecast and their reliability in indigenous communities in comparison with the reliability of IKS and indigenous indicators. It will find out whether it would be beneficial to integrate IKS and western forecasting techniques given the issues with environmental degradation and lack of understanding of western techniques.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 Study Area

The uMkhanyakude District Municipality is a Category C municipality located along the coast in the far northern region of the KwaZulu-Natal province. It shares its borders with Swaziland and Mozambique. The Jozini community is located in Jozini Local municipality, which is a category B municipality located within the uMkhanyakude District in northern KwaZulu-Natal. It is one of four municipalities in the district, making up a quarter of its geographical area. A municipality falling under Category C is one that exercises municipal executive and legislative power over a multi-municipality region. A municipality comes into category B if it shares municipal executive and legislative authority with a municipality falling into category C in its area.

The rural regions of this area struggle with challenges relating to a lack of development, poverty and poor service provision (STATS SA, 2020). The district municipality is largely rural and has a population estimate of 625,846 people and a population density of 45.17 people per km^2 (STATSSA, 2011). The population of UMkhanyakude is relatively young, with more than 50% of the population in the district below the age of 35 years and women being the majority (Mkhize, 2018). Women and the youth bear much of high unemployment problem. The district racial composition is composed of all racial groups found in the country, which are, Black/African (90.6%), Coloured (0.3%), Indian/Asian (4.3%), and White (3.2%) (STATS SA, 2011).

Jozini is predominantly a rural municipality with 89% of the population residing in rural areas under the jurisdiction of traditional authorities. The study area (Figure 1) is characterized by periodic flooding with seasonal dry winters and wet summers; temperatures range from 23 - 40°C in summer and from 16-25°C during winter (Mndawe et al., 2015). A large proportion of this rural district is under thicket, grassland, and wetland, while remaining areas are cultivated land and settlement (Mkhize, 2018). According to Patrick (2021), the municipality ranks 51 of the 55 most socioeconomically deprived municipalities in South Africa and is considered one of the poorest municipalities in the country. Its population is largely youthful (Mkhize, 2018), uneducated and predominantly dependent on agriculture to support livelihood (Patrick, 2021). Large areas of land are under communal tenure, located in the traditional authority areas (UKMD, 2021). The reason for specifically focusing on Jozini Community in uMkhanyakude district municipality is its proximity to Mozambique, where tropical cyclone Eloise made landfall.

It is argued that the well-being of coastal communities is constantly threatened by risks from the sea in the northern part of KZN due to the loss of homes, infrastructure, and services. Such risks have long-term effects on the environment, society, and the economy (Kovacs et al., 1985). KZN has been experiencing tropical cyclone-related flooding, from Tropical Cyclone Domoina that developed on 16 January 1984 and affected the northeastern coast of Mozambique and northern KZN (Kovac et al., 1985). According to Kovacs et al. (1985), the Tropical cyclone caused widespread flooding, destruction to property and death. Tropical Cyclone Imboa affected KZN on the same year few weeks apart from the occurrence of Tropical Cyclone Domoina. Other tropical cyclones that affected KZN after Tropical Cyclone Imboa were Tropical Cyclone Eline that occurred in February 2000 and killed 21 people in South Africa, where damage reached at least US$300 million (Reason and Keibel, 2004).

Another tropical cyclone Irina occurred in March 2012 and South Africa reported four fatalities as waves of up to 3 m battered the port of Durban and forced all ships to seek safety (Chikoore et al., 2015). The latest Tropical Cyclone related flooding to affect KZN is Tropical Cyclone Eloise that affected northern parts of KZN, including Jozini, the area of interest of this study. The map below represents the exact location of Jozini in KZN.

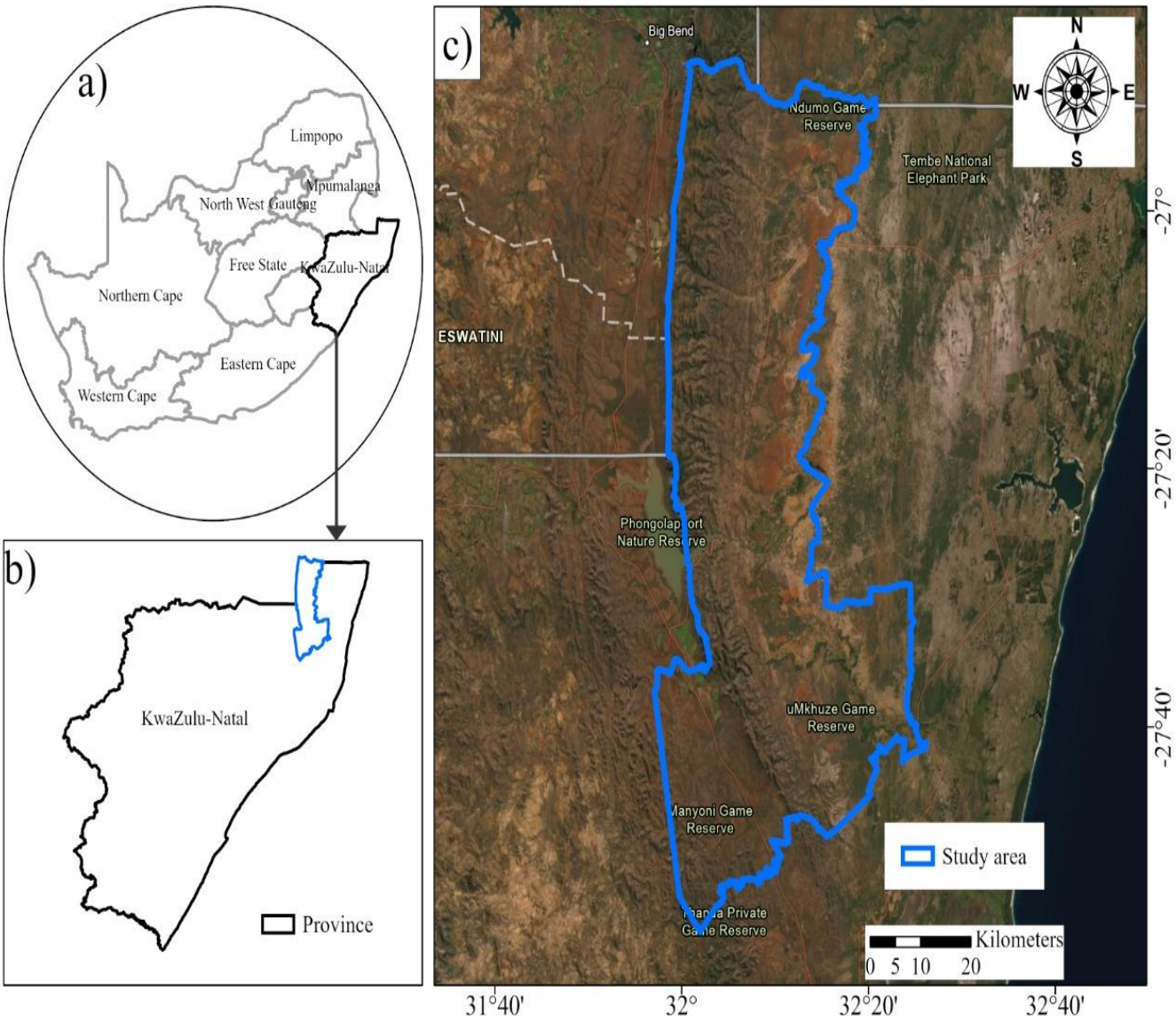

Figure 3.1: Map of South Africa with an extract of the study area. (*source of image: google earth, 2022)*

3.2 Methodology

3.2.1 Introduction

The overall aim of this study was to investigate whether people from Jozini community used and relied on their indigenous knowledge to predict and prepare for Tropical Cyclone Eloise. The methodology chapter lays out the steps taken to collect, process, verify, and analyze the data. The results of the study were collected through semi-structured interviews with 46 residents from Jozini community. This chapter details the sampling methods used to acquire data for this research. It follows by outlining data collection and analyses techniques used for the write up of the research results. Moreover, ethical protocols that were followed to ensure integrity are explained. Thereafter, researcher's positionality is explained, as well as limitations and challenges of the study.

3.2.2 Sampling

To acquire data for this research, 46 participants from 43 households comprising of both males and females were identified and asked to participate in semi-structured interviews. In total, 54 participants were approached, 46 agreed to be interviewed while eight refused. From the eight participants that refused, four refused based on religious beliefs because they believed that a woman only wears skirts and dresses, therefore entrance to their homes was denied. Three participants refused without giving reasons and the last participant was not feeling well.

Participants were identified through snowball sampling, after identification of the first participant through the assistance of a local resident. Bailey (1998) states that snowball sampling is used when few persons having the requisite characteristics are identified and interviewed and there after used as informants to identify to others who qualify for inclusion

in the sample. Participants were between the ages of 22 years and 99 years. In line with the ethics clearance granted for this study, the sample group comprised of persons over the age of 18, however, the main focus was based on people older than 40 years of age, who would have a long-standing understanding of the climate of the area, and of the inter-generational indigenous knowledge. Of the 46 participants that were interviewed, 40 participants were older than 40 years of age.

In terms of paradigmatic assumptions, research on IKS does not seek to test or assume a measured accuracy or inaccuracy of the methods used in forecasting weather, planning agricultural activities, or adapting to climate change. Rather, such research seeks to understand these approaches, and to engage with community members on how they perceive the relative efficacy of their methods. This study explicitly assumes that there are community members in Jozini who would have relied on IKS when responding to the tropical cyclone, and that for some of these community members this would preclude the use of western weather forecasts. Thereafter, this study takes an exploratory and inquisitive approach.

3.2.3 Data collection

The 46 respondents from Jozini community in KZN who were affected by Tropical Cyclone Eloise were asked to share their experiences, understandings, and perceptions of the application of IKS on extreme weather events through semi-structured interviews (Appendix E). The interviews were conducted in person in participant's yards from the 16th to the 20th of November 2021. During this period, the lockdown regulations relating to the third wave of COVID-19 were lifted and the country was on level 1 of lockdown. Regulations relating to

level-1 lockdown were wearing of masks; gathering of not more than 50 people indoors; frequent sanitizing and social distancing. All the mentioned regulations were adhered to, the interview were conducted while wearing a mask and observing the social distance. The interviews took place outdoors (in verandas, under trees and yard) with frequent sanitization (Including sanitization of the participants that agreed). The interview conversations were captured through audio recordings (with the permission of participants). In cases where participants refused to be recorded, notes were taken during the interviews (with participant's permission). On average, the interviews took about 15 minutes and the longest interview took 22 minutes. Interview questions were translated into IsiZulu language as the community is dominated by Zulu speaking people.

3.2.4 Data analyses

All collected qualitative data (audios and notes) were transcribed and translated into English. Thereafter these transcriptions were explored through thematic analysis. Thematic analysis looks mainly at what the data says and aims at identifying themes within the data (Sgier, 2012). Thematic analysis is especially appropriate for the analysis of qualitative interview data obtained from in-depth semi structured interviews (Sgier, 2012). Thematic analysis affords direct representation of an individual's own point of view and descriptions of experiences, beliefs, and perceptions. The interpretation of themes in human experiences provides insight into beliefs, motivations, planning, interpretation, and responses to events (Butcher et al., 2012). Therefore, all the transcribed data were read and analyzed to identify main themes and preliminary topics. During the analyses, notes were taken, and preliminary topics were identified and summarized. A preliminary topic is a descriptive label or code listed

as either a phrase or word summarizing the grouping together of common themes (Butcher et al., 2001). Themes, which refer to generalized precise statements by respondents about their thoughts, feelings, beliefs, attitudes, values, or sentiments (Butcher et al., 2021) were identified, categorized, and reviewed as per thematic analyses (Guest et al., 2012) with consideration of the purpose of the study and the relevant content that can be included in results. After identification of themes and note taking, these were written down as a report with some informative quotes shown on the results.

3.2.5 Ethical considerations

For ethical consideration, I am aware of the importance of obtaining ethics clearance before conducting research, especially one that involves interacting with people. There are legislations that involve the right to privacy. Of particular importance is the Protection of Personal Information Act 4 of 2013 (POPIA), which deals with data protection. Ethics clearance is necessary for academic integrity and for the protection of research participants. Therefore, I applied for ethics clearance from the school of GAES ethics committee. My application was reviewed and approved, and I received ethics clearance certificate with the clearance number: GAES-2021/GEOG-04.

To comply with academic integrity and POPIA, participant's information and recorded audios were kept and are still kept in a security-protected computer. No participants were required to provide their full names to ensure that their identities were not revealed. Participants were required to sign a consent form where they agreed that they were keen to participate on the research with requirements of participation outlined to them. Participants were allowed to withdraw at any time of the research when they wished to. None of the participant's

information was revealed during result writing. To reference quotes from the participants, they were given code names like participant 1 and participant 2 etc. The possible risks of this project during the COVID-19 pandemic was addressed through conducting the interviews only when country was on level-1 of the lockdown, with lockdown rules such as wearing of masks, sanitizing and social distancing observed.

3.2.6 Researcher's Positionality

Positionality in research refers to the opinions and stance a researcher takes about the subject of their research (Manohar et al., 2017; Bourke, 2014). The identities of both the researcher and the participants have the ability to have an impact on the research process because research is a shared environment that is shaped by both the researcher and the participants (Bourker, 2014). Age, sexual orientation, ethnicity, social class, languages, location intellectually and geographically, culture, and race are just a few examples of the variables that can affect the viewpoint that a researcher takes (Qin, 2016). Because of the nature of qualitative research, the researcher serves as the instrument for gathering data. It is logical to assume that the researcher's beliefs, political views, and cultural background (including gender, race, class, socioeconomic status, and educational background) are significant factors that could influence the research process (Secules et al., 2021). Additionally, Magaya and Fitchett (2022) write on the power that researchers have when collecting, interpreting and presenting findings from IKS, and therefore positionality of a researcher in this case needs to be engaged critically. My positionality has affected the way I collect and interpret data, as well as the way participants perceive and engage with me.

I am 25-year-old black, Xhosa women. I was born and raised in Mtambalala location, a rural village under Lusikisiki in the Eastern Cape. My village is predominantly black, and the most dominant ethnic group is Xhosa. I spent the first 18 years of my life there (Childhood, primary school and High school). I started learning IsiZulu and other languages when I got to University in Johannesburg. That was through interacting with other people and doing IsiZulu first year course during my undergraduate studies. One thing I have heard about when I got to Johannesburg was a conflict between Zulu and Xhosa people. I have interacted with Zulu speaking people a lot and have never experienced such. However, it became one of my worries and at the forefront of my mind during interview process. My worry was the imaginary conflict being the real issue in Jozini and myself being in trouble because of my ethnicity.

I would describe my home village as indigenous community. This is something I learnt a few months prior to data collection in 2021, during a master's course called '*sustaining populations and resources*' that had a section on IKS. Before that, I took the way of doing things in my village as another way of living that is different from city's way of life. Growing up at home, we used to fetch firewood, water from the river, use cow dung as form of cleaning, use to sleep on grass mats, used grass brooms etc. We did not have electricity until 2014. Elders in the family used to tell us about certain animal and plant species that indicated various weather conditions, times of the day and activities to be undertaken, also traditional medications that were used for headaches, flu, stomach-ache, sores etc. I was also exposed to different traditional things such as certain ways of greeting elders and which side of the room should I not occupy as a woman when I got to other people's homes.

The most frequent question I was asked before interviews was “where are you from”, with participants expecting me to point around the community. When I would tell them that my home is in the Eastern Cape, they would ask why did I not conduct the research in Eastern Cape, why did I choose their community. Others mentioned that they could tell by my Zulu speaking that I was not from the community. A few participants went to the extent of asking my clan name, which is similar to one of the Zulu clans. They would say a few praises and ask what I visited them for, with interest.

Some community members showed that they did not trust me, thinking that I represented some insurance company or political party. In some cases, this affected the way they were answering my questions because they wanted me to be quick and leave their homes. Some would give me one-word answers and not want to answer follow up questions. As a result, some of my research participants refused to sign consent form and opted for verbal agreement instead. There were two cases of participants that did not want to answer honestly and openly because they did not believe that I was doing the interviews for research purpose for the fulfilment of the requirements of my degree. They thought that I was sent by someone to steal their knowledge, as that is how “Our forefathers lost their resources, they sent one of our own to deceive them” said Participant 34, a 77-year-old male. One of the main reasons why some community members withheld some information from me was that I was not from the community. Perhaps they would have been more trusting and freer around me if I was from the same community.

Four households denied me access because I was wearing trousers. Based on their religious beliefs, a woman cannot wear trousers but only dresses and skirts. This is a common belief in many households in the area but fortunately, majority of the households welcomed me the

way I was. The only dressing code I took note of was to make sure that I wear clothes that fully cover my body. I never anticipated that what I wear would cost me access to some homes. I was not aware of religious beliefs that completely impede women from wearing pants/trousers.

3.2.7 Limitations and challenges of the study

As any other study in qualitative research, there were limitations and challenges associated with the research design and data collection. However, these limitations did not affect the reliability and validity of the results obtained from the 46 participants as presented in the results chapter. Challenges that were faced during this study will be discussed below.

a) The size of the study group

One of the most apparent disadvantages of qualitative research is that the findings cannot be generalized to larger populations with the same degree of confidence (Ochieng, 2009). Therefore, the results obtained from this study, although the IKS used is similar to those of the studies from other parts of southern Africa and some parts of the world regarding the use of IKS indicators in foresting of weather and reliability of weather forecast methods, their applicability is mostly limited to the people that were interviewed. Compared to the number of people residing in Jozini, definite results or information cannot be obtained by just speaking to 46 community members.

These results may represent views and knowledge of some of the residents. However, getting more accurate and relatable results for the whole community would require a larger sample

size and inclusion of focus groups in methodology. This is also because IKS cues and approaches are mostly based on subjective assessments of the natural environment in relation to a certain community (Lefale, 2010; Chand et al., 2014). As a primary data collection method, this study used individual interviews. This strategy is based on gathering data in a sense that enables the attribution of only one participant's perspective on the subject under investigation at a time (Dworkin, 2012). This is a different approach from focus groups where participants from one area can gather and express different insights and observations of events and interpretation of observed changes. Focus groups could not be included in the methodology of this research because the interviews took place during the COVID-19 pandemic. Although it was during level 1 of lockdown with ease on some restrictions, gathering of crowds was still risky and not advised. It would have been difficult to control a crowd of elder people and ensure that they social distance. For their safety and mine, I had to interview them individually at their homes and the results obtained are still valid and accurate.

b) The time between occurrence of Tropical Cyclone Eloise and interview period

Some of the community members could not remember the occurrence of Tropical Cyclone Eloise. Some would remember the events like damage of houses and floods but struggled to remember whether it was the weather event in question or something that happened a long time ago. The time between the occurrence of Tropical Cyclone Eloise and data collection was 10 months, maybe if the interviews were conducted earlier, for example within 3 months of the event, participants would have immediately remembered all the important details about the event. However, the data collection process could not take place earlier than this because

I had to write up and submit a proposal first and therefore get an ethics clearance certificate before going to the field. Nevertheless, the time between the occurrence of Tropical Cyclone Eloise and interview period was not years apart, therefore it was not unreasonable to expect the research participants to remember information about the occurrence of the Tropical Cyclone.

CHAPTER FOUR

RESULTS

4.1 Introduction

This study investigated whether residents of Jozini use IKS to forecast and protect themselves from extreme weather events, with a focus on Tropical Cyclone Eloise that occurred in January 2021. The study group of this research comprised of people from Jozini location, a rural community under uMkhanyakude district that was affected by Tropical Cyclone Eloise.

This chapter covers the results from the study, starting with the demographics of the participants that entails age group, number of participants, gender and the duration of staying in Jozini. This is followed by thematic analyses of the results, starting with the use of IKS. Additionally, understanding of tropical cyclones by the participants is explored. This section is then followed by the discussion of indigenous indicators used to forecast tropical cyclones, then the reliability on weather versus reliability on IKS by the respondents is analysed and compared. This chapter further analyses the prediction of Tropical Cyclone Elosie by participants, as well as the indigenous indicators they use to take precautions against tropical cyclones. Lastly, the perceived difference in the occurrence, frequency and severity of tropical cyclones is outlined.

4.2 Participants demographics

A total of 46 participants were recruited through snowball sampling and interviewed. The first participant was participant 10, a 38-year-old female that was born and raised in Jozini.

Participant 10 then directed me to a few households she knew had elderly people after being interviewed. Some participants referred me to elderly people they knew around, based on the questions that were asked. After being interviewed, they would tell me about someone that is older and could provide me with 'better answers'. In some cases, participants were asked to show households that had elderly people. I kept being shown different households until I got the number of participants needed.

The study group comprised both male and female participants, with male participants making up to 37% (n=17) of the study participants while females made up to 63%(n=29) of the study participants. The age group of the participants was between 22 and 99, with the youngest participant being 22 years and the oldest being 99 years. Participants were also asked the duration of their stay in Jozini. All participants indicated that they have been living in Jozini for at least 15 years, with 44 participants being born and raised from the community, while participant 15 has been residing in Jozini for 15 years, and participant 19 for over 20 years. This suggests that the data they provided was more representative. One can learn about environmental indicators and how they are used to predict the weather by spending a lot of time living in the community. The table below represents demographics of participants and these include age group; gender and duration of stay in Jozini.

Table 4.1: demographics of participants

Age group	**No. of participants**	**Genders**		**Duration in Jozini**
		Male	Female	
20 to 30 years	2	1	1	Born in Jozini
31 to 40 years	5	1	4	1-15 years 4- Born in Jozini
41 to 50 years	13	5	8	Born in Jozini
51 to 60 years	6	2	4	1- 20 years 5- Born in Jozini
61 to 70 years	8	3	5	Born in Jozini
71 to 80 years	8	4	4	Born in Jozini
81 to 90 years	3	1	2	Born in Jozini
91 to 100 years	1	0	1	Born in Jozini
Total No. of participants	46	17	29	

4.3 Thematic Analyses

4.3.1 Indigenous knowledge systems in forecasting extreme weather events

All 46 participants indicated that they use their IK on daily basis. According to the participants, they apply this knowledge to farming, and on weather forecasting. Some participants (33%, n=15) mentioned that they entirely depend on this knowledge for their day-to-day activities, while 52% (n=24)said that they started integrating their IKS with information from the news when televisions started to be common in their village. In this regard, participant 14 said:

> "Because these days we have TVs and we are always watching TV, we see everything from it and then get a confirmation when we step outside. Sometimes the TV tells us incorrect information…" (Participant 14).

The remaining 14% (n=7) of participants said they get informed about their weather conditions through watching TV and listening to radio, they do not use IKS because it has become hard to forecast weather using their IKS. This included the 99-year-old female participant that commented:

> "We hear from the news everything now because these things have become hard to predict using our knowledge, at least they have technologies that enable them to predict things from afar".

It is important to note that the 14% of participants did not say they completely abandoned their IKS, but they rely more on TV and radio in terms of forecasting weather. From the 33% (n=15) of participants that said they entirely depend on IKS, all of them said they do not watch or listen to weather forecast at all. Reasons included inability to understand scientific weather forecast; not having TVs or radios; incorrect weather forecast and trusting their own knowledge. In this regard, participant 2 commented:

> "No! I do not trust radio and TV… these people sometimes predict weather incorrectly; they tell us that it will rain but sometimes it does not happen. The best way to predict weather correctly is by going outside a night before and look at the moon and the stars they show the condition of the weather of the following day. Then you wake up in the morning and observe the mist/fog, if it is there is means that it will be very hot on that day" (Participant 2).

Another 71-year-old female participant said:

> "We grew up using our own knowledge, we did not have TV and radio… some of us still use that knowledge. The people from TV are not very certain about what they tell us so that is why I just observe the weather myself" (Participant 37).

The 53% (n=24) of participants that said they use both their IK and scientific forecast implied that they watch weather from news and observe using their IK. Some meant that they use IKS some days and watch from the news other days. Others watch their TV then go out to confirm using their IK. To substantiate this point, a participant said: "…we see everything from TV and then get a confirmation when we step outside" (participant 14). Participant 45, an 81-year-old male said: "now we watch on TV, we mostly used our traditional knowledge before we had TVs and radios". Participant 29 further said, "I watch TV, I can see by myself but to be sure I watch on TV".

4.3.2 Challenges associated with the use of Indigenous knowledge systems.

According to the participants of this study, there are challenges associated with the use of IKS that make it hard to rely on them. These include climate change, lack of indigenous species and environmental degradation. A few participants (30%, n=14) mentioned issues of the changing environment that makes it difficult to use this knowledge accurately. To substantiate this point, said:

> "Yes, I use the knowledge that I learnt growing up. But the problem is that we used to have a lot of birds that showed us different seasons and weather

> conditions, but we don't have them anymore. The state of nature is changing, and we must adapt to the new changes" (Participant 42).

People still use their IK despite the problems with the lack of indigenous animals and plants that showed them the signs and the changing climate that makes it hard for them to forecast. They have not abandoned their knowledge, "… even though sometimes it is not accurate" (Participant 20). There were participants that have strong belief and use only their knowledge despite the problems mentioned above, and the information from weather services. In this regard, participant 19 (56 years) said:

> "I use the knowledge I acquired from my elders on everything I do from farming, livestock, and weather. I don't even know what goes on TV and radio; I don't understand what they say" (Participant 19).

Another participant said:

> "Yes, I use the knowledge that I learnt growing up. However, the problem is that we used to have many birds that showed us different seasons and weather conditions, but we do not have them anymore. The state of nature is changing, and we must adapt to the new changes" (Participant 42).

Participant 11 shared similar experience when he said:

> "I can't anymore, I just see things happening. Sometimes it seems like it's going to rain but end up not raining, it is hard to predict nowadays… climate has changed" (Participant 11).

A few more participants (11%, n=5) aged 47 (female); 48 (female); 80 (male); 81(male) and 85 (female) mentioned how they would have loved to still be using their knowledge for certain

things in their lives, but they do not use this knowledge on everything anymore because they have adopted the western ways of doing things. To support this statement, a participant revealed that:

> "There are a lot of traditions that we used to do but do not do anymore, for example growing up we were told to show respect when there is thunderstorm... we were not allowed to stand, eat, laugh, or be outside, we don't do those things anymore, people don't have respect for certain weather conditions that traditionally needed to be respected" (Participant 22).

Another participant mentioned religion as one of the challenges faced when using IK and said:

> "We have pastors that judge us when we practice our traditions as if it is something wrong. We cannot do these things openly now because they will accuse us of being evil. The western religion and beliefs are invalidating our traditional ways of doing things". Participant 45, an 81-year-old male said.

Participant 30 shared concerns about how everything is becoming hard to predict recently by commenting:

> "During the day we normally experience strong winds and then it starts in the afternoon but now I don't know what has changed, everything has changed… it's hard to predict tropical cyclones and other weather conditions. Things can just happen anytime and anywhere, it's hard to keep track" (Participant 30).

Elderly participants were voicing their concerns about how their indigenous plants and animals have gone extinct, making it hard for them to predict certain things. In this regard, Participant 39, a 72-year-old female said:

> "These days we are inclined to radio and television… these people tell us everything, so we don't necessarily go outside to observe weather. Now we are forced to depend on what they tell us because a lot of things have changed. Plants and animals that used to be very useful for us when it comes to these things have gone extinct" (Participant 39).

Participant 46 further said "Our knowledge and predicting things were more accurate before compared to now" (Participant 46).

Even though there are difficulties associated with the use of IKS because of changing times, people shared their understandings of tropical cyclones and the indigenous things they do to protect themselves from tropical cyclones. These will be discussed on the paragraphs below.

4.3.3 Understanding of Tropical Cyclones

One of the objectives of this study was to understand the IKS used by Jozini residents in predicting tropical cyclone Eloise. To get into this objective, participants were first asked what they understand about the phenomenon of tropical cyclones and their use of IKS to protect themselves from losses resulting from these storms. Tropical cyclones, according to 64% (n=29) of participants, happen in the summer, whereas 15%(n=7) of the participant claimed they happen in the winter. The remaining 21% (n=10) of participants were not sure and could not remember when tropical cyclones take place. The majority of the participants could not give clear understanding of why tropical cyclones occur and where they come from. While 28% (n=13) of the participants believed that a tropical cyclone is a snake that moves towards climates that are more suitable. In this regard, participant 15 commented:

> "They occur when it's very hot, it comes with heavy rainfall and strong rotating winds. It is believed that it comes with a snake that moves across rivers and oceans. The water gets too hot that the snake needs to move elsewhere, and its movement comes with heavy rainfall and winds" (Participant 15).

Another participant with similar understanding said:

> "Tropical cyclones are caused by a snake… a river snake when it wants to change from one location to another. It can move from Jozini dam to Mkhomazi… that is when heavy rain comes with thunder and causing floods. All rivers and dams have snakes that sometimes move from one place to another. For example, when the snake moves from Jozini to Durban, they experience heavy rains in Durban, but it starts from here" (Participant 2).

Three participants associated the occurrence of tropical cyclones with climate, specifically air pollution. They believe that they occur mostly in summer due to high temperatures. To substantiate this statement, a participant said:

> "Some people associate their occurrence with air pollution… for example in the industries as they make their products and producing dirty air in the process that becomes very dangerous and forms tropical cyclones, when it becomes too much on the atmosphere, if forms heavy rainfall" (Participant 3).

The most commonly cited characteristics of tropical cyclones were strong winds; dark clouds; heavy rainfall and sometimes thunderstorms. All these characteristics were mentioned by all 46 participants as indicators when experiencing a tropical cyclone. Participants shared that people that are in valleys are more prone to the disaster that a tropical cyclone might cause

compared to people that are in communities that are on flat surfaces. The floods that come with tropical cyclones are less likely to damage their properties because "…for example here this place is very flat, so a tropical cyclone loses power very fast" (Participant 3).

Another finding about tropical cyclones was that this community has no indigenous ways of forecasting them. They have no sign (plants or animals) that specifically shows that a tropical cyclone is coming. The indigenous signs are there when a tropical cyclone will be accompanied by thunderstorm, heavy rainfall, or flooding. Animal behaviour such as movement of a cat and disappearance of livestock (goats) occur during the tropical cyclone. The respondents have indicated that there are indigenous signs that indicate that thunderstorms or heavy rainfall will occur for example, but they have no way of knowing if it will just be heavy rainfall or come with a tropical cyclone. All 46 participants said that the most accurate way of knowing that a tropical cyclone is coming is seeing the signs like strong winds and dark clouds on the day a tropical cyclone will occur. One participant when she was asked about her understanding of tropical cyclones said, "we see them by very strong and dark clouds, unusual clouds but I cannot forecast it before the signs show" (Participant 6). This response is similar to that of participant 17 who said "…They are characterized by very dark clouds and strong winds. They are not predictable days before they take place… using our knowledge" (Participant 17).

The following section will cover indigenous signs that participants said they indicate possibility of a tropical cyclone. Participants mentioned that most of the signs are not directly linked to the occurrence of tropical cyclones but what comes with the tropical cyclones, for example heavy rainfall and thunderstorms.

4.3.4 Indigenous signs that indicate possibility of Tropical Cyclones

To further understand how well the participants understand tropical cyclones, they were asked the indigenous signs that indicate a possibility of tropical cyclones. About 61% (n=28) of the participants were certain that there are no indigenous signs that expressly point to the possibility of a tropical cyclone but they continued to share signs that show when a tropical cyclone will come with heavy rain, strong winds, floods, and thunderstorms. The most accurate way of confirming if these signs were indeed, indicating an impending tropical cyclone is by observing weather and seeing the signs on the day a cyclone takes place. Below are the few signs that participants said they indicate a possibility of a tropical cyclone. The most common used signs for weather forecasting are cloud appearance, sun, fog in the morning, and wind. These are the things that they are left with to check when they want to know weather because they do not have forests that kept their indigenous animals, they do not have trees that used to be all around their neighbourhood, "… the land is dry, our animals and insects have left us… we are left with nothing" (Participant 46). The table and figure 4.1 below represents indigenous signs that indicate possibility of a tropical cyclone.

Table 4.2: Indigenous signs that indicate possibility of tropical cyclone

Meteorological	**Animals**	**Human ailments**
Cloud density	Swallows	Children
Wind speed	Ants	Elders with operation scar
Temperature	Cat	Fatigue

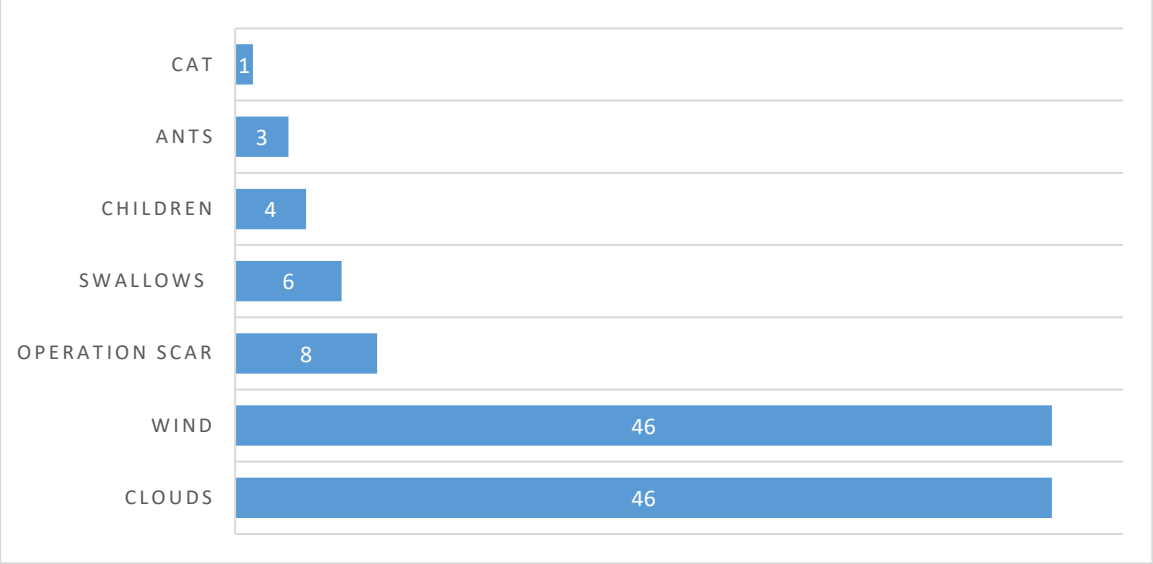

Figure 4.1: A bar showing indicators used to forecast tropical cyclones and the number of participants that mentioned them

a) Swallows

Not many people mentioned this indication, 13% (n=6) of participants mentioned it and even the ones that mentioned it said that they are no longer there, and they believe that they have gone extinct because they hardly see them. However, when they were still a lot, they would move up and down across the neighbourhood if heavy rainfall were coming. In this regard, one participant (80 years, male) said:

> "We can only forecast them if they come with heavy rainfall because swallows are believed to be an indication of heavy rainfall. However, swallows may indicate a heavy rainfall or a tropical cyclone that comes with a heavy rainfall. However, using swallows as indigenous signs is becoming useless because they are extinct now, we… we have lost forests and environments that supported our indigenous animals" (Participant 40).

Only six participant mentioned swallows as an indication of a possible tropical cyclones. Maybe this is because they are not a direct sign of a tropical cyclone, or it is because they do not have abundance of them in the neighbourhood, so they do not rely on them anymore. One participant further said:

> "Sometimes animals also have meanings, for example birds like swallows have meanings. When they fly low, it means that there will be heavy rainfall accompanied by strong winds. Another animal is goose they move up and down making noise with their mouths and wings" (Participant 17).

b) Ants called 'oMakoti'

Three participants said there used to be big ants named omakoti, which translates into English as 'the brides'. These ants would appear out of nowhere and start to roam around the yard only when a heavy rainfall with strong wind will come. In this regard, participant 7 said:

> "Long time ago we used to see by seeing ants called "Omakoti" but now we hardly see those. There were a lot of animals and insects that used to indicate certain things other than weather but now they have disappeared" (Participant 7).

c) A cat

One participant mentioned a cat as a symbol of an impending tropical cyclone. She did not mention weather it indicates a certain weather condition that comes with a tropical cyclone but said:

> "Our elders used to say that a cat usually moves form one room to another when it senses a tropical cyclone and we had to follow it" (Participant 3).

She further said, "When the tropical cyclone was too bad, we usually see by a dead goat" (Participant 3).

d) Clouds density and wind speed

All 46 participants said that the characteristics of a tropical cyclone are strong rotating winds and very dark clouds. It was also mentioned that these signs can only be seen on the day a tropical cyclone will take place and they are the most accurate in informing people. Clouds and wind speed are what some of the participants were referring to as signs that show on the day, they are not a prediction method as they are part of the tropical cyclone that is already taking place. Moreover, one participant said that she is able to differentiate between the wind that comes with a tropical cyclone and normal wind through the movement of big trees.

e) Scar from a surgical procedure

About eight participants, all females said that when a tropical cyclone is coming, they feel on the scars where they had an operation. When the scar becomes very painful for no reason, it indicates that bad weather such as tropical cyclone is about to occur. This scar is usually the one that they get during childbirth, but all other operation scars show. "And my abdomen becomes very painful and some people who gave birth through operation can feel it where they were cut" (Participant 7).

f) Children

Four participants said that young children are able to feel when a tropical cyclone is coming, and they express this feeling through crying for no reason nonstop. In this regard, participant 17 commented: “Children… children can show when there will be tropical cyclone, but very young children from zero to six months. They cry nonstop” (participant 17). Another one said: “We can also see that a tropical cyclone will come by observing our bodies as elders and also observing children, we become exhausted” (Participant 12).

Participants were further asked to indicate whether they could see the difference between tropical cyclones that cause damage and the ones that do not. As the majority of them said that they could not predict tropical cyclones before they occur, the same concerns came up for this particular question. Because they said there is no way of forecasting before a tropical cyclone shows signs, this also meant that there is no way of telling the amount of damage it will cause until it takes place or passes. There is exceptional minority that mentioned a few things that might indicate that the tropical cyclone will be dangerous. These will be discussed on the following section. The table below represents traditional indicators used to forecast tropical cyclones and their behavioural signs.

Table 4.3: Behavioural signs of traditional indicators used to forecast tropical cyclones

Indicators	**Behavioural signs**
Cloud density	The sky becomes very dark and totally covered by dense clouds
Wind speed	Strong rotating winds that forms dust and destroys property
Surgical scar	Pain or discomfort on the scar on people who had surgical operation before
Ants	Appearance and movements of ants called omakoti that appear from underground
Cat	Strange movement of a cat from one room to another
Swallows	Movement of swallows up and down across the neighbourhood
Children	Unrest of infants (children younger than 1 year old)

4.3.5 Difference between Tropical Cyclones that causes more damage and the ones that causes less

Participants were asked if they have an indigenous way of knowing or telling if a tropical cyclone will cause more or less damage. The majority of participants indicated that there is no way of telling how much damage a tropical cyclone will cause before it takes place, as they have no ways of accurately forecasting it. The damage can only be seen during or after the tropical storm has passed. In this regard, participant 10 said, "I cannot tell the difference in severity of tropical cyclones, I can only see after everything that oh… this one was very dangerous, it caused a lot of damage" (Participant 10).

28% (n=13) of the participants mentioned a few things that they notice when a tropical cyclone will cause damage. This included behaviour of domestic animals, the direction of the

winds, wind speed and cloud density. Only one participant mentioned something about the behaviour of domestic animals, and he said:

> "If it is going to be very dangerous, domestic animals give us signs… most of the times when we are about to experience tropical cyclones our domestic animals such as goats and sheep just disappear. They go to the nearest forest for shelter, and they disappear for 2 to 3 days until weather becomes normal" (Participant 34).

In terms of the wind direction, participant 12 said she believes that tropical cyclones that come from the north and south are usually very powerful compared to the ones that develop from east and west. Another participant said that she believes a cyclone that takes place during the night is dangerous because they do not see it coming and therefore do not take the necessary precautions to protect themselves. To substantiate this point, participant 7 commented:

> "I can tell the difference. One that will cause damage usually begins in the evening and not during the day. This one it is very difficult to protect yourself from, because you cannot even sprinkle salt and ashes at night. But the one that occurs during the day is easy to protect yourself from because you can see it coming and do the necessary things for protection" (Participant 7).

Out of the 28% (n=13)of participants, most of them emphasized strong winds and wind speed as the main indicators of a strong tropical cyclone that causes disaster. Participant 29 said, "I can tell the difference… for a tropical cyclone that is very dangerous, the wind rotates very fast and make some unusual noise in the process. That is how we know that it is very bad". On the other hand, participant 5 supported this statement by saying "when the cyclones do

not pose danger, clouds do not become very dark. But when it is very dark it even makes noise and that shows that it is very dangerous, and it will damage houses" (Participant 5).

Out of the 28%(n=13) of participants that agreed to be able to tell a difference between cyclones that cause damage and the ones that do not, only three said something different. The most mentioned sign were strong winds and dark cloud, which is something that shows on the day a tropical cyclone takes place. The sections above have shown that there is not much understanding of tropical cyclones and the knowledge they have is mostly applicable on short terms bases. The following section will cover reliability of news versus IK. With the issues of the changing climate and extinction of species, the section will assess whether people are still holding on to their knowledge or adapting to the new technologies.

4.3.6 Reliability on weather services vs reliability on IKS

All participants were asked if they depend on news (radio and television) or on their own knowledge to forecast weather. 15%(n=7) of the participants said they only watch weather on news; they do not use their IK. On the other hand, 33%(n=15) of the participants said they only use their IK for weather and their day-to-day activities; they do not use television and radio at all. In addition, the last 52% (n=24) of the participants said they use both their IK and news. By using both IKS and scientific forecast, they meant that they watch news then confirm using their IK when they step outside, or they observe weather using IK then watch news to confirm. In some cases, they use these alternatively, "I use both, sometimes I watch on the news and sometimes I check for myself" (Participant 11). There are three main reasons why people gave the answers they gave. These were inability to understand what is said on television and radio, incorrect weather forecast, lack of indigenous signs that used to help

people predict and changing climate that makes it difficult to predict weather accurately. These will be highlighted below.

a) Incorrect weather prediction by weather services

The concern about incorrect weather forecast came from people that said they only use their IK and a few people from the ones that said they use both their IKS and weather services. They said they still listen to radio and television because their IK is becoming useless with the lack of plants and animals that used to help them forecast. Some said they would rather go outside and observe the weather than watch on television. Participant 2 was asked if she depends on radio and television or her IK, and she said:

> "No! I do not trust radio and TV… these people sometimes forecast weather incorrectly; they tell us that it will rain but sometimes it does not happen. The best way to forecast weather correctly is by going outside a night before and look at the moon and the stars they show the condition of the weather of the following day. Then you wake up in the morning and observe the mist/fog, if it is there is means that it will be very hot on that day" (Participant 2)

Participant 3 said sometimes the television tells them incorrect information about weather, so using the knowledge they were taught by their elders is more accurate. "So, I use my own knowledge because I do not even listen to news anymore" (Participant 3).

Sometimes the news forecast something that does not happen. Sometimes it happens somewhere else but not in their area, "so they are unable to tell us our weather condition specifically" (Participant 11). "The people from TV are not very certain about what they tell

us so that is why I just observe the weather myself" (Participant 37), "but they are getting better with time" (Participant 18).

b) Inability to understand television language

Two participants spoke about how they do not understand what they say on television and radio. The representation of weather with numbers confuses them. A 63-year-old male participant said:

> "…TV… TV can be hard to understand sometimes, they tell us about weather using numbers. It is hard to understand" (Participant 41).

One of the two participant also mentioned that she has eyesight problem so she cannot see the visual presentation of weather on television. In this regard, she said:

> "They do tell us about weather on TV and I don't understand what they say. I have eyesight problem so I cannot even see the things they put on screen… these things just become blur. However, even my knowledge is no reliable. Therefore, I just see things happen… but sometimes I can tell when it will rain. There are times where I forecast something, and it does not happen" (Participant 23, 68-year-old female).

c) Changing climate

Climate change and environmental change were mentioned as the reasons why is has become difficult to forecast weather using IK. Even when sometimes the signs of a certain weather

condition are there and people assume that it will take place, sometimes it does not, and this is something that did not happen before. A 70-year-old female said:

> "The state of weather has changed… it is not like before anymore. I used to be able to tell but now it is difficult. Before we never went wrong when it comes to forecasting… now the weather gives us false signs, the things we forecast do not happen anymore" (Participant 43).

Climate change is also the reason why people from Jozini have lost plants and animals that were meaningful to them and that were very useful in terms of weather forecasting and farming practices. With these plants and animals no longer existing, they are losing hope in their IK, especially things that require certain plants and animal species to know. In addition, one participant said that there is no hope of ever getting their species back because the whole area has houses now, the plants will never grow back. Therefore, this implies that climate change is not the only reason behind loosing certain species, but overpopulation too. Given all that has been discussed above, the following section will assess whether people were able to predict Tropical Cyclone Eloise, the most recent tropical cyclone that first made landfall in Mozambique and affected parts of KwaZulu-Natal including Jozini in January 2021.

4.3.7 Prediction of Tropical Cyclone Eloise

As mentioned above by the participants that there is no indigenous sign that shows possibility of a tropical cyclone, other than the signs that indicate weather events that will come with the tropical cyclone like heavy rainfall and thunderstorms. In the case of Tropical Cyclones Eloise, other than hearing about it from the news, people did not forecast it before it happened but saw its characteristics like strong rotating winds and dark clouds on the day it

reached Jozini. Out of the 46 participants, only 7% (n=3) of them said that they saw Tropical Cyclone Eloise coming. About 48% (n=22) heard about it from the news and 45% (n=21) only saw it when it occurred. Participant 5 shared that:

> "It started off by very dark clouds that went up and then down. It felt like thunderstorms. There were also very strong winds that destroyed our house and the house next door" (Participant 5, 40-year-old male)

None of the participants mentioned seeing things like ants and swallows as they said that they represent possibility of a tropical cyclone, it seems like nothing showed for Tropical Cyclone Eloise other than strong winds and dark clouds on the day it reached their location. In this regard, participant 3 commented:

> "I was not able to forecast it, but I heard that it was reported that its coming, but it did not happen the way they told us it would. It did come but the media exaggerated the severity of it. It caused damage in Mozambique but here it was better. there were signs of a coming heavy rainfall, but the signs were that of thunderstorms… we were expecting something big based on what we were told on the news, but the cyclone was nothing compared to what we expected" (Participant 3, 43-year-old female).

One more participant (47, female) said "

> "Meteorologists have their own ways of seeing if a cyclone is coming even days before. We cannot predict for a long term like days… we can only see the signs on the day that a cyclone will take place. There are no indigenous ways of

forecasting days before. I don't remember if I was able to forecast Tropical Cyclone Eloise" (Participant 13).

The following section will cover indigenous ways of protection when there is a tropical cyclone.

4.3.8 Indigenous ways of protection against Tropical Cyclones

Participants mentioned various things that they do to protect themselves from tropical cyclones. These included use of rough salt and ashes, which is the second most common used technique coming after 'uk'shaya amagogogo' (which means making noise using tins and drums when explained). A few more techniques that were mentioned included covering of shiny things and switching off televisions and cell phones, burning of car tires, burning of cow dung, and a few more. Table 4.4 below represents indigenous ways of protecting the community against tropical cyclones.

Table 4.4: A summary of indigenous ways of protecting the community against tropical cyclones

Indigenous ways of protection	**Direct quote**
Sprinkling salt and ashes	I usually mix sand from the sea and ashes, mix is with salt and sprinkle the mixture all over my yard for protection, and it prevents tropical cyclone from causing damage on our properties (Participant 3)
The rod	Another method of protection is "Ukukhipha induku" (which means to remove the rod). The rod is usually put by the doorway of a rondavel that is made of grass. But these rods are not accessible to everyone, they are usually used by traditional healers (Participant 5)
Amagogogo	"ukshaya amagogogo" using anything from the yard that can cause noise to prevent a cyclone from coming or not to have much power (Participant 8)
Trees	Another way is planting of trees, it is very important to have trees all around your yard because they protect from strong winds by preventing wind from damaging houses. That is why they are important. (Participant 12)
Firstborn child	Based on our religious belief we prevent cyclone from causing damage by sending firstborn a child outside wearing a white doek. She has to the first born from both parents.

a) Sprinkling salt and ashes

The sprinkling of salt and ashes as soon as the signs of a tropical cyclone show was the most mentioned indigenous method of protection against tropical cyclones. People believe that this method chases the cyclone away or weakens it so that it does not cause damage. The method is used by 72% (n=33) of the participants whenever a tropical cyclone approaches. In support of this statement, participant 3 said:

> "Sometimes when it becomes cloudy, I usually mix sand from the sea and ashes, mix it with salt and sprinkle the mixture all over my yard for protection, it prevents tropical cyclone from causing damage on our properties" (Participant 3).

b) 'Ukshaya amagogogo' (making noise using empty tins and drums

This method refers to making of noise using containers and tins that are empty to chase away the tropical cyclone. It is done by the whole village; everyone comes out and start making noise with whatever that is in front of them. They believe that this makes a tropical cyclone stand still up there until it dies or loses power, or it goes somewhere else. 93% (n=43) of the participants said they use this method to protect themselves from tropical cyclones. To substantiate this point, participant 3 said:

> "…And then I make noise using empty containers so that the tropical cyclone will not come near my yard. We do this because when a cyclone sees the roof zinc we build our houses with, it thinks that it is a dam and want to land on it, so by making noise we want it to move far away" (Participant 3).

Participant 3 said "I believe it does… and I'm not the only one who does the noise making but the whole neighbourhood, that is how we protect ourselves" when she was asked if she thinks this method makes a difference.

c) The Rod called Iskhonkwane sezulu (weather nail)

A number of people mentioned different uses of the rod. The end goal for all the uses it to prevent tropical cyclones and thunderstorms from causing damage. Some people mentioned using just one rod and sticking it on the yard. Other people mentioned using four rods and sticking it on four sides of a rondavel. Others said they use just one rod and put it just on top of the doorway of a rondavel. Participant 40 was asked if there is anything he uses to protect himself from tropical cyclones and he said "Ukukhipha induku" (which means to remove the rod). The rod is usually put by the doorway of a rondavel that is made of grass. But these rods are not accessible to everyone, they are usually used by traditional healers". In this regard, participant 21 said:

> "To protect ourselves we use something called weather rod (induku yezulu). They give it to 4 young girls that have not reached puberty stage… it has to be 4 sticks and 4 girls, and they point these sticks to all 4 directions, opposite directions (That is if one girl is standing at north, she will point her stick south). After that, they put them down and go inside the house and an elderly man comes to pick up the sticks. The sticks come from a plant called 'umsuzwane'. That is what we used to do growing up… but now we see things from the TV" (Participant 21).

Participant 21 further mentioned that now they depend on news because these things were supposed to be done by young girls before they reach puberty and get their periods. The problem is that they get their periods while they are still very young and they don't even tell their parents that they have started their periods, "we used to tell our mothers these things" (Participant 21).

d) Planting of trees

A few participants emphasized the importance of planting trees, not just the traditional meaningful trees but also trees that can block wind from damaging property. Participant 41 said, "I also have trees all over my yard that are protecting me from any form of disastrous weather condition."

Participant 39 further supported the statement from participant 41 by saying:

> "Another way is planting of trees; it is very important to have trees all around your yard because they protect from strong winds by preventing wind from damaging houses. That is why they are important".

e) First born child with four stones

Participant 37 shared another method of protection even though she was not sure if it is still applicable. But she said growing up they were taught that when a tropical cyclone is coming, the first-born female child would need to take 4 stones for four directions… that is north, east, south and west. Sometimes they would be told to hold the fifth one to throw up. "It strictly had to be a first born from both parents, not just anyone," she said.

f) Other methods of protection

One participant that happened to be a traditional healer said that they have their own ways of protecting themselves, especially as traditional healers. There are herbs they use but could not disclose that information with me. Another method of protection is using intelezi, which

refers to traditional herbal medicine called charm. “They use this medicine to sprinkle inside the room where the whole family is gathered during a tropical cyclone” (Participant 37). Burning of car tires and burning of cow dung also came up three times. Covering of shiny things and “We also need to stay in a room that is safe such as rondavel that is made of grass and mud” participant 3 said. One participant said that based on her religion, sending a child outside wearing a white head wrap helps to prevent tropical cyclone from causing damage. In addition, another one said: “have you noticed how many traditional houses have bull horns just on top of the doorway on a rondavel? That is a traditional way of protection” (participant 41). There is one participant that said, “A traditional healer from Mozambique once told me to spit on a shoe and throw it outside when there is a tropical cyclone that is accompanied by thunderstorms” (Participant 41).

4.3.9 Difference in frequency and severity of Tropical Cyclones over time

Participants were asked if they have noticed any changes in the occurrence of tropical cyclones over time. Majority of the participants said they have not noticed anything in terms of frequency, and a few mentioned how tropical cyclones occur more frequently compared to how tropical cyclones were taking place before. Participant 24 said: “There are some changes in the frequency because before they took years to occur but now almost every year there is a tropical cyclone. Even the severity now is much more compared to before”.

People believe that the damage caused by tropical cyclones is becoming worse and more dangerous. Participant 23 said “…but nowadays tropical cyclones even cause death but long ago the consequences were not this severe.” One of the frequently mentioned reasons was the fact that people now have cell phones and televisions, but that is not the direct problem,

the problem is that they do not respect tropical cyclones anymore. Before, they knew that cell phones and television need to be switched off and covered until it passes. But now they do not do those things anymore. The emphasis was on children that do not want to obey but question everything they are told. In this regard, participant 5 said: “Thing is that before, we did not have phones and TV and these are very dangerous during tropical cyclones, so they need to be switched off, but children today do not want to listen.”

a) Environmental change

Some participants believe that the reason behind the severity of tropical cyclones is climate change that is caused by pollution. They believe that the extreme temperatures they experience are also the reason why tropical cyclones occur more frequently and cause more damage. Participant 33 could tell that something has changed but could not point out what exactly has changed when she said: “…they are changing and there is something behind this change, but we just don’t know it, something wrong is being done somewhere” (Participant 33). On the other hand, another participant said: “things have changed; strange things are happening now… we don’t understand what is going on. It feels like we are losing touch with nature” (Participant 30). Participant 25 said that according to his observation, everything has changed “… everything from farming, to rainfall, weather, the environment in general… things are strange now. It is believed that these changes are caused by pollution… especially air pollution” (Participant 25).

b) Lack of trees that are supposed to protect

Participants raised the issue of the lack of trees that were meant to protect them. Moreover, they were not only referring to trees that have indigenous meaning or provide indigenous signs for certain things. They were also referring to trees in general that provided physical protection against extreme weather events. These trees have been cut because people started being many in the village and built their houses all over the neighbourhood. The growing population necessitated the destruction of forests and trees. This had an impact because there are animals that used to inhabit the forests. In addition, the animals were important in terms of IKS. Therefore, the growing population and deforestation caused two problems. Extinction of wild animals and loss of meaningful trees. Participant 19 spoke on the loss of meaningful trees by saying:

> "Eish… it has changed, they are more dangerous now. And I think it is because there are trees that used to protect us, but we don't have them anymore. The trees we have now have no meaning to our tradition. There are trees that were not meant to be cut or lost, they were only meant to be there and serve as protection, but we have lost all of them. A lot of things have changed in a bad way, climate and natural environment have changed" (Participant 19).

This means that it is believed tropical cyclones are becoming more dangerous now because things have changed. People used to have plants that indicated some knowledge, which are no longer growing, "Instead, now we have these ones that we do not even know their names or use. It is hard to be protected and informed about a lot of things" (participant 33).

c) Shift from indigenous ways of protection

Some participants believe that tropical cyclones are becoming more severe because people are changing traditional ways of living, they no longer use or practice things that they were taught by their elders. In this regard, participant 36 commented:

> "Things are not the same anymore, these tropical cyclones are very disastrous now. I think the reason behind that is because we do not respect our traditions anymore… people are doing things that were not allowed before and they do not care about the impact these have on our communities. We used to respect our land but now we just do whatever we want and whenever… that is wrong. Before, everything had its own time, we did not just do things anyhow" participant 36 said.

Participant 17 said that tropical cyclones are more dangerous now and cause more damage. Before, tropical cyclones hardly caused any damage because their elders were able to stop it from causing damage using their traditional techniques, but people today are referring to those techniques as expired beliefs that should not be followed anymore. To add on, another participant mentioned how there are pastors that judge them when they practice their traditions as if it is something wrong. "We cannot do these things openly now because they will accuse us of being evil... The western religion and beliefs are invalidating our traditional ways of doing things" (Participant 45). Participant 42 said that he believes that the disrespect of traditions and IK came with the introduction of televisions. "…we don't do the things that we used to do to show respect and for protection. We need to respect nature so that it protects us from disasters" participant 34 said.

d) Shift from mud and stick houses

A number of participants blamed the way they have built their modern houses for the severity of tropical cyclones. They believe that the houses that are made up of zinc as roofing are putting them in danger physically because during a tropical cyclone, the zinc is easily blown away and could injure anyone. The zinc roofing is also dangerous in terms of the indigenous belief that it attracts tropical storm. One participant supported this by saying:

> "…but what I have noticed is that… before, our households were made of grass and mud but now we are using bricks and zinc for roofing and tropical cyclones attacks anything that shines. So, our modern houses and ways of living are putting us at risk. Before we were safe because of the types of houses we built" (Participant 36)

Besides the properties of the modern houses being dangerous, they also encourage the shift from the use of traditional and indigenous techniques meant to protect from extreme weather events. Participant 38 said that there are certain practices that were only meant to be performed on a rondavel, but people have gradually shifted from those and started building bricks houses. For example, as mentioned above that one of the indigenous ways of protection against tropical cyclones is putting bullhorns on the top doorway of a rondavel and putting weather nail. Therefore, with the way the modern houses are built, it would be difficult or meaningless to do those on bricks houses.

e) Impact of the lack of indigenous knowledge literacy

Seven participants raised concerns about how this knowledge is being lost because elders do not pass it to younger generations. And also, younger generation makes it hard to keep the knowledge because:

> "They are always questioning everything, so we just let things be. Because they want to know reasons behind everything, we tell them they do the opposite of what we tell them not to do because they want to see what will happen" (Participant 10).

They find it necessary for the younger generation to know and practice this knowledge, as they believe that protect and prevent certain disastrous events. "Sticking to traditional ways of doing things would help us and reduce the dangers of tropical cyclones" (Participant 9).

4.3.10 Evacuation plans

There was no direct question on evacuation plans on the interview questions during the interviews. As a result, majority of the participants did not mention anything about evacuation plans in case their houses are destroyed or damaged. Only 4% (n=2) of the participants said something about evacuation, with the first one saying:

> "I do not have any ways of protecting myself in case of destruction of property; I just stay in the house. If anything could happen to my house then I would depend on the state for evacuation" (Participant 2).

On the other hand, the other participant has experienced destruction of property from tropical cyclone, specifically Tropical Cyclone Eloise. However, she did not get any help from the government but made her own plans.

> "…The tropical cyclone that occurred in January destroyed my houses. As you can see that all my houses are roofed with zincs, they all were destroyed. The state did not do anything, I had to move to my neighbour's house and stay there until my home was fixed" (Participant 12).

In the case of Tropical Cyclone Eloise, participants protected themselves by putting tires on top of their house to prevent them from being destroyed and staying indoors for safety.

4.4 Summary

These results have shown that IKS is still valued and utilised in Jozini. However, the issue is with the argument that the people are slowly losing their indigenous indicators due to environmental and climate change. The reason why people started relying more on news and western forecasts is that they have lost meaningful species that represented important information for their indigenous practices. The knowledge is still there but the indicators are gradually getting extinct according to the participants. The indicators used in forecasting Tropical Cyclone Eloise were mostly meteorological, that is wind speed and cloud cover. Most participants only saw when the tropical cyclone occurred while others heard about it on the news. Very few participants saw it coming. Challenges associated with the use of both IKS and scientific weather forecast were raised, as well as the effectiveness of using IKS and scientific weather forecasts. Challenges associated with using scientific forecast include inability to understand, incorrect forecasting and lack of access to radios and TVs. Another issue associated with IKS is that the knowledge is not passed on to the younger generations; this might be because it is becoming irrelevant in terms of its applicability because of the lack of

indigenous indicators or because the younger generation is not making it easy to be taught about IK. However, majority of the participants still believe and use their knowledge despite the challenges faced.

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter aims to discuss the results collected from the interviews conducted in Jozini and to contextualise these findings within the framework of existing literature related to the topic of IKS, climate and more specifically tropical cyclones. This discussion aims to contribute to the gap in the literature regarding the use of IKS in forecasting of tropical cyclones and reflecting on how to improve preparedness for extreme weather events such as tropical cyclones using a combination of IKS and western science.

The chapter entails an analysis of the use of IKS in forecasting climate and tropical cyclones. With details from global literature, Africa and Southern Africa, in relation to the use of IKS in this study, therefore creating a platform for comparison between literature and results obtained from this study. The chapter also addresses use of IKS in informing adaptation to climate change through an analysis of the participant's responses and IKS adaptation strategies from existing literature. Furthermore, challenges associated with the use of IKS in forecasting climate in Jozini are discussed, and it is addressed in relation to what the literature has covered in terms of IKS and scientific weather forecasting techniques. This chapter then provides detailed analyses of the confidence of Jozini community in using IKS, in combination with what the literature has covered regarding the topic.

5.2 Continued general use of IKS

Africa is thought to be one of the continents most impacted by climate change, which is one of the biggest concerns facing humanity (Apraku et al., 2018). The "many stressors" of climate change such as sea level rise, droughts and frequent floods on Africa are becoming increasingly evident, and it is becoming clear that solely scientific and contemporary methods alone are unable to address those (Apraku et al., 2018). Community members of Jozini have shown that the many stressors of climate change have affected them as they have noticed many changes in their environments that have negatively affected them. Even though the subject of IKS is controversial because of climate variability that makes IKS to forecast future weather events accurately (Ebhuoma and Simatele, 2019), some academics agree that, if properly utilized, these systems can aid in empowering local populations to lessen the effects of climate change (Basdew et al., 2017; Apraku et al., 2018; Balehegn et al., 2019). Respondents of this study from Jozini have indicated that they have used and relied on their IK for a long time and continue to use it. With the introduction of science-based weather forecasting, some have started to use both their IK and scientific weather forecast.

The ongoing use of IKS is evident in a study conducted by Viriri (2022) that investigated medicinal indigenous knowledge systems in Buhera South, Zimbabwe, the participants of this study have indicated that they use IKS on traditional medicine. Another recent study by Seile et al. (2022) supports the continuous use of IKS on conservation of traditional medicine. Additionally, it has been found that farmers in Zimbabwe, Masvingo district use their IKS for cattle disease management for different types of animals (Gamira, 2022). It has been found that traditional communities in the Eastern Cape have indigenous ways of conserving water and they continue to adopt these methods (Fanteso and Yessoufou, 2022). The data of this study from Jozini suggested that people still use IKS to predict extreme weather conditions.

All the participants agreed that they use IKS for weather prediction and farming purposes. A study by Apraku et al. (2018) supports this finding because IKS has also been investigated in Eastern Cape and it was found that people use their IK in assessing weather conditions and for food production using indigenous indicators (Apraku et al., 2018).

However, the results have shown that the extent to which participants use IKS is limited. This limitation is due to the introduction of science-based weather prediction models and the changing climate and environmental degradation. The results showed that science-based weather prediction models have an impact on the use of IKS by people in Jozini because everything is reported on the news therefore some have mentioned that they do not see the need to go outside to observe weather. This is contrary to the observed impact of scientific based weather forecast on IKS in Sanni et al. (2012) findings, where it is demonstrated that farmers in some states in Nigeria (Kano, Jigawa, and Kaduna) have access to scientific forecasts through extension agents, radio, and television, yet they claim to rely on traditional forecasts more (Sanni et al., 2012). Some farmers also stated that they had access to scientific weather forecasts via radio, television, and extension agents, which they utilize to enhance their own traditional weather predicting methods. It is argued that the data is utilized to supplement their existing prediction techniques. If the scientific weather forecast disputes their prediction, they make their decision based on their own forecast (Gamira, 2022). This relates to the participants that said they use both IKS and science but trust their own observations more because it is unusual for them to predict incorrectly. On the other hand, environmental degradation has resulted to the limited use of IKS because animal and plant species that assisted and represented certain weather conditions have gone extinct, leaving some of the interviewed residents of Jozini with no choice but to rely on what is reported on

the news. A study by Apraku et al. (2021) highlights the impact of environmental change on the use of IKS and how this has affected the reliability of IK in indigenous communities

In terms of using IK in this study, participants stated that they use their IKS in forecasting weather, taking precautionary measures and in farming practices. As mentioned above that indigenous people in southern Africa and across the world use elements like trees, plants, their bodies and meteorological substances to inform themselves about their weather conditions farming decisions to make, in most cases they use the same elements to take precautionary measures (Garutsa and Nekhwevha, 2018) . People from Jozini have shown a good understanding of their IKS and how they apply it on their normal daily activities and especially on weather. They have indicated that they use things like trees, certain plant and animal species; they also observe the direction of the wind and wind speed, cloud cover, as well as temperature. These are the same components that the literature such as Jiri et al. (2016); Vilakazi (2019); and Ngongondo et al. (2021) has mentioned on IK and IK indicators.

5.3 IKS Used in Forecasting Climate and Tropical Cyclones

Early forecast decisions in Pacific Islands countries were totally based on knowledge that had been gathered through many generations of local observations (Waiwai et al., 2013). Indigenous farmers, for instance, whose livelihoods are directly impacted by the weather and climate, frequently keep an eye on and forecast weather and seasonal climate events using locally observed factors like the behaviour of plants and animals, meteorological conditions like wind speed and direction, and astronomical indicators such as sun, the moon and stars (Waiwai et al., 2013; Chand et al., 2014). These are indicators used by Jozini community members for forecasting of tropical cyclones as a number of participants has mentioned

these. It was mentioned that community members observe behavioural signs of their animals (cats, swallows and ants), plants (flowering of certain plants and meteorological conditions (wind speed and cloud density) to forecast weather. According to the study from Jozini, there are various issues associated with using IKS and using scientific weather information. These include lack of understanding of what is being forecasted, unreliability and incorrect forecasts and lack of access to broadcasting service. These meteorological challenges observed from this study are similar to Chand et al. (2014) findings. It has been found that in Vanuatu, rural farmers may tune in to radio broadcasts that provide current weather and seasonal forecasts, but they may choose not to act on the information due to a variety of factors, such as a strong reliance on local knowledge, a long history of viewing outside knowledge with suspicion, or a failure to comprehend the forecast provided (Chand et al., 2014).

The most common IKS indicators mentioned on this study from Jozini was wind direction and speed and cloud cover. There has not been much literature on the IKS indicators used to predict tropical cyclones, therefore it would be hard to relate these finding to those of existing literature to find out if other African countries use the same indicators and take the same precautions for tropical cyclones. However, these indicators have been used by other communities such as in northern Ghana for rainfall and flood forecasting as per the study by Nyadzi et al. (2021). Irumva et la. (2021) also mentions the use of wind direction, cloud cover and temperatures as indicators used to predicts the onset of rainfall.

Participants of the Jozini community study have mentioned higher temperatures and wind speed as well as other various animal behaviour and human ailments as an indication of an impending tropical cyclone. These indicators relate to a study conducted by Magee et al. (2016) on tropical cyclone perceptions, impacts and adaptations shows that participants had

indigenous ways of forecasting impending tropical cyclones. In Fiji, Vanuatu and Tonga, tropical cyclone activity is associated with higher fruit output, and the form of tomatoes is considered as a potential tropical cyclone warning indication (Magee et al., 2016). Additionally, it is stated on Magee et al. (2016) that the presence of cattle and dogs acting unusually vocal during the days can signal the approach of a storm. Cattle and dogs acting unusual can be related to the movement of a cat in between house and disappearance of domestic animals such as goats and sheep, which are indicators that also came up during this study. Even though in Magee et al. (2016) study these are signs of a storm and in Jozini community they indicate a tropical cyclone. This shows that there is similarity of the indigenous indicators used in forecasting and preparation of extreme weather events in other parts of the world outside Africa. Participants of my study have mentioned higher temperatures and wind speed as an indication of a tropical cyclones and Magee et al. (2016) says the presence of hot and muggy weather both during the day and at night indicates a tropical storm (Magee et al., 2016). Their traditional precautionary measures include "tying down their roofs and securing their houses at length. Depending on the conditions of the roof, heavy objects (such as tyres or sandbags) are often placed on top to protect the roof from strong winds" (Magee et al., 2016, pp. 1098). Jozini community members did mention that as a form of protection and preventing tropical cyclones from damaging houses, community residents use car tires and put them on top of their house, which is a similar precautionary measure as the study above.

There has also been a study in Malawi that found that indigenous people use their IK to adapt to the impact of climate change, and they have indigenous ways of forecasting weather and farming techniques (Nkomwa et al., 2014). Communities identified trustworthy IKS, such as

flora, wildlife, and atmospheric measurements used before the start of and during the rainfall events for floods projections (Kijazi et al., 2013).

The indigenous signs documented by Kijazi et al. (2013) include terminates worms, swallows, mango trees, wind, moon and temperature and they are used to forecast rainfall. “When swallow flock are seen flying all over in the atmosphere it indicates heavy rain to come at that particular time” (Kijazi et al., 2013, p. 277). Some of these indicators are similar to the indicators mentioned by participants from Jozini but used for forecasting different weather events. For example, swallows flocking around the neighbourhood was mentioned as an indication of a tropical cyclone, although in the study by Kijazi et al. (2013) swallows indicate impending heavy rainfall. Wind, clouds and temperature appear to be the most commonly used indicators in and outside of Africa, as per the reviewed studies. These were also the most commonly mentioned indicators by Jozini residents, even though for some parts of Africa, they indicate different weather events such as flood occurrence and rainfall (Kijazi et al., 2013; Nkomwa et al., 2014).

The appearance of ants called termites are said to indicate floods occurrence. In Jozini, ants called *‘omakoti’* (which is a Zulu name meaning ‘brides’ when translated) were mentioned as indicators of an impending tropical cyclone. It might be possible that they were also referring to termites and *‘omakoti’* is a local name for termites in Jozini. Some of the indicators that participants from Jozini said they use for tropical cyclone prediction are used for floods and rainfall prediction in Africa and other parts of the world.

There have not been much literature on the use of IKS in forecasting tropical cyclones. However, Bernardin De Saint-Pierre (1973) as sited in Walshe et al., (2022) writes about cultural indicators that people used to note an impending tropical cyclone. “The pets seemed

worried. The air was heavy and warm, although the wind had not fallen. With these signs promising a cyclone, everybody rushed to prop up their houses with poles and close all their doors and windows" (Bernardin de Saint-Pierre, 1973, sited in Walshe et al., 2022). The quote from Walshe et al. (2022) relates very well to some parts of the results obtained in this study. The movement of a cat as an indicator can be viewed as the worried pets, changes in wind density was mentioned and putting tires on top of the roofs as a form of protection was one of the precautionary measures taken for protection against tropical cyclones. Although the quote is from an old article, it proves some useful and relevant information for this study and its relevance. There are similarities in traditional weather forecasting techniques and precautionary measures taken between this study and other parts of Africa.

It is evident that some communities in other parts of the world still use and rely on IKS despite the contemporary challenges relating to climate. The challenges of climate change have not stopped rural farmers in southern Africa from surviving for decades (Nkomwa et al., 2014). These farmers in rural areas can use their native expertise to adapt to and cope with climate change (Jiri et al., 2015). In order to make significant strategic, calculative, and operational decisions on agricultural production, including the management of food stocks and social safety nets, communities in Makoni, Zimbabwe rely heavily on local biological and geographical indicators of seasonal forecasts as well as traditional knowledge (Mapfumo et al., 2016). To develop seasonal forecasts, farmers employed a variety of biological (such as plant and animal behaviour), geographical (such as wind direction and temperatures), and astronomical indications (Mapfumo et al., 2016). This paper provide evidence that there is an ongoing use of IKS for climate forecasting in southern Africa and the groups of indicators used are similar to the ones from other parts of Africa as indicated above.

A Ssouth African study from Mpumalanga mentions appearance of birds, locust, grasshoppers, ants, spiders, frogs and worms as traditional indicators used to forecast weather, with birds (swallows) and ants (termites) being the most common. The observation of dark clouds, north winds, and warm temperatures were mentioned as signs of impending severe rainfall. In addition, considered indicators of the climate were human conditions like excessive sweating and sore joints or surgical scars (Ubisi et al., 2020). These indicators are similar to the ones that were mentioned by Jozini residents as highlighted in chapter 4. Like from the section on African IKS and climate forecasting, swallows and ants came up in this study by Ubisi et al. (2020). These are indicators of heavy rainfall or floods according to these studies. This might suggest various IK indicators are used for various climatic events in certain communities and they may indicate different things for different communities. Dark clouds and warm temperatures came up again in this study as it has been mentioned by studies from other parts of the world and participants of this study. Additional indicators included human ailments like sweating, sore joints and sore surgical scars. These are similar to feeling fatigued and pain on operations scar as Jozini participants mentioned, although in the case of Ubisi et al. (2020) these indicated oncoming severe climatic events and not particularly tropical cyclones.

In terms of forecasting floods in southern Africa, it is said that indigenous people in Swaziland use their IK to forecast the occurrence of floods by observing the height between nest of the birds and surfaces of the river (Dube and Manyani, 2022). With lower nests, indicating slimmer chances of floods and higher nests indicating likelihood. On the other side, in Zimbabwe they use dark clouds and some animal behaviour as a symbol of floods and heavy rainfall (Dube and Manyani, 2022). There have not been any studies that explored the use of IKS in forecasting tropical cyclones in South Africa. The birds nest indication did not come up

in the study from Jozini, however dark clouds were frequently mentioned and have been common in all the studies referenced above. However, on the other studies they mostly indicate floods and heavy rainfall and not occurrence of tropical cyclones. Indigenous indicators of tropical cyclones mentioned by participants relates to those from existing literature because it has been mentioned that indigenous people use biological, atmospheric conditions, astronomic and relief features are used to predict weather over short and long periods of time (Risiro et al., 2012). The study by Risiro et al. (2012) also notes that temperature and wind patterns were regarded as pointers to weather changes. "The behaviour of animals and insects were less mentioned as useful in determining weather conditions. Human ailments such as operations were pointed out as accurate indicators of impending weather changes" (Risiro et al., 2012). These indicators mentioned in Risiro et al. (2012) paper relates to those of the results of this study. However, the participants of the study conducted in Jozini mentioned that it was becoming harder to rely on and use certain plants and animals because they are becoming extinct, not that they were less useful compared to other indicators.

A study conducted by Sanni et al. (2012) asserts that people that still use IK suggested that historically proven methods of rainfall prediction be combined with modern ways to develop dependable forecasts that will lessen hazards in their rain fed farming systems (Sanni et al., 2012). According to this study, the most popular and dependable way of predicting the commencement of rainfall is based on shifts in wind direction from west to east. Wind was also the most mentioned indicator in this study, maybe it could be that it is something that cannot be lost or go extinct, unlike biological indicators. This might mean that the indicators that people from Jozini community mentioned are culturally specific to them, it is things that they have noticed and natured about their environments as time goes by. Alternatively, these

indigenous signs could be well known in most indigenous communities across the African continent but have not been studied or documented.

5.4 Effectiveness of IKS in informing adaptation to climate

Most of the adaptation strategies from literature relate more to farming practices than actual extreme weather events. This shows that indigenous communities cannot prevent the impacts of climate change but try to live with the aftermath from the climatic events. There was no specific question from the study in Jozini that specifically asked about adaptation strategies, therefore, there was not much information on adaptation. The use of IKS in informing adaptation strategies for tropical cyclones needs to be investigated. Some studies have investigated adaptation strategies of indigenous communities to climate change. To adapt to climate change, changing types of crops grown has been an adaptation technique adopted by indigenous people in southern Malawi (Nkomwa et al., 2014). More early-harvesting and drought-tolerant types of the crops that people sow are increasingly being grown (Mugambiwa, 2018; Makondo and Thomas, 2018). Furthermore, People are moving away from conventional farming methods like flat cultivation toward cultivating on plain and tie ridges, using manure, planting one seed per station, using sunken beds for irrigation to conserve water and reduce irrigation frequency, frequent pesticide application in cotton, which is costly and labour-intensive, and short-duration crop varieties (Petzold et al., 2020). The study also found that today's livestock farming is more diverse than in the past, which helps with risk management and income diversification. Goats and chickens are more prevalent than cattle. It has been determined that goats are more resilient and flexible than cattle because of pasture and water shortages. Goats, cattle, pigs, and poultry are the most

prevalent types of livestock in that order (Nkomwa et al., 2014). Other adaptation strategies include maintenance of available resources and moving to near sources of resources (Makondo and Thomas, 2018).

In terms of challenges associated with the use of IKS, Ngongondo et al. (2021) mentions the issue with the extinction of certain species and their effect on the use of IKS by saying "Most of the IK indicators are threatened by environmental degradation and may not be suited to forecasts of patterns or intensity of rainfall at large spatial and temporal scales, such as floods from rainfall in upstream catchment. Therefore, IK indicators may not provide sufficient foreknowledge to respond to climate events such as cyclones" (Ngongondo et al., 2021, p. 207). Research participants from Jozini have also mentioned how it has become difficult to use their IKS to forecast weather due to extinction of certain plant and animal species that aided them to forecast weather. Some were not aware of what causes that while other blamed in on environmental degradation and overpopulation on the community that leads to people building houses all around the neighbourhood and therefore destroying ecosystems as a result.

Scholars in climate science are advocating for integration of science and IK because IK is easy to understand at community level, but has downfalls, and forecasts can be made at both small and large spatial and temporal dimensions using scientific climate knowledge, but it also has its disadvantages (Nkomwa et al., 2014). As a result, in low-resource environments, combining contextualized IK and scientific climate knowledge can give reliable flood forecasts (Ngongondo et al., 2021). Because of the challenges associated with IKS, majority of the participants from Jozini have opted to using both their IK and meteorological forecast because they both have downfalls for indigenous communities. Conservation of biodiversity,

especially IK related species might aid in retaining traditional knowledge and traditional weather forecasting techniques. Integration of IKS and scientific knowledge would be difficult without indigenous species.

Risiro et al. (2012) also states that due to climate unpredictability and human activity, flora and animals are rapidly disappearing. Most of the natural prediction entities such as wildlife that were abundant in the past are no longer available (Risiro et al., 2012; Nkomwa et al., 2014). This is similar to the observations from the participants of the study from Jozini community about their changing environment. Their community have gone through environmental degradation and as a result, they have lost meaningful species, making harder for IK prediction and precautions. It was also mentioned that this is one of the reasons they inclined to using scientific weather forecast because they do not have much traditional indicators left. "Birds such as Mbungu (Vultures) and trees such as Misombe (fruit trees) and birds that were used as rainfall indicators by local communities in Ismani ward have disappeared. Deforestation and climate changes were linked to the disappearance of these local attributes" (Kijazi et al., 2013, p. 277). The participants of this study from Jozini have shown that using IK in predicting and preparing for tropical cyclones has its benefits and limitations. The benefits to it are that it is understood at local and community level, unlike science-based weather forecasting techniques. Elders understand the knowledge and can pass it to the younger generations. While the science-based knowledge can be complicated for indigenous people and some of them may not have means to access it. Although this is a case, it has been argued that IK is becoming hard to maintain and preserve because of the changing climate and degrading environment. A few participants raised this concern about how it has become harder to predict and take precautions against certain weather conditions because of the lack of plants and animals that aided their knowledge. One participant said,

"…and now we are forced to depend on what they tell us because a lot of things have changed. Plants and animals that used to be very useful for us when it comes to these things have gone extinct" (Participant 39).

Ziervogel and Opere (2010) review how downscaling of meteorological information and integrating it with local knowledge might enhance practices and productivity for indigenous communities. Because IKS are created locally by individuals who live in the area where the prediction is made and are often based on generations of experience, climate information must be tailored to local indigenous communities (Ziervogel and Opere, 2010). This would aid in closing the gap in science and IK by providing people with more accurate and easier to understand weather information. Some studies have shown that in indigenous communities, IKS are utilized alone or in combination with science-based meteorological forecasts (Sanni et al., 2012; Shoko and Shoko, 2013). Furthermore, Shoko and Shoko (2012) further state that because where meteorological forecasts are obtained over the radio, lack of expertise in interpretation and execution of these forecasts becomes a challenge, the majority of the participants in their study did not get seasonal and daily weather forecasts from weather reporting stations (Shoko and Shoko, 2013).

Despite the challenges associated with the use of indigenous indicators as highlighted above, some people in indigenous communities still use and rely on their traditional knowledge. Ebhuoma (2020) states that farmers in Delta, Nigeria still heavily rely on IKS despite occasional contradictions, even though information about future weather occurrences is typically available from both IKS and seasonal climate projections. Participants from Jozini have mentioned that despite challenges of environmental degradation and climate change, they still trust and rely on their knowledge over scientific weather forecast. With 33% (n=15) of

the participants strictly depending on their IK, while 52% (n=24) use both IK and scientific forecast but trusting their IK more. The reason behind this is incorrect weather forecast from weather stations and inability to understand what is being communicated. More studies have discovered that among other factors, the farmer's ongoing dependence on IKS has been caused by being deceived by a false scientific forecast and a lack of understanding of how anthropogenic actions contribute to climate change (Ebhuoma and Simatele, 2019; Ebhuoma, 2020). In some cases, the confidence in using IKS for weather forecasting in some communities is motivate by the lack of confidence in scientific weather forecasting techniques (Mapfumo et al., 2016).

Some participants from Jozini have access to TVs and radios but choose not to depend on them for reasons similar to the above. They have argued that scientific weather forecast does not provide data that is village specific and these results to what they predict being inaccurate at community level. For this reason, sticking to their IK is the best option. This was also discovered by Mapfumo et al. (2016) where it is argued that in order to predict the seasons, farmers use meteorological data with local knowledge and fewer than 25% of farmers said they made decisions based on the meteorological data. The majority of farmers acknowledged newspapers, radio, and television as sources of climate information, but they made it apparent that the outlets were not always accessible (Mapfumo et al., 2016). Farmers observed an increase in patchiness in rainfall distribution despite the meteorological services' dissemination of data that covered an entire district and therefore, farmers frequently turned to local knowledge when making strategic and operational choices. Any meteorological data that was provided seemed to be supplementary (Mapfumo et al., 2016).

Additionally, Chand et al. (2014) says that rural farmers may tune in to radio broadcasts that provide current weather and seasonal forecasts, but they may choose not to act on the information due to a variety of factors, such as a strong reliance on IKS, a long history of viewing outside knowledge with suspicion, or a failure to comprehend the forecast provided (Chand et al., 2014). Research participants of this study from Jozini have mentioned that they use both their IK and scientific weather forecast. In addition, it was also mentioned that relying on either of these have their own disadvantages but using their indigenous knowledge has been more accurate in predicting their weather conditions than listening on radio and watching on TV. Participants have shared that observing weather using their own knowledge has given them more accurate results than scientific forecasts because they are able forecast weather that is specific for their location while news reporters predict for a larger scale and end up presenting incorrect forecast for some parts.

CHAPTER SIX

CONCLUSION

6.1 Synthesis of the study

Indigenous knowledge systems have the potential to empower local communities to lessen the effects of climate change, if they are properly utilized (Apraku et al., 2018). This knowledge is crucial for helping indigenous communities adapt to and, in some cases, mitigate the negative effects of extreme weather events (Apraku et al., 2018). Farmers in indigenous communities forecast the weather and use their understanding of environmental factors, which is derived from experience and long-term occupancy in the communities, to guide agricultural decision-making (Fitchett and Ebhuoma, 2018). IK is influenced by how members of the community perceive and interpret the natural environment; as a result, the knowledge system is regional and largely influenced by cultural values in a given location (Chambers et al., 2019). In the design and execution of contemporary mitigation and adaptation initiatives, Ajani et al. (2013) states that this knowledge is, however, infrequently taken into account.

The aim of this study was to investigate the extent to which residents comprising Jozini community in KZN used IKS to forecast Tropical Cyclone Eloise and take precautionary measures. The research objectives as listed in chapter 1 aided to answer the primary aim by investigating the IKS indicators used in Tropical Cyclone Eloise, as well as its reliability when compared to news. The major interest of the research was to find out if people from Jozini community were able to forecast Tropical Cyclone Eloise using their IKS, the indicators they used and their accuracy. Another concern was to find out if they were dependent on their IKS or the information provided by weather stations during that time. The data used to address

the objectives of this study was obtained through semi-structured interviews with 46 community residents from Jozini in KZN, which was hit by Tropical Cyclone Eloise in January 2021.

The results obtained from Jozini residents assisted in the achievement of the set of objectives for this research report. Participants of this study shared different and some similar understanding of tropical cyclones, IK used to forecast them as well as indigenous actions taken for precautionary measures. The results have shown that people from this community use biological and meteorological data for prediction and protection, as it has been mentioned in IKS and climate African studies. It was also apparent that people from Jozini have challenges using their IKS due to environmental degradations and climate change.

6.2 Achievements of study aim and objectives

i. *Determining the extent to which Jozini community uses IKS in forecasting weather, climate and extreme climate events at daily, seasonal and inter-annual scales through assessing their reliability on IKS on daily basis.*

The first objective of this study was to determine the extent to which Jozini community residents uses IKS in forecasting weather. To attain this objective, community members of Jozini were asked during interviews if they use IKS on daily bases. Jozini residents have indicated that they use IKS on their day-to-day activities for weather forecasting, farming activities as well as their household activities. All 46 participants agreed that they use their IK. Some use this knowledge automatically because it has been part of their lives for a long time. For example, a few elderly participants mentioned that they do not go outside to observe weather, but by doing their normal activities, it has become automatically that they will notice

the changes in their weather. Additionally, noticing certain changes in plants or movements of certain animals that have indigenous meaning is something common and these things happen on their day-to-day lives. This research has found that Jozini is a rural indigenous community that still use and rely on traditional knowledge and therefore, the first objective was achieved. Results pertaining this objective can be found on (Section 4.3.1).

ii. Understanding the IKS used in predicting and preparing for tropical Cyclone Eloise by interviewing Jozini community members about the indigenous techniques they used and how these helped them to prepare for the cyclone

The second objective was to understand IKS used in predicting and preparing for Tropical Cyclone Eloise. The method used to achieve this objective was asking Jozini community members if they were able to forecast Tropical Cyclone Eloise and therefore asking IK that informed them. Participants that noticed the impending tropical cyclone were informed by clouds cover as well as wind direction and speed. Some of them saw by observing high temperature before the cyclone occurred. There are a few cases where participants felt it by the reaction of their bodies, which is fatigue (Section 4.3.7). None of the participants mentioned plants or animal behavior that indicated the impending tropical cyclones. Those that were able to notice did that by observing meteorological changes, and some of the participants heard about the cyclone from the news while the rest only saw it when it occurred (Section 4.3.7). The reason behind this could be that the tropical cyclone did not originate in their region but only got there as a strong rainfall. Hence the suggestion (Section 6.3) that conducting research in Mozambique on this topic would provide essential findings and contribution to IKS and climate research.

iii. Determining the extent to which households in Jozini community relied on IKS compared to South African Weather Service (SAWS) to prepare for Tropical Cyclone Eloise.

The third objective was to determine the extent to which households in Jozini relied on IKS compared to news to prepare for Tropical Cyclone Eloise. To achieve this objective, participants were asked if they were able to forecast Tropical Cyclone Eloise and take precautions. The occurrence of Tropical Tyclone Eloise was described by participants as the one that occurred unexpectedly. Very few participants (3 out of 46) said they saw it coming and the precautions taken included putting heavy things like tyres on top of their roofs to prevent the houses from being destroyed, some covered everything that shines in the household to prevent it from causing damage. About 21 participants only realized when it was already taking place and the precaution they were able to take was putting heavy materials on their roofs and staying indoors. In terms of relying on IKS or the news concerning awareness, three participants were informed by their IK, 24 heard about it from the news and 21 only saw it when it occurred (Section 4.3.7). To protect themselves, they used and relied on their traditional knowledge (Section 4.3.10).

iv. Determining the perceived effectiveness of IKS and SAWS warnings in the context of Tropical Cyclones by describing indicators used (IKS and SAWS) in determining the risks and actions to be taken.

Lastly, the fourth objective was to determine the perceived effectiveness of IKS and SAWS warning in the context of tropical cyclones. For general weather forecasting as well as making informed decisions about farming practices, very few participants (5) said they entirely depend on their news reports. Majority (26 out 0f 46) of the participants said that they use both their traditional knowledge and what is reported on the news while the rest said they entirely depend on their IK (15 out of 46) (Section 4.3.6). Challenges regarding both techniques were mentioned. These challenges lead to each technique being regarded as ineffective or hard to rely on. While majority of the participants said that they trust their own knowledge more than what is reported on TV because it is unusual for them to forecast weather incorrectly. They mentioned a few challenges affecting their use of IKS (Section 4.3.2). These included climate change and environmental degradation as well as extinction of species. They acknowledged that this affect the effectiveness of their IK because they are dependent mostly on biological indicators. In addition, due to climate change, recently for them it has been common to predict a certain weather condition but only get something different from what they have predicted. On the other hand, challenges associate with news reports include scale, inability to understand, and incorrect weather forecast (Section 4.3.6). These make it hard to rely on news either, and discredit their effectiveness.

6.3 Significance of the study to the field of climate and IKS research

Through this study, the importance of indigenous knowledge, especially in rural indigenous communities was revealed. With the introduction of science, people have gradually shifted from using their IKS to using science-based knowledge. This is especially the case for people that have migrated from rural to urban areas because urban life tends to be more science

oriented. This makes it easy to forget indigenous ways of living or not to partake in them. The more people migrate to the cities, the less IK is used on day-to-day basis and if IK is not used more frequently, it is easy to not recognize its importance. This study has revealed that there are communities that still build and centre their lives on IK and therefore it is important to ensure that the knowledge is kept for future generations. The reason why IK is important is that the use of biological and social data by indigenous knowledge bases in some parts of West Africa has also aided in the adoption of mitigation techniques and biodiversity conservation that may have come from climate change (Sanni et al., 2012). IK should be preserved because it is essential to any planning process at the local level, as it allows authorities to act quickly (Shoko and Shoko, 2013).

According to a study conducted by Nyong et al. (2007) in the African Sahel on the value of indigenous knowledge in climate change mitigation revealed that indigenous knowledge had been utilised as an adaptation strategy in this region in climate change mitigation. Adaptation strategies included assessment of vulnerability and implementation of appropriate adaptation strategies for climate change. Community-based adaptation can help local people become less vulnerable to climatic unpredictability and change while also increasing their resilience (Mugambiwa, 2018).

Knowing the IKS used for certain practices can help in the documentation and preservation of indigenous information. It has been argued that IKS are rapidly vanishing, and that now is the moment to recover and document lost knowledge, as it is critical to Africa's development and drought management (Shoko and Shoko, 2013). There has not been much research done on IKS and tropical cyclones, and therefore this research may aid in knowing the IK used in tropical cyclones and preserving it for generations to come by documenting it. The

preservation of IKS and help preserve certain plants and animals that are at risk of degradation and extinction. Certain indigenous knowledge requires certain species to be applicable, therefore, to keep the knowledge will require preservation of the species as well. The integration of IK and science-based knowledge that has been advocated by schoolers will also need IK to be preserved and documented. According to Enock (2013), if IK is methodically researched, documented, and then integrated into traditional forecasting systems, it can give significant value and raise forecasting accuracy and reliability.

The findings of the study might be combined with weather forecasting data from the meteorological office to optimize the scheduling of agricultural operations and disaster relief efforts. It has provided valuable information that helps residents of Jozini to know about their weather conditions and take precautionary measures. This information can be used in the future for alert, prevention and precautions for Jozini community at large. Other communities from the region can also adopt it, in this way this will serve as a form of awareness and ensuring that the knowledge is passed on to other people.

6.4 Recommendations for future research

This study has shown that Jozini is an indigenous community that still use IKS. However, the study's focus was only on the use of IK for tropical cyclones. Therefore, exploring use of IKS more broadly in north-eastern KZN would contribute to knowledge production. Tropical Cyclone Eloise did not only affect Jozini in South Africa, but some parts of Mpumalanga and Limpopo as well. Conducting research for the three provinces would bring some useful information because IKS and IKS indicators are cultural/ village specific. Perhaps the result obtained from Jozini would differ from the ones that would be obtained in Mpumalanga or

Limpopo depending on their traditions and beliefs. This would promote wider understanding of IKS and how broad it is in the country. Bigger sample size and inclusion of focus groups in a research methodology would provide useful and more diverse information from a community and therefore, conducting the same research with a larger sample size, introduction of focus groups and inclusion of the other 2 provinces would be beneficial and very informative for science and IKS research. Jozini was affected by a tropical cyclone that first made landfall in Mozambique; a study directly conducted in Mozambique from the people that were impacted from the onset of the event would provide a rather different perspective about the characteristics of the cyclone, indigenous indicators observed for its occurrence and indigenous knowledge used for protection. Additionally, comparing the broad use of IKS in Mozambique and KZN would be a good study. Research that relates to conservation of biodiversity could also be conducted and it should look specifically on the indigenous species used for Tropical Cyclone forecasting, their availability and ways of conserving them for the purpose of preservation. Another recommendation would be to improve early warning systems, and this does not only mean to improve the accuracy and effectiveness of scientific models but also access to the information provided. It must be communicated in a way that everyone can understand and the warning systems try to be location specific, and the state must invest in response capability for each community.

References

Abah, J., Mashebe, P. and Denuga, D.D., 2015. Prospect of integrating African indigenous knowledge systems into the teaching of sciences in Africa. *American Journal of Educational Research*, *3*(6), 668-673.

Ajani, E.N., Mgbenka, R.N. and Okeke, M.N., 2013. Use of indigenous knowledge as a strategy for climate change adaptation among farmers in sub-Saharan Africa: implications for policy. *Asian Journal of Agricultural Extension, Economics and Sociology*, 2(1), 23-40.

Ajayi, O.C. and Mafongoya, P.L., 2017. *Indigenous knowledge systems and climate change management in Africa*.

Ajibade, L.T. and Shokemi, O.O., 2003. Indigenous approach to weather forecasting in ASA LGA, Kwara State, Nigeria. *Indilinga African Journal of Indigenous Knowledge Systems*, *2*(1), 37-44.

Alley, R. B., Emanuel, K. A. and Zhang, F., 2019. Advances in weather prediction. *Science*, 363(6425), 342-344

Anthes, R. ed., 2016. *Tropical cyclones: their evolution, structure and effects*, (Vol. 19), Springer.

Appiah-Opoku, S., 1999. Indigenous economic institutions and ecological knowledge: A Ghanaian case study. *Environmentalist*, *19*(3), 217-227.

Apraku, A., Akpan, W. and Moyo, P., 2018. Indigenous knowledge, global ignorance? Insights from an Eastern Cape climate change study. *South African Review of Sociology*, *49*(2), 1-21.

Apraku, A., Morton, J.F. and Gyampoh, B.A., 2021. Climate change and small-scale agriculture in Africa: Does indigenous knowledge matter? Insights from Kenya and South Africa. *Scientific African*, *12*, 1-13.

Ash, K.D. and Matyas, C.J., 2012. The influence of ENSO and the subtropical Indian Ocean Dipole on tropical cyclone trajectories in the southwestern Indian Ocean. *International Journal of Climatology,* 32(1), 41-56.

Bailey, K., 1998. *Methods of Social Research* (4thEd). The Free Press, United States of America.

Balehegn, M., Balehey, S., Fu, C. and Liang, W., 2019. Indigenous weather and climate forecasting knowledge among Afar pastoralists of northeastern Ethiopia: Role in adaptation to weather and climate variability. *Pastoralism*, *9*(1), 1-14.

Balica, S.F., Wright, N.G. and Van der Meulen, F., 2012. A flood vulnerability index for coastal cities and its use in assessing climate change impacts. *Natural hazards*, *64*(1), 73-105.

Barnett, J., 2011. Dangerous climate change in the Pacific Islands: food production and food security. *Regional Environmental Change*, *11*(1), 229-237.

Barnhardt, R. and Oscar Kawagley, A., 2005. Indigenous knowledge systems and Alaska Native ways of knowing. *Anthropology and Education Quarterly*, *36*(1), 8-23.

Basdew, M., Jiri, O. and Mafongoya, P.L., 2017. Integration of indigenous and scientific knowledge in climate adaptation in KwaZulu-Natal, South Africa. *Change and Adaptation in Socio-Ecological Systems*, *3*(1), 56-67.

Bopape, M.J.M., Sebego, E., Ndarana, T., Maseko, B., Netshilema, M., Gijben, M., Landman, S., Phaduli, E., Rambuwani, G., Van Hemert, L. and Mkhwanazi, M., 2021. Evaluating South African Weather Service information on Idai tropical cyclone and KwaZulu-Natal flood events. *South African Journal of Science*, *117*(3-4), 1-13.

Bourke, B., 2014. Positionality: Reflecting on the research process. *The Qualitative Report*, *19*(33), 1-9.

Bouwer, L.M. (2019). Observed and Projected Impacts from Extreme Weather Events: Implications for Loss and Damage. In: Mechler, R., Bouwer, L., Schinko, T., Surminski, S., Linnerooth-Bayer, J. (Eds) *Loss and Damage from Climate Change. Climate Risk Management, Policy and Governance.* Springer, 63-82.

Breidlid, A., 2009. Culture, indigenous knowledge systems and sustainable development: A critical view of education in an African context. *International Journal of Educational Development*, *29*(2), .140-148.

Butcher, H.K., Holkup, P.A., Park, M. and Maas, M., 2001. Thematic analysis of the experience of making a decision to place a family member with Alzheimer's disease in a special care unit. *Research in Nursing & Health*, *24*(6), 470-480.

Buthelezi, A.T., 2009. *An investigation into poverty alleviation involving land reform*: *a case study in Umkhanyakude District*. Doctoral thesis submitted to the University of Zululand, Richards Bay.

Cairncross, S. and Alvarinho, M., 2013. The Mozambique floods of 2000: health impact and response. In: Rogger Few and Franziska Mathies (Eds). *Flood Hazards and Health*, Earthscan: London, 123-139.

Cámara-Leret, R., Fortuna, M.A. and Bascompte, J., 2019. Indigenous knowledge networks in the face of global change. *Proceedings of the National Academy of Sciences*, *116*(20), 9913-9918.

Cardone, V.J. and Cox, A.T., 2009. Tropical cyclone wind field forcing for surge models: Critical issues and sensitivities. *Natural Hazards*, *51*(1), 29-47.

Chambers, L.E., Plotz, R.D., Dossis, T., Hiriasia, D.H., Malsale, P., Martin, D.J., Mitiepo, R., Tahera, K. and Tofaeono, T.I., 2017. A database for traditional knowledge of weather and climate in the Pacific. *Meteorological Applications*, *24*(3), 491-502.

Chambers, L., Lui, S., Plotz, R., Hiriasia, D., Malsale, P., Pulehetoa-Mitiepo, R., Natapei, M., Sanau, N., Waiwai, M., Tahani, L. and Willy, A., 2019. Traditional or contemporary weather 192 and climate forecasts: reaching Pacific communities. *Regional Environmental Change,* 19(5), 1521-1528

Chand, S.S., Chambers, L.E., Waiwai, M., Malsale, P. and Thompson, E., 2014. Indigenous knowledge for environmental prediction in the Pacific Island countries. *Weather, Climate, and Society*, *6*(4), 445-450.

Chanza, N., Musakwa, W. and de Wit, A., 2022. Prospects for Strengthening Adaptation Governance through Indigenous Knowledge Systems. In: Ebhuoma, E.E, and Leonard, L. (Eds). *Indigenous Knowledge and Climate Governance*, Sustainable Development Goals Series: Johannesburg 141-152.

Charrua, A.B., Padmanaban, R., Cabral, P., Bandeira, S. and Romeiras, M.M., 2021. Impacts of the Tropical Cyclone Idai in Mozambique: A multi-temporal Landsat satellite imagery analyses. *Remote Sensing*, 13(2), 201.

Chen, Z., Gong, Z., Yang, S., Ma, Q. and Kan, C., 2020. Impact of extreme weather events on urban human flow: A perspective from location-based service data. *Computers, Environment and Urban Systems*, *839(1)*, 101520.

Chikaire, J., Osuagwu, C.O., Ihenacho, R.A., Oguegbuchulam, M.N., Ejiogu-Okereke, N. and Obi, K.U., 2012. Indigenous knowledge system: The need for reform and the way forward. *Global Advanced Research Journal of Agricultural Science*, 1(8), 201-209.

Chikoore, H., Vermeulen, J.H. and Jury, M.R., 2015. Tropical cyclones in the Mozambique channel: January–March 2012. *Natural Hazards*, *77*(3), 2081-2095.

Chisadza, B., Mushunje, A., Nhundu, K. and Phiri, E.E., 2020. Opportunities and challenges for seasonal climate forecasts to more effectively assist smallholder-farming decisions. *South African Journal of Science*, *116*(1-2), 1-5.

Codjoe, S.N. and Atiglo, D.Y., 2020. The implications of extreme weather events for attaining the sustainable development goals in sub-Saharan Africa. *Frontiers in Climate*, *2*, 592658.

Curtis, S., Fair, A., Wistow, J., Val, D.V. and Oven, K., 2017. Impact of extreme weather events and climate change for health and social care systems. *Environmental Health*, 16(1), 23-32.

Davis-Reddy, C.L., Vincent, K. and Mambo, J., 2017. *Socio-economic impacts of extreme weather events in Southern Africa.* CSIR, 30-46.

Davis, C.A., 2018. Resolving tropical cyclone intensity in models. *Geophysical Research Letters*, *45*(4), 2082-2087.

De, U.S., Dube, R.K. and Rao, G.P., 2005. Extreme weather events over India in the last 100 years. *J. Ind. Geophys. Union*, *9*(3), 173-187.

Defra, U.K., 2012. Climate Change Risk Assessment: Government Report. *Department for Environment, Food and Rural Affairs, London*.

Dintwa, K.F., Letamo, G. and Navaneetham, K., 2022. Vulnerability perception, quality of life, and indigenous knowledge: A qualitative study of the population of Ngamiland West District, Botswana. *International Journal of Disaster Risk Reduction*, *70*, 102788.

Diver, S., 2017. Negotiating Indigenous knowledge at the science-policy interface: Insights from the Xáxli'p Community Forest. *Environmental Science & Policy*, *73*, 1-11.

Donat, M.G., Sillmann, J. and Fischer, E.M., 2020. Changes in climate extremes in observations and climate model simulations. From the past to the future. *Climate Extremes and their implications for impact and risk assessment*, 31-57.

Done, J.M., PaiMazumder, D., Towler, E. and Kishtawal, C.M., 2018. Estimating impacts of North Atlantic tropical cyclones using an index of damage potential. *Climatic Change*, *146*(3), 561- 573.

Dube, K. and Nhamo, G., 2021. Concluding Remarks: De-risking Tropical Cyclones in the Era of Climate Change Emergency. *Cyclones in Southern Africa*, 261-270.

Dube, E. and Manyani, A., 2022. Indigenous Knowledge Systems for Building-back-better Flood-Impacted Communities in Zimbabwe. *Re-imagining Indigenous Knowledge and Practices in 21st Century Africa: Debunking Myths and Misconceptions for Conviviality,* 209- 225.

Dube, K., Nhamo, G. and Chikodzi, D., 2022. Flooding trends and their impacts on coastal communities of Western Cape Province, South Africa. *GeoJournal*, *87*(4), 453-468.

Dube, K., Nhamo, G. and Chikodzi, D., 2020. Climate change-induced droughts and tourism: Impacts and responses of Western Cape Province, South Africa. *Journal of Outdoor Recreation and Tourism*, 1-10.

Dworkin, S.L., 2012. Sample size and policy for qualitative studies using in-depth interviews. *Archives of Sexual Behavior*, 41(6), 1319-1320.

Ebi, K.L., Vanos, J., Baldwin, J.W., Bell, J.E., Hondula, D.M., Errett, N.A., Hayes, K., Reid, C.E., Saha, S., Septor, J. and Berry, P., 2021. Extreme weather and climate change: Population health and health system implication. *Annual Review of Public Health*, 42, 293-31.

Ebhuoma, E.E. and Simatele, D.M., 2019. 'We know our Terrain': indigenous knowledge preferred to scientific systems of weather forecasting in the Delta State of Nigeria. *Climate and Development*, *11*(2), 112-123.

Ebhuoma, E. and Leonard, L., 2020. An operational framework for communicating flood warnings to indigenous farmers in southern Nigeria: A systems thinking analyses. *GeoJournal*, 1-8.

Elum, Z.A., Modise, D.M. and Marr, A., 2017. Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. *Climate Risk Management*, *16*, 246-257.

Emanuel, K., 2003. Tropical cyclones. *Annual Review of Earth and Planetary Sciences*, *31*(1), 75-104.

Engelbrecht, F.A. and Vogel, C.H., 2021. When early warning is not enough. *One Earth*, *4*(8), 1055-1058.

Enock, C.M., 2013. Indigenous knowledge systems and modern weather forecasting: exploring the linkages. *Journal of Agriculture and Sustainability*, *2*(2), 98-141.

Epstein, P.R., 1999. Climate and health. *Science*, *285*(5426), 347-348.

Eriksen, S., Schipper, E.L.F., Scoville-Simonds, M., Vincent, K., Adam, H.N., Brooks, N., Harding, B., Lenaerts, L., Liverman, D., Mills-Novoa, M. and Mosberg, M., 2021. Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance. *World Development*, *141*, 1-16.

Falvey, R., 2012. Summary of the 2011 Western Pacific/Indian Ocean tropical cyclone season. In *Proc. 66th Interdepartmental Hurricane Conference*, 25 January 2012.

Fanteso, B. and Yessoufou, K., 2022. Diversity and determinants of traditional water conservation technologies in the Eastern Cape Province, South Africa. *Environmental Monitoring and Assessment*, *194*(3), 1-14.

Field, C.B. and Barros, V.R. eds., 2014. *Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects*. Cambridge University Press, 1-9.

Fitchett, J.M. and Grab, S.W., 2014. A 66-year tropical cyclone record for south-east Africa: temporal trends in a global context. *International Journal of Climatology*, *34*(13), 3604-3615.

Fitchett, J.M. and Ebhuoma, E., 2018. Phenological cues intrinsic in indigenous knowledge systems for forecasting seasonal climate in the Delta State of Nigeria. *International Journal of Biometeorology*, *62*(6), 1115-1119.

Fitzpatrick, P.J., 2014. Tropical cyclones. *Encyclopaedia of Natural Resources*.

Ford, J.D., King, N., Galappaththi, E.K., Pearce, T., McDowell, G. and Harper, S.L., 2020. The resilience of indigenous peoples to environmental change. *One Earth*, *2*(6), 532-543.

Gamira, D., 2022. 'Indigenous Knowledge Systems for Sustainable Disease Management in Masvingo District, Zimbabwe', in Muyambo, T.M. (ed.) *Re-imagining Indigenous Knowledge and Practices in 21st Century Africa,* Langaa, 317-335.

Garutsa, T.C. and Nekhwevha, F.H., 2018. Indigenous knowledge, food production and food security in rural Khambashe in the Eastern Cape, South Africa. *South African Review of Sociology*, *49*(3-4), 16-31.

Goerss, J.S., 2000. Tropical cyclone track forecasts using an ensemble of dynamical models. *Monthly Weather Review*, *128*(4), 1187-1193.

Gomez-Zavaglia, A., Mejuto, J.C. and Simal-Gandara, J., 2020. Mitigation of emerging implications of climate change on food production systems. *Food Research International*, *134*, 109256.

Grey, M.S., 2019. Accessing seasonal weather forecasts and drought prediction information for rural households in Chirumhanzu district, Zimbabwe. *Jàmbá: Journal of Disaster Risk Studies*, *11*(1), 1-9.

Groppo, V. and Kraehnert, K., 2017. The impact of extreme weather events on education. *Journal of Population Economics*, *30*(2), 433-472.

Guest, G., MacQueen, K.M. and Namey, E.E., 2012. Validity and reliability (credibility and dependability) in qualitative research and data analysis. *Applied Thematic Analysis Sage Publications*, 79-106.

Gupta, S., Jain, I., Johari, P. and Lal, M., 2019. Impact of climate change on tropical cyclones frequency and intensity on Indian coasts. In *Proceedings of International Conference on Remote Sensing for Disaster Management*, 359-365.

Gwimbi, P., 2021. A Review of Tropical Cyclone Idai Forecasting, Warning Message Dissemination and Public Response Aspects of Early Warning Systems in Southern Africa. *Cyclones in Southern Africa*, 37-52.

Hajat, S. and Haines, A., 2002. Associations of cold temperatures with GP consultations for respiratory and cardiovascular disease amongst the elderly in London. *International Journal of Epidemiology*, 31(4), 825-830.

Harnos, D.S. and Nesbitt, S.W., 2011. Convective structure in rapidly intensifying tropical cyclones as depicted by passive microwave measurements. *Geophysical Research Letters*, *38*(7), 1-5.

Hashemi, M.R., Spaulding, M.L., Shaw, A., Farhadi, H. and Lewis, M., 2016. An efficient artificial intelligence model for prediction of tropical storm surge. *Natural Hazards*, 82(1), 471-491.

Hatfield, S.C., 2009. *Traditional ecological knowledge of Siletz tribal members*. Doctoral thesis submitted to Oregon State University, Corvallis.

Hatfield, S. C., Marino, E., Whyte, K.P., Dello, K.D. and Mote, P.W., 2018. Indian time: time, seasonality, and culture in Traditional Ecological Knowledge of climate change. *Ecological Processes*, *7*(1), 1-11.

Hoffman, R.R., LaDue, D.S., Mogil, H.M., Roebber, P.J. and Trafton, J.G., 2017. *Minding The Weather: How Expert Forecasters Think*. MIT Press.

Hoogendoorn, G. and Fitchett, J.M., 2018. Perspectives on second homes, climate change and tourism in South Africa. *African Journal of Hospitality, Tourism and Leisure*, *7*(2), 1-18.

Hoppers, C.A., 2001. Indigenous knowledge systems and academic institutions in South Africa. *Perspectives in Education*, *19*(1), 73-86.

Hosen, N., Nakamura, H. and Hamzah, A., 2020. Adaptation to climate change: Does traditional ecological knowledge hold the key? *Sustainability*, *12*(2), 1-18.

IPCC, 2021: Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 3-32.

Irumva, O., Twagirayezu, G. and Nizeyimana, J.C., 2021. The need of incorporating indigenous knowledge systems into modern weather forecasting methods. *Journal of Geoscience and Environment Protection*, *9*(2), 55-70.

Jiri, O., Mafongoya, P., Mubaya, C. and Mafongoya, O., 2015. Seasonal climate prediction and adaptation using indigenous knowledge systems in agriculture systems in Southern Africa: a review. Journal of Agricultural Science, 8(5), 156-172.

Johnson, M., 1992. Research on traditional environmental knowledge: its development and its role. *Capturing Traditional Environmental Knowledge*. IDRC, Ottawa,

Jury, M.R., 1993. A preliminary study of climatological associations and characteristics of tropical cyclones in the SW Indian Ocean. *Meteorology and Atmospheric Physics*, 51(10, 101-115.

Kam, J., Sheffield, J., Yuan, X. and Wood, E.F., 2013. The influence of Atlantic tropical cyclones on drought over the eastern United States (1980-2007). *Journal of Climate*, 26(10), 3067-3086.

Kamara, J., 2005. Indigenous knowledge in natural disaster reduction in Africa. *Environmental and Poverty Times*, *3*.

Kalanda-Joshua, M., Ngongondo, C., Chipeta, L. and Mpembeka, F., 2011. Integrating indigenous knowledge with conventional science: Enhancing localised climate and weather forecasts in Nessa, Mulanje, Malawi. *Physics and Chemistry of the Earth, 36*(14-15), 996-1003.

Kenote, T.R., 2020. *Indigenous Phenology: An Interdisciplinary Case Study on Indigenous Phenological Knowledge on the Menominee Nation Forest*, Doctoral thesis submitted to the University of Minnesota, Minneapolis.

Kijazi, A.L., Chang'a, L.B., Liwenga, E.T., Kanemba, A. and Nindi, S.J., 2013. The use of indigenous knowledge in weather and climate prediction in Mahenge and Ismani wards, *Journal of Geography and Regional planning*, Tanzania, 274-279.

Klein, J.A., Hopping, K.A., Yeh, E.T., Nyima, Y., Boone, R.B. and Galvin, K.A., 2014. Unexpected climate impacts on the Tibetan Plateau: Local and scientific knowledge in findings of delayed summer. *Global Environmental Change*, *28*, 141-152.

Knutson, T.R., McBride, J.L., Chan, J., Emanuel, K., Holland, G., Landsea, C., Held, I., Kossin, J.P., Srivastava, A.K. and Sugi, M., 2010. Tropical Cyclones and climate change. *Natural Geoscience,* 3(3), 157-163.

Kolawole, O.D., Wolski, P., Ngwenya, B. and Mmopelwa, G., 2014. Ethno-meteorology and scientific weather forecasting: Small farmers and scientists' perspectives on climate variability in the Okavango Delta, Botswana. *Climate Risk Management*, *4*, 43-58.

Kolstad, E.W., 2021. Prediction and precursors of Idai and 38 other tropical cyclones and storms in the Mozambique Channel. *Quarterly Journal of the Royal Meteorological Society*, *147*(734), 45-57.

Kom, Z., Nethengwe, N.S., Mpandeli, S. and Chikoore, H., 2022. Indigenous knowledge indicators employed by farmers for adaptation to climate change in rural South Africa. *Journal of Environmental Planning and Management*, 1-16.

Kossin, J.P., 2018. A global slowdown of tropical cyclone translation speed. *Nature*, 558(7708), 104-107.

Kovacs, Z.P., Du Plessis, D.B., Bracher, P.R., Dunn, P. and Mallory, G.C.L., 1985. Documentation of the 1984 Domoina floods. *TR122. Department of Water Affairs*.

Ledger, M.E. and Milner, A.M., 2015. Extreme events in running waters. *Freshwater Biology*, *60*(12), 2455-2460.

Lefale, P.F., 2010. Ua 'afa le Aso Stormy weather today: traditional ecological knowledge of weather and climate. The Samoa experience. *Climatic Change*, *100*(2), 317-335.

Lennard, C. and Hegerl, G., 2015. Relating changes in synoptic circulation to the surface rainfall response using self-organising maps. *Climate Dynamics*, *44*(3-4), 861-879.

Lin, N. and Emanuel, K., 2016. Grey swan tropical cyclones. *Nature Climate Change*, *6*(1), 106-111.

Letsatsi, N. and Kruger, A., 2022. The April 2022 floods in comparison with other recent flooding events in KwaZulu-Natal. *Weatersmart*, 5-9.

Lubchenco, J. and Karl, T.R., 2012. Extreme weather events. *Phys. Today*, *65*(3), 31.

Mafongoya, O., Mafongoya, P.L. and Mudhara, M., 2021. Using Indigenous Knowledge Systems in Seasonal Prediction and Adapting to Climate Change Impacts in Bikita District in Zimbabwe. *The Oriental Anthropologist*, 21(1), 195-209.

Magaya, S. and Fitchett, J.M., 2022. Approaching Positionality in Research on Indigenous Knowledge Systems. In *Indigenous Knowledge and Climate Governance*, 81-93.

Magee, A.D., Verdon-Kidd, D.C., Kiem, A.S. and Royle, S.A., 2016. Tropical cyclone perceptions, impacts and adaptation in the Southwest Pacific: an urban perspective from Fiji, Vanuatu and Tonga. *Natural Hazards and Earth System Sciences*, *16*(5), 1091-1105.

Makondo, C.C. and Thomas, D.S., 2018. Climate change adaptation: Linking indigenous knowledge with western science for effective adaptation. *Environmental Science & Policy*, *88*, 83-91.

Malherbe, J., Engelbrecht, F.A. and Landman, W.A., 2013. Projected changes in tropical cyclone climatology and landfall in the Southwest Indian Ocean region under enhanced anthropogenic forcing. *Climate Dynamics*, *40*(11), 2867-2886.

Malherbe, J., Landman, W.A. and Engelbrecht, F.A., 2014. The bi-decadal rainfall cycle, Southern Annular Mode and tropical cyclones over the Limpopo River Basin, southern Africa. *Climate Dynamics*, *42*(11), 3121-3138.

Maloney, E.D., Gettelman, A., Ming, Y., Neelin, J.D., Barrie, D., Mariotti, A., Chen, C.C., Coleman, D.R., Kuo, Y.H., Singh, B. and Annamalai, H., 2019. Process-oriented evaluation of climate and weather forecasting models. *Bulletin of the American Meteorological Society*, *100*(9), 1665-1686.

Manohar, N., Liamputtong, P., Bhole, S. and Arora, A., 2017. Researcher positionality in cross-cultural and sensitive research. *Handbook of Research Methods in Health Social Sciences*, 1-15.

Mapfumo, P., Mtambanengwe, F. and Chikowo, R., 2016. Building on indigenous knowledge to strengthen the capacity of smallholder farming communities to adapt to climate change and variability in southern Africa. *Climate and Development*, *8*(1), 72-82.

Marizka, C. (27 January 2021). "Cyclone Eloise: Death toll in SA rises to four". The Citizen. Retrieved 27 January 2021.

Masoga, M.A. and Shokane, A.L., 2019. Indigenous knowledge systems and environmental social work education: Towards environmental sustainability. *Southern African Journal of Environmental Education*, *35*, 1-11.

Mattern, S., 2020. Media research methods. *Words on Space*, 1-8.

Mavume, A.F., Rydberg, L., Rouault, M. and Lutjeharms, J.R., 2009. Climatology and landfall of tropical cyclones in the south-west Indian Ocean. *Western Indian Ocean Journal of Marine Science*, *8*(1), 15-36

Mavhura, E., Manyena, S.B., Collins, A.E. and Manatsa, D., 2013. Indigenous knowledge, coping strategies and resilience to floods in Muzarabani, Zimbabwe. *International Journal of Disaster Risk Reduction*, *5*, 38-48.

Mazzocchi, F., 2020. A deeper meaning of sustainability: Insights from indigenous knowledge. *The Anthropocene Review*, 71(1), 77-93.

Mbah, M., Ajaps, S. and Molthan-Hill, P., 2021. A Systematic Review of the Deployment of Indigenous Knowledge Systems towards Climate Change Adaptation in Developing World Contexts: Implications for Climate Change Education. *Sustainability*, *13*(9), 1-24.

Mbewe, M., Phiri, A. and Siyambango, N., 2019. Indigenous knowledge systems for local weather predictions: A case of Mukonchi Chiefdom in Zambia. *Environment and Natural Resources Research*, *9*(1), 16-26.

Menne, B., Murray, V. and World Health Organization, 2013. *Floods in the WHO European Region: health effects and their prevention.* World Health Organization. 1-133.

Mercer, J., Dominey-Howes, D., Kelman, I. and Lloyd, K., 2007. The potential for combining indigenous and western knowledge in reducing vulnerability to environmental hazards in small island developing states. *Environmental Hazards,* 7(4), 245-256.

Mercer, J., Kelman, I., Taranis, L. and Suchet-Pearson, S., 2010. Framework for integrating indigenous and scientific knowledge for disaster risk reduction. *Disasters*, 34(1), 214-239.

McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J. and White, K.S. eds., 2001. *Climate change 2001: Impacts, adaptation, and vulnerability:* contribution of *Group II to the third assessment report of the Intergovernmental Panel on Climate Change*, 2. Cambridge University Press.

Mirza, M.M.Q., 2003. Climate change and extreme weather events: can developing countries adapt? *Climate Policy*, *3*(3), 233-248.

Mkabela, Q., 2005. Using the Afrocentric method in researching indigenous African culture. *The Qualitative Report*, *10*(1), 178-190.

Mkhize, M.W., 2018. *Population and human development indicators of UMkhanyakude District Municipality*, Doctoral thesis submitted to the University of KwaZulu Natal, Durban.

Mndawe, M.B., Ndambuki, J.M., Kupolati, W.K. and Badejo, A.A., 2015. Assessment of the effects of climate change on the performance of pavement subgrade. *African Journal of Science, Technology, Innovation and Development*, *7*(2), 111-115.

Molongwane, C., Bopape, M.J.M., Fridlind, A., Motshegwa, T., Matsui, T., Phaduli, E., Sehurutshi, B. and Maisha, R., 2020. Sensitivity of Botswana Ex-Tropical Cyclone Dineo rainfall simulations to cloud microphysics scheme. *Open Research Africa*, *3*(30), 30.

Mugambiwa, S.S., 2018. Adaptation measures to sustain indigenous practices and the use of indigenous knowledge systems to adapt to climate change in Mutoko rural district of Zimbabwe. *Jàmbá: Journal of Disaster Risk Studies*, *10*(1), 1-9.

Municipality, J.L., 2012. Jozini local Municipality. *URL: http://www. local government. co. za/features/view/34*.

Murakami, H., Wang, Y., Yoshimura, H., Mizuta, R., Sugi, M., Shindo, E., Adachi, Y., Yukimoto, S., Hosaka, M., Kusunoki, S. and Ose, T., 2012. Future changes in tropical cyclone activity projected by the new high-resolution MRI-AGCM. *Journal of Climate*, 25(9), 3237-3260.

Muthige, M.S., Malherbe, J., Englebrecht, F.A., Grab, S., Beraki, A., Maisha, T.R. and Van der Merwe, J., 2018. Projected changes in tropical cyclones over the South West Indian Ocean under different extents of global warming. *Environmental Research Letters*, *13*(6), 1-13.

Naab, F.Z., Abubakari, Z. and Ahmed, A., 2019. The role of climate services in agricultural productivity in Ghana: The perspective of famers and institutions. *Climate Services*, 13, 24-32.

National Academies of Sciences, Engineering, and Medicine, 2016. *Attribution of extreme weather events in the context of climate change*. National Academies Press.

Neuman,W. L., 2014. Social Research Methods: Qualitative and Quantitative approaches, Pearson International Edition.

Ngongondo, C., Kalanda-Joshua, M.D., Monjerezi, M., Chipungu, F., Kasei, R. and Malidadi, C., 2021. Exploring Linkages Between Indigenous Knowledge Systems and Conventional

Flood Forecasting in the Aftermath of Tropical Cyclone Idai in Chikwawa, Malawi. *Cyclones in Southern Africa*, 207-226.

Ngulube, P. ed., 2016. *Handbook of research on theoretical perspectives on indigenous knowledge systems in developing countries*. IGI Global, 50-84.

Nguyen, T.C., Robinson, J., Kaneko, S. and Komatsu, S., 2013. Estimating the value of economic benefits associated with adaptation to climate change in a developing country: A case study of improvements in tropical cyclone warning services. *Ecological Economics*, *86*, 117-128.

Nkomwa, E.C., Joshua, M.K., Ngongondo, C., Monjerezi, M. and Chipungu, F., 2014. Assessing indigenous knowledge systems and climate adaptation strategies in agriculture: A case study of Chagaka Village, Chikhwana, Southern Malawi. *Physics and Chemistry of the Earth*, 164-172

Nyadzi, E., Werners, S.E., Biesbroek, R. and Ludwig, F., 2021. Techniques and skills of indigenous weather and seasonal climate forecast in Northern Ghana. *Climate and Development*, *13*(6), 551-562.

OCHA, 2021. 'SOUTHERN AFRICA – TROPICAL CYCLONE ELOISE', *Flash Update No.7*. 24 January 2021, 1-2.

Ochieng, P.A., 2009. An analysis of the strengths and limitation of qualitative and quantitative research paradigms. *Problems of Education in the 21st Century*, *13*, 13.

Otto, F.E., Boyd, E., Jones, R.G., Cornforth, R.J., James, R., Parker, H.R. and Allen, M.R., 2015. Attribution of extreme weather events in Africa: a preliminary exploration of the science and policy implications. *Climatic Change*, *132*(4), 531-543.

Ouedraogo, A., Egyir, I.S., Ouedraogo, M. and Jatoe, J.B.D., 2022. Farmers' Demand for Climate Information Services: A Systematic Review. *Sustainability*, *14*(15), 9025.

Owusu-Ansah, F.E. and Mji, G., 2013. African indigenous knowledge and research. *African Journal of Disability*, *2*(1), 1-5.

Patrick, H.O., 2021. Climate change and water insecurity in rural uMkhanyakude District Municipality: an assessment of coping strategies for rural South Africa. *H2Open Journal*, *4*(1), 29-46.

Paul, S.K. and Routray, J.K., 2013. An analysis of the causes of non-responses to cyclone warnings and the use of indigenous knowledge for cyclone forecasting in Bangladesh. In Leal Filho, W. (eds) *Climate change and disaster risk management*, Climate change management, Berlin, 15-39.

Petzold, J., Andrews, N., Ford, J.D., Hedemann, C. and Postigo, J.C., 2020. Indigenous knowledge on climate change adaptation: A global evidence map of academic literature. *Environmental Research Letters*, *15*(11), 113007.

Pörtner, H.O., Roberts, D.C., Adams, H., Adler, C., Aldunce, P., Ali, E., Begum, R.A., Betts, R., Kerr, R.B., Biesbroek, R. and Birkmann, J., 2022. Climate change 2022: Impacts, adaptation and vulnerability. *IPCC Sixth Assessment Report*.

Qin, D., 2016. Positionality. *The Wiley Blackwell encyclopedia of gender and sexuality studies*, 1-2.

Rataj, E., Kunzweiler, K. and Garthus-Niegel, S., 2016. Extreme weather events in developing countries and related injuries and mental health disorders- a systematic review. *BMD Public Health*, 16(1), 1-12.

Reason, C.J.C. and Keibel, A., 2004. Tropical cyclone Eline and its unusual penetration and impacts over the southern African mainland. *Weather and Forecasting*, *19*(5), 789-805.

Reason, C.J.C., 2007. Tropical cyclone Dera, the unusual 2000/01 tropical cyclone season in the South West Indian Ocean and associated rainfall anomalies over Southern Africa. *Meteorology and Atmospheric Physics*, *97*(1), 181-188.

Risiro, J., Mashoko, D., Tshuma, Doreen, T. and Rurinda, E., 2012. Weather forecasting and indigenous knowledge systems in Chimanimani District of Manicaland, Zimbabwe. *Journal of Emerging Trends in Educational Research and Policy Studies*, 3(4), 561-566.

Rosenzweig, C., Iglesius, A., Yang, X.B., Epstein, P.R. and Chivian, E., 2001. Climate change and extreme weather events-Implications for food production, plant diseases, and pests. *NASA Publications*, 24(1), 90-104.

Rumore, D., Schenk, T. and Susskind, L., 2016. Role-play simulations for climate change adaptation education and engagement. *Nature Climate Change*, *6*(8), 745-750.

Sanni, S.A., Oluwasemire, K.O. and Nnoli, N.O., 2012. Traditional capacity for weather prediction, variability and coping strategies in the front line states of Nigeria. *Agricultural Sciences*, 3(4), 625-630.

Secules, S., McCall, C., Mejia, J.A., Beebe, C., Masters, A.S., L. Sánchez-Peña, M. and Svyantek, M., 2021. Positionality practices and dimensions of impact on equity research: A collaborative inquiry and call to the community. *Journal of Engineering Education*, 110(1), 19-43.

Seile, B.P., Bareetseng, S., Koitsiwe, M.T. and Aremu, A.O., 2022. Indigenous knowledge on the Uses, Sustainability and Conservation of African Ginger (Siphonochilus aethiopicus) among Two Communities in Mpumalanga Province, South Africa. *Diversity*, 14(3), 192.

Sgier, L., 2012. Qualitative data analysis. *An Initiat. Gebert Ruf Stift*, *19*, 19-21.

Shah, P., Ifejika Speranza, C., Opiyo, R. and Ngaina, J., 2012. *Options for improving the communication of seasonal rainfall forecasts to smallholder farmers: The case of Kenya* (No. 17/2012). Briefing Paper.

Shava, S., Saurombe, T., Sibanda, M. and Matowanyika, J.Z., 2021. Impact of Cyclones and Extreme Floods on Traditional Medicines and Indigenous Knowledge Systems in Chimanimani, Zimbabwe. In Nhamo, G., Dube, K. (eds) *Cyclones in Southern Africa*, 169-178.

Shoko, K. and Shoko, N., 2013. Indigenous weather forecasting systems: A case study of the abiotic weather forecasting indicators for Wards 12 and 13 in Mberengwa District Zimbabwe. *Asian Social Science*, 9(5), 285-297.

Sillitoe, P., 1998. The development of indigenous knowledge: a new applied anthropology. *Current Anthropology*, 39(2), 223-252.

Smith, A.B. and Katz, R.W., 2013. US billion-dollar weather and climate disasters: Data sources, trends, accuracy and biases. *Natural Hazards*, *67*(2), 387-410.

Soden, B.J., Collins, W.D. and Feldman, D.R., 2018. Reducing uncertainties in climate models. *Science*, *361*(6400), 326-327.

Son, H.N., Chi, D.T.L. and Kingsbury, A., 2019. Indigenous knowledge and climate change adaptation of ethnic minorities in the mountainous regions of Vietnam: A case study of the Yao people in Bac Kan Province. *Agricultural Systems*, *176*, 1-9.

Stocker, T. ed., 2014. *Climate change 2013: the physical science basis: Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Thornton, P.K., Ericksen, P.J., Herrero, M. and Challinor, A.J., 2014. Climate variability and vulnerability to climate change: a review. *Global change biology*, *20*(11), 3313-3328.

Stott, P., 2016. How climate change affects extreme weather events. *Science*, *352*(6293), 1517-1518.

Ubisi, N.R., Kolanisi, U. and Jiri, O., 2019. Comparative review of indigenous knowledge systems and modern climate science. *Ubuntu: Journal of Conflict and Social Transformation*, *8*(2), 53-73.

Ubisi, N.R., Kolanisi, U. and Jiri, O., 2020. The role of indigenous knowledge systems in rural smallholder farmers' response to climate change: case study of Nkomazi local municipality, Mpumalanga, South Africa. *Journal of Asian and African Studies*, *55*(2), 273-284.

UMkhanyakude District Municipality 2021. Available at http://www.ukdm.gov.za/index.php/municipality/background.

Ummenhofer, C.C. and Meehl, G.A., 2017. Extreme weather and climate events with ecological relevance: a review. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *372*(1723), 1-13.

Vilakazi, B.S., Zengeni, R. and Mafongoya, P., 2019. Indigenous strategies used by selected farming communities in KwaZulu Natal, South Africa, to manage soil, water, and climate extremes and to make weather predictions. *Land Degradation & Development*, *30*(16), 1999-2008.

Viriri, M., 2022. Medicinal Indigenous Knowledge Systems and Gender among the Shona People of Buhera South, Zimbabwe. *Re-imagining Indigenous Knowledge and Practices in 21st Century Africa: Debunking Myths and Misconceptions for Conviviality a*, 227-242.

Vecchi, G.A., Delworth, T., Gudgel, R., Kapnick, S., Rosati, A., Wittenberg, A.T., Zeng, F., Anderson, W., Balaji, V., Dixon, K. and Jia, L., 2014. On the seasonal forecasting of regional tropical cyclone activity. *Journal of Climate*, *27*(21), 7994-8016.

Vecchi, G.A., Landsea, C., Zhang, W., Villarini, G. and Knutson, T., 2021. Changes in Atlantic major hurricane frequency since the late 19th century. *Nature Communications*, 12(1), 1-9.

Voosen, P., 2019. New climate models forecast a warming surge. *Science*, 364 (6437), DOI: 10.1126/science.364.6437.222Waiwai, M., and P. Malsale, 2013: National Workshop on Traditional Knowledge of Weather and Climate. *Vanuatu Meteorology and Geo-Science Dept*, 48.

Walshe, R.A., Rouphail, R.M., Adamson, G.C. and Kelman, I., 2022. Werewolves and warning signs: Cultural responses to tropical cyclones in Mauritius. *Geoforum*, *133*, 56-65.

Wehner, M., Reed, K.A., Stone, D., Collins, W.D. and Bacmeister, J., 2015. Resolution dependence of future tropical cyclone projections of CAM5. One in the US CLIVAR Hurricane Working Group idealized configurations. *Journal of Climate*, *28*(10), 3905-3925.

Yesuf, M., Di Falco, S., Deressa, T., Ringler, C. and Kohlin, G., 2008. *The impact of climate change and adaptation on food production in low-income countries: evidence from the Nile Basin, Ethiopia*. Intl Food Policy Res Inst. 1-16.

You, J. and Wang, S., 2021. Higher probability of occurrence of hotter and shorter heat waves followed by heavy rainfall. *Geophysical Research Letters*, *48*(17), 1-11.

Zhongming, Z. and Wei, L., 2021. Tropical Cyclone Eloise hits Mozambique. World Meteorological Platform.

Ziervogel, G. and Opere, A., 2010. Integrating meteorological and indigenous knowledge-based seasonal climate forecasts for the agricultural sector: lessons from participatory action research in sub-Saharan Africa. CCAA Learning paper, 1, 1-18.

Appendices

Appendix A: Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF GEOGRAPHY, ARCHAEOLOGY & ENVIRONMENTAL STUDIES ETHICS COMMITTEE

CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE **PROTOCOL NUMBER: GAES-2021/GEOG-04**

PROJECT TITLE: The use of Indigenous Knowledge Systems to predict extreme weather events and take precautions: Exploring the case of tropical cyclone Eloise.

INVESTIGATOR	Unathi Dada
SCHOOL/DEPARTMENT OF INVESTIGATOR	Geography, Archeology and Environmental Studies
DATE CONSIDERED	9th July 2021
DECISION OF THE COMMITTEE	Approved unconditionally
RISK LEVEL	MINIMAL RISK
EXPIRY DATE	30th December 2022

ISSUE DATE OF CERTIFICATE: 17th August 2021

CHAIRPERSON:
(Professor Mulala Danny Simatele)

cc: Supervisor:

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

_____ _____/_____/_____

Signature **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix B: Participants consent form

Title of project: The use of Indigenous Knowledge Systems to predict extreme weather events and take precautions: Exploring the case of tropical cyclone Eloise.

Name of researcher: Unathi Dada

I,……..,agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his / her research report	YES	NO
I agree that the interview may be audio recorded	YES	NO
I agree that the information I provide may be used anonymously after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.	YES	NO

…… (signature)
…… (name of participant)
…… (date)

…… (signature)
…… (name of person seeking consent)
…… (date)

Appendix C: Participant consent form In IsiZulu

Isihloko se prhojekthi: Ukusetshenziswa kwezinhlelo zolwazi lwendabuko ukubikezela izimo zesimo sezulu esibi kakhulu kanye nokuthatha izinyathelo zokuphepha: Ukuhlola isimo se-Tropical cyclone Eloise

Igama lomcwaningi: Unathi Dada

Mina……. Ngiyavuma ukubamba iqhaza kulo msebenzi wocwaningo. Ucwaningo seluchazelwe mina futhi ngiyaqonda ukuthi ukuhlanganyela kwami kuzobandakanya ini. Ngivumelana nalokhu okulandelayo:

(Sicela uzungeze izinketho ezifanele ngezansi)

Ngiyavuma ukuthi ukuhlanganyela kwami kuzohlala kungaziwa	Yebo	Cha
Ngiyavuma ukuthi umcwaningi angasebenzisa izingcaphuno ezingaziwa embikweni wakhe wocwaningo	Yebo	Cha
Ngiyavuma ukuthi inhlolokhono ingase irekhodwe	Yebo	Cha
Ngiyavuma ukuthi ulwazi engilunikezayo lungasetshenziswa ngokungaziwa ngemva kokuphela kwale phrojekthi, ngezinjongo zemfundo ngabanye abacwaningi, kuncike ekutholeni imvume yabo yokuziphatha.	Yebo	Cha

……(Isiginesha)

……..(Igama lombambi qhaza)

……..(Usuku)

……(Isiginesha)

……(Igama lomuntu ofuna imvume)

……(Usuku)

Appendix D: Participants information sheet

Title of project: The use of Indigenous Knowledge Systems to predict extreme weather events and take precautions: Exploring the case of tropical cyclone Eloise.

Name of researcher: Unathi Dada

Dear Sir / Madam,

My name is Unathi Dada and I am a Masters student in Environmental Sciences at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the use of Indigenous Knowledge Systems to predict extreme weather events and take precautions, Exploring the case of tropical cyclone Eloise under the supervision of Prof. Jennifer Fitchett. The aim of the study is to investigate the extent to which residents comprising the Jozini community used IKS to predict tropical cyclone Eloise and take precautionary measures.

As part of this project, I would like to invite you to take part in an interview. This activity will take around 30 minutes. With your permission, I would also like to record the interview using a digital device.

There will be no personal costs to you if you participate in this project, You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The interview will be completely confidential and anonymous as I will not be asking for your full name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. I will be using a pseudonym (false name) to represent your participation in my final research report. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. The data collected from this research project will be stored in password protected computer and will be used for the purpose of this research only. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone: 011 717 1408, email: hrec-medical.researchoffice@wits.ac.za.

Yours sincerely,

Researcher:
Unathi Dada, 1578877@students.wits.ac.za, 0718008481

Supervisor:
Jennifer Fitchett, Jennifer.fitchett@wits.ac.za, 011 717 6514

Appendix E: Interview questions

Research tittle: **The use of Indigenous Knowledge Systems to predict extreme weather events and take precautions: Exploring the case of tropical cyclone Eloise.**

Researcher: Unathi Dada

- Do you utilize indigenous knowledge to predict extreme weather events such as tropical cyclones?
- What do you understand about tropical cyclones? (When and how they happen, their characteristics)
- How do you predict tropical cyclones (what are the indigenous signs that indicate the possibility of a tropical cyclone?)
- How do you differentiate between the tropical cyclones that causes more damage and the ones that causes less?
- Do you rely on the news/the weather service, or do you still rely on indigenous knowledge systems?
- Were you able to predict tropical cyclone Eloise before it was announced on the news? What did you notice?
- How do you predict when a storm will happen, or where it will go to, or when you must evacuate?
- Do you have and indigenous way of protecting yourself from a tropical cyclone or are you dependent on the evacuation plan provided by the state?
- Do you think tropical cyclones are changing in their frequency/severity/location? If so, how do you explain this?
- As time goes by, is it becoming harder to predict tropical cyclones using indigenous knowledge or nothing has changed?
- How does your indigenous knowledge system inform this - e.g. is there a certain bird they listen for; do they see some ants moving?

Appendix F: Interview questions in IsiZulu

Isihloko se prhojekthi: Ukusetshenziswa kwezinhlelo zolwazi lwendabuko ukubikezela izimo zesimo sezulu esibi kakhulu kanye nokuthatha izinyathelo zokuphepha: Ukuhlola isimo se-Tropical cyclone Eloise

Igama lomcwaningi: Unathi Dada

• Ingabe uyalusebenzisa ulwazi lwendabuko ukuze ubikezele izehlakalo zesimo sezulu esibi njengesishingishane?

• Yini oyiqondayo ngezishingishane zasezindaweni ezishisayo? (Ziyenzeka nini futhi kanjani, izici zazo)

• Uzibikezela kanjani izivunguvungu zasezindaweni ezishisayo (ziyini izimpawu zomdabu ezibonisa ukuthi kungenzeka kube nesishingishane sasezindaweni ezishisayo?)

• Uhlukanisa kanjani phakathi kwezivunguvungu zasezindaweni ezishisayo ezidala umonakalo omkhulu nalezo ezibangela omncane?

• Ingabe uthembele ezindabeni/isevisi yesimo sezulu, noma usathembele ezinhlelweni zolwazi lwendabuko?

• Ingabe ukwazile ukubikezela isishingishane sase-tropical Eloise ngaphambi kokuba simenyezelwe ezindabeni? Yini oyiqaphele?

• Ubikezela kanjani ukuthi isiphepho sizokwenzeka nini, noma sizoyaphi, noma ukuthi kufanele uphume nini?

• Ingabe unayo kanye nendlela yendabuko yokuzivikela esivunguvungwini esishisayo noma uncike ohlelweni lokuphuma oluhlinzekwa nguhulumeni?

• Ucabanga ukuthi izishingishane zasezindaweni ezishisayo ziyashintsha ngobuningi bazo/ubunzima/indawo? Uma kunjalo, ukuchaza kanjani lokhu?

• Njengoba isikhathi sihamba, ingabe kuba nzima ukubikezela izishingishane zasezindaweni ezishisayo usebenzisa ulwazi lwendabuko noma akukho okushintshile?

• Uhlelo lwakho lolwazi lwendabuko lukwazisa kanjani lokhu – umzekelo ikhona yini inyoni abayilalelayo; zibona izintuthwane ezinyakazayo?