An analysis of smallholder farmer's perceptions on climate change and changes in weather patterns compared to meteorological data in uMziwabantu, Ugu District, KwaZulu-Natal

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DECLARATION

I Rodah Gudyanga declare that this mini-dissertation which I hereby submit for the degree of MA Environment and Society at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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Abstract

In most cases smallholder farmers' perceptions to climate change and weather variability are less researched on and yet smallholder farming forms the backbone of rural community livelihood and food security. Climate change is hampering smallholder farmers' progress in food sustenance as they rely on rain-fed agriculture. Objective of this study was to assess smallholder farmers' perceptions to climate change and weather variability in relation to meteorological data from South African Weather Services (SAWS), for the period 2005-2019 in uMziwabantu Local Municipality, Ugu District, KwaZulu Natal. Structured questionnaires were administered randomly to 150 smallholder farmers, as well as key informant interviews and focus group discussions in uMziwabantu and the results were compared to daily weather information collected from SAWS. The results showed that most household heads in uMziwabantu were female headed who were between the ages of 50-69 years. Between the years 2005 to 2019 smallholder farmers observed high temperatures and increased rainfall. Majority of smallholder farmers had access to climate/weather forecast information through the radio/television, newspapers, government extension officers and also IKS. Most of the farmers indicated that seasonal and climate information timeliness was good but daily information timeliness was ranked fair. In terms of reliability all categories were ranked fair by smallholder farmers in uMziwabantu. The results from the smallholder farmers' perceptions to climate change and weather variability were corroborated by the meteorological data which showed also that temperature and total rainfall increased for the period studied. It is therefore imperative for policy makers and donors to engage smallholder farmers in the decision making process in matters that affect them as they proved that they are aware of what is happening around them. Most solutions are effective if the beneficiaries are involved in decision making known as the bottom-up approach rather than the top-down approach. More-so where smallholder farmers are conscious of climate change and weather variability it enhances their adaptive strategies.

Keywords: Smallholder farmers, meteorological data, perceptions, climate change.

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List of Abbreviation

BUHI	Botswana Upper High Influence
ENSO	El-Nino Southern Oscillation
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GHG	Green House Gas
IKS	Indigenous Knowledge System
ITCZ	Inter Tropical Convergence Zone
KZN	KwaZulu-Natal
NGO	Non-Governmental Organisation
RAI	Rainfall Anomaly Index
REOSA	Regional Office for South Africa
SAWS	South Africa Weather Services
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
TAI	Temperature Anomaly Index

CHAPTER 1: INTRODUCTION

1.1 Background

Climate change is becoming a worldwide headache for all generations and a hindrance to sustainable development. Climate change effects are varied and more detrimental in Africa for their overdependence on agriculture and natural resources for livelihood. It leads also to food and water insecurity, political and economic instability among other things. Schaeffer et al, (2013), depicts that Africa carries the larger weight of climate variability and yet it emits lesser greenhouse gas (GHG) compared to other continents. However developed countries are equally impacted by climate change hence the need for joint effort to minimise the effects.

According to IPCC (2007), climate change is any change in the atmosphere over time whether due to natural variability or as a result of human activity. This shows that climate change can be as a result from natural systems or human actions. This is further supported by Antwi (2013), who describes climate change as alterations in the normal patterns of an area's average weather over several years. This change can be attributed to both natural and human activities. Research has shown that anthropogenic activities over generations have artificially raised the greenhouse gas concentration in the atmosphere and scholars have concluded that that's the other reason why the planet has warmed up in recent history.

According to Bezabih et al (2014), weather variability is the day to day meteorological conditions which include temperature, cloudiness and rainfall affecting a specific place. Weather pattern is the daily experience while climate change is attributed to extended periods. Rainfall patterns and temperature are the main determinants that affect agriculture and livelihood security of most rural areas in developing countries as farming is mostly done by poor smallholders at subsistence level (Kolawole et al, 2016).

Agriculture is the backbone of most African countries economies and it entails cultivation of plants, animals and crops for feeds, fibre, energy and other purposes for man's sustenance (Musemwa et al, 2012). In most cases it is done at small scale level depending also on rain-fed farming as 70% of its population live in rural areas where agriculture is the pillar of livelihood (Antwi, 2013). According to IPCC (2001), the third assessment reported that in most parts of Africa there is increased temperature and reduced precipitation due to climate change leading to less agricultural yields resulting in food insecurity and disturbance of the general welfare of rural households.

According to Jiri (2015), in SSA besides negative effects of climate change there is also poverty, unequal distribution of land, rain-fed farming and minimal adaptive competence. This goes on to show the multiple problems crippling Africa in terms of development. Lobel et al (2008), reiterates that by 2050 average temperatures over most Sub-Saharan African countries are estimated to be 2-4 degrees Celsius higher and rainfall decrease by 10-20 % than the 1961-1990 baselines. This gives rise to the need to investigate if these small scale farmers are familiar with climate change and weather variability so as to understand the corrective measures put in place to minimise the effects on their livelihood.

In South Africa, agriculture plays a major role in the economy contributing 2.9% of GDP, 10 % of formal employment and 10% of the total export value in the year 2000 (Benhin, 2008). However, due to global environmental change and climate change rain-fed agriculture has been affected negatively in most cases. Kruger and Shongwe (2004), denotes that annual temperature has been increasing by 0.13 degrees Celsius per decade between 1960 and 2003. Masipa (2017), further notes that temperature is expected to increase by 1.2 degrees Celsius in 2020, 2.4 degrees Celsius in 2050 and 4.2 degrees Celsius by the year 2080, whilst rainfall is expected to decrease by 5.4% in 2020, 6.3% in 2050 and 9.5% in 2080. This is providing a clear picture that the environment is changing and there is a need to act to reduce the projected rate at which things are set to be going at.

Climate change is viewed with a lot of scepticism and uncertainty by different people. Hulme et al (1999), reiterates that compared to other hazards, climate change takes time to fulfil in nature which makes it hard to be differentiated from the natural inconsistency of a particular place. Thus the way smallholder farmers' view climate change is very crucial as it determines how they are going to respond to this change. The importance of smallholder farmers in South Africa should not be undermined as they provide employment, support rural welfare and food security (Aliber and Hall, 2012). Small scale farming is the backbone for rural livelihood and sustenance.

1.2 Statement of the problem

Smallholder farmers in South Africa and the continent at large are exposed to weather variability and climate change which limit their development (Shiferaw et al, 2014). This is due to their over dependency on natural rain-fall, cultivation of marginal areas, lack of access to technical and financial support that could help them move to climate-resilient agriculture among other reasons. On the other hand, large scale farmers have the capacity to deal with the harsh climatic conditions and allow them to sustain their livelihoods and actively manage their environment in a sustainable manner (Nhemachena and Hassan 2010). However the major question is, do the small scale farmers perceive the local climate trends accurately?

By smallholder farmers, the research focused on those farming a farm size of two hectors or less and they practice subsistence farming that is for family consumption. Smallholder farmers constitute the majority of the rural poor and practice seasonal farming and they contribute most food production in Africa (Baur and Scholz, 2010). For one to adapt to climate change there is need to observe that the climate and weather patterns have changed so as to come up with useful adaptation measures suitable for the place and implement. Thus adaptive measures are easy to implement when there is an accurate perception of the climate. Hein et al (2019), depicts that farmers' perceptions to climate change are personal, area dependent among other factors hence the need to look at the meteorological data from weather stations and compare if they tally with the farmers' perceptions.

Therefore this study looks at how smallholder farmers in uMziwabantu Ugu District understand climate change in their area compared to meteorological information from the South African Weather Services (SAWS). Ideally, where there is a higher understanding of climate change there is intensified implementation adaptation strategies.

1.3 Objectives of the study

Main aim of this study is to identify smallholder farmer's perceptions to climate change and weather variability in relation to meteorological evidence captured at weather stations in uMziwabantu local municipality in KZN.

1.3.1 Specific Objectives

- To find out smallholder farmers knowledge and views on climate change and weather variability.
- To evaluate the accuracy of farmers perceptions in relation to records from the South Africa Weather Service (SAWS).

1.3.2 Hypothesis

- **Null hypothesis H_o**: The perceptions of smallholder farmers on climate change and weather variability corresponds with results observed from SAWS meteorological data from 2005 to 2019.

- **Alternative hypothesis H_1**: The perceptions of small scale-scale farmers on climate change and weather variability contradicts the results observed from SAWS meteorological data from 2005 to 2019.

1.4 General Methodology and Study Approach

In this study both qualitative and quantitative approaches were used in collecting data. Structured questionnaires were used to acquire information from smallholder farmers in uMziwabantu. At the same time meteorological data was used from the SAWS to validate people's perceptions compared to what was actually happening on the ground. Data was analysed using Statistical Package for Social Sciences (SPSS) version 20.0 and R studios.

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CHAPTER 2: Literature Review

Climate change is a burden to small holder farmers and it is undermining world-wide progress towards poverty reduction and food availability. In order to come up with effective coping strategies, small-scale farmers need to take note of the environmental changes taking place in their area. This chapter explores what other scholars say about climate change effects and things that shape farmers' perception of climate change.

2.1 Understanding Climate Variability

Shanahan et al (2013), refers to climate change as the long-term changes in climate trends such as the increase in the global average temperature over a long period of time, whereas weather pattern is what we experience from day to day. The earth's climate has always been changing as a result of higher levels of GHGs as developed countries are heading for continual economic growth. According to Turral (2011), globally agriculture contributes to 14% of global annual GHG emission and attributes indirectly to 4-8% from forest clearance for livestock production and land preparation for farming.

Human activities are contributing in polluting the atmosphere with GHG emissions through fossil fuel burning, cutting down of trees and unsustainable farming practices especially by developed countries is degrading the world at large (Althor et al, 2015). This increased concentration of GHGs has resulted in the change being faster than it was some years ago. These GHG emitting activities have increased the atmosphere's absorption of the outgoing infrared radiation, thereby enhancing the existing natural greenhouse effect and then re-radiating part of it back to earth resulting in the rising trend in global temperatures as shown in Fig 2.1 below.

Hitayezu, (2017), reiterates that South Africa's weather system has many characteristics ranging from the El-Nino Southern Oscillation which brings dry conditions, the Inter-Tropical Convergence Zone and occasional cyclones to mention but a few. This explains all the variations which happen in South Africa. Over 80% of the land surface in South Africa is said to be arid with only 18% being sub-humid, and has limited potential for crop production (Schulze 2016). This gives rise to many serious effects on food security, human health, water resources and socio-economic activities among other things.

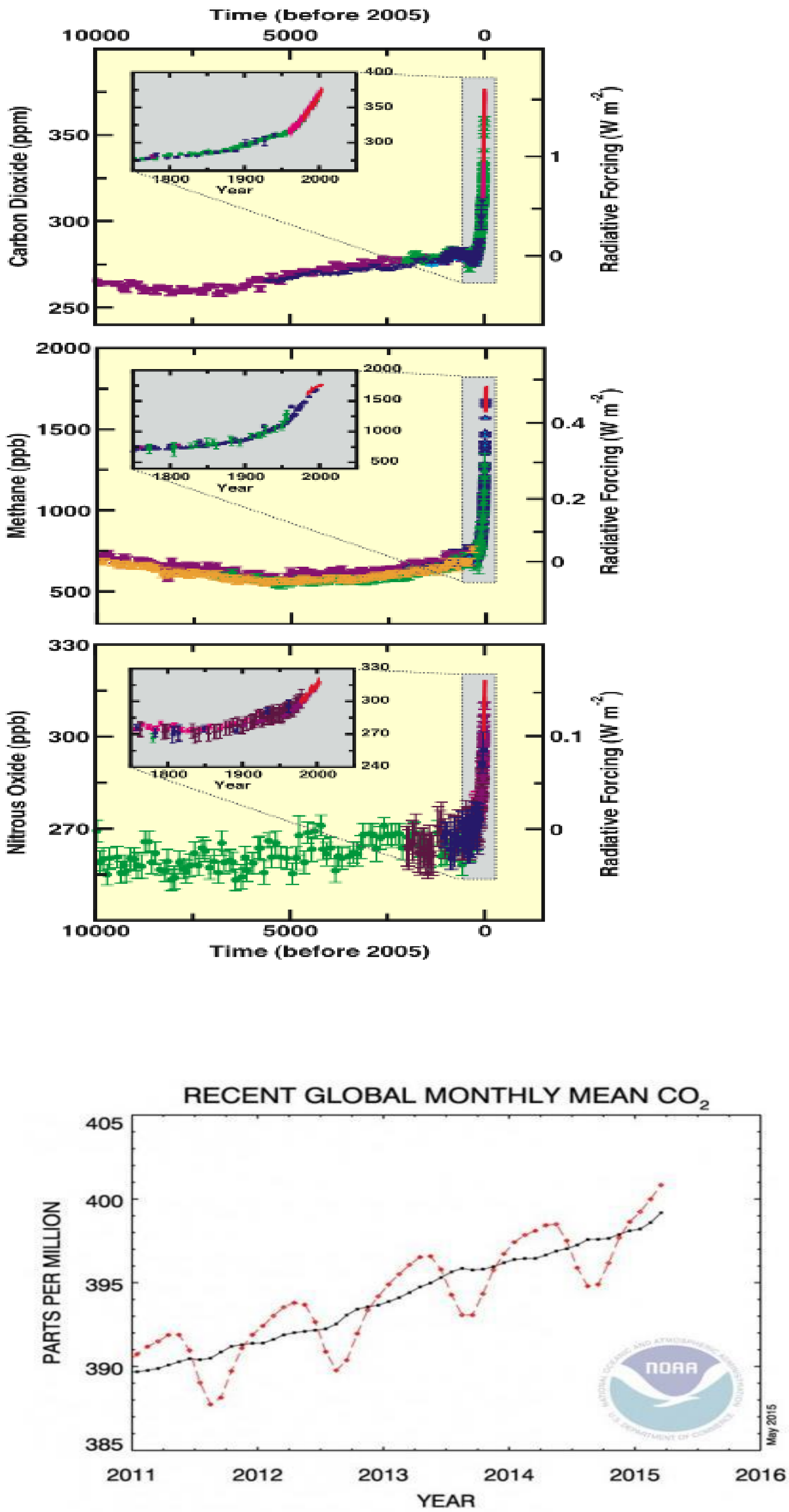

Figure 2.1 GHG emissions in the recent past (upper graphs), with recent global monthly mean CO2 concentrations (Schulze, 2016).

Schulze (2016) argues that future projections for South Africa shows a decrease in winter precipitation in the southern parts of the country, whilst summer rainfall region shows a slight increase. Then most regions in South Africa will increase in temperature.

Studies have shown that in most parts of Africa a lot of farmers hardly recognise the nature of climate change (Maddison, 2007). However, Bryan et al (2009) acknowledged that most provinces in South Africa show that 80% of smallholder farmers noticed some variations in weather patterns. Never the less, in regions largely dry land, small scale farmers' showed that climate change awareness levels remained low. There is always the need to validate smallholder farmers' perceptions with recorded evidence from the meteorology department so as to show consistency.

2.2 Climate change and food security

International Fund for Agricultural Development (2010), acknowledges that globally there are about 500 million smallholder farms sustaining almost 2 billion people and Africa constitute about 33 million small farms. These smallholder farmers generate considerable amount of food with limited use of artificial enhancers and technological advancement (Altier, 2009). Instead they relied on natural process, local equipment which was readily available and local knowledge to farm.

According to Thompson et al (2010), food security is a condition whereby people at all times have access to enough and nutritious food to meet their needs for an active as well as healthy lifestyle. Food security comprises food availability, access and utilization and they all depend on weather systems. Climate change and exponential population growth are significant issues that affect food security in SSA.

Turpe and Visser (2014) points out that, subsistence farmers usually keep 58% of the total crop production output for household consumption as well as 26.7% of total livestock products for household needs. Therefore climate change affects also food adequacy for farmers who participate in agriculture to sustain their household income and food requirements.

The rising temperature and extreme events like drought and floods are likely to threaten crops and livestock across the African Continent. Diseases or pests increase coupled with the global environmental change in water resource availability, land cover and altered nitrogen cycle creates a dilemma in attaining food security for smallholder farmers at large (Gregory et al, 2005).

According to the World Bank (2013), by 2040 drought and increased temperatures could reduce the area in Sub Saharan Africa suited for maize, millet or sorghum by 40-80%. More so 2 degrees increase in temperature projected for 2040 could reduce maize yield by 5-22 %, wheat by 10-17 % and sorghum by 15-17% (Shanahan et al 2013). This goes on to show the devastating effects of climate variability on food security and the general well-being of poor rural households which depend on rain-fed agriculture.

According to Tshikovhi et al (2021), climate change and weather variability has effects on cropping systems in Southern Africa, in the sense that temperature variations and rainfall fluctuations have effects on crop yields and productivity. In most cases where rainfall increases, outbreak of pests and diseases on crops also increases which affects the quality of crops. At the same time frequent extreme events like drought can damage crops making agricultural operations timing even more difficult.

According to Zinyengere et al (2014), effects of climate change to agriculture may differ spatially depending on crop varieties as well, meaning some places may be affected negatively while others benefit. As evidenced in Tanzania where climate change impacts on maize were strongly negative for small holders while on coffee and cotton impacts were positive (Agrawala et al, 2003).

2.2.1 Impacts climate change on livestock production

Livestock production in Southern Africa is quite diverse and climate change has several effects on pastoral, agro-pastoral and mixed crop-livestock farming. Silvestri et al (2012), argues that livestock grazing areas can be affected by changes precipitation and temperature. Furthermore high temperatures may result in decline in livestock productivity as conception rate and the general health will be affected by heat stress. Pests and disease outbreaks increase the likelihood of livestock mortality.

Jones and Thornton, (2009) reiterates that despite the negative impacts of climate change on livestock production, farmers may find it as a solution in some instances where they can shift from crop-farming to livestock farming. As shorter growing season and increased erratic rainfall makes it hard for farmers to invest in crop production goat farming can be done as they are drought resilient animals.

2.3 Effects of climate change on small holder farmers in Central America

Smallholder farming in Central America is mainly done by the poor and they cultivate on land that is infertile. They normally cultivate basic crops such as maize and beans and small-scale coffee farming and it is of great cultural importance in their region as coffee production creates employment for 4 million in Central America (Donatti et al, 2018).

Smallholder farmers in Central America are susceptible to climate change as the crops they mainly cultivate are delicate to increasing temperatures as well as less rainfall as they entirely depend on rain-fed agriculture. For an example, drought in 2014-2016 in Central America resulted in 1.6 million people in poverty and 3.5 million requiring humanitarian assistance (Harvey, 2018). More so hurricanes have also impacted smallholder farmers' livelihoods as strong winds and heavy rainfall disrupted coffee plantations resulting in massive crop damage.

According to Ayanlade et al (2020), effects of climate change on smallholder farmers are likely to worsen in future years as climate models predict increase in temperature, more erratic rainfall and increase in frequency of extreme events in most parts of the world. This goes on to show how people are going to suffer in the hands of weather patterns variability. Harvey (2018), further states that studies show that by 2025, bean production in Central America would have been reduced by more than 20% and maize yields by 15% in Honduras, El Salvador and Nicaragua due to climate change. This shows that the effects of climate change are felt globally especially by the poor subsistence farmers who heavily rely on rainfall for farming.

Additionally, climate change indirectly affects crop production by altering the occurrence and severity of pest and disease outbreaks. This has been evidenced in the recent coffee leaf rust outbreak in 2012 and 2013 which had major economic loss of 479.2 million USD and social impacts across Central America (Donatti et al, 2018).

2.4 Importance of Farmers perceptions to climate change

Although there is evidence from models of climate change, local understanding of climate prediction and analysis by people in the environment should not be overlooked (Gandure et al, 2013). When people understand what is happening around them they would come up with solutions tailor made for the problem. According to Bryant et al (2008), farmers' views on climate change and variability is important as it influence decisions in agricultural planning and management. Initiatives to minimise effects of climate change and weather variability should be considered by the farmers on the ground so that they will be effective rather than being imposed to them by the government or different organisations. It is therefore imperative to know the perceptions of farmers to climate change and weather variability as it determines their plan of action.

Sanfo et al (2014), reiterates that the donor community, NGOs, farmers unions and policy makers involved in coming up with adaptation strategies promotion should take into consideration views of small-scale farmers to climate change as it is crucial to enhance adoption of adaptation strategies.

2.5 Factors that influence Perception

Normally, differences in the way we understand any environmental change can be attributed to how and from whom we learn about these changes. In this regard Slegers (2008), describes perception as a set of beliefs, judgements and experiences that depend on one's context as shown in Fig 2.2 below.

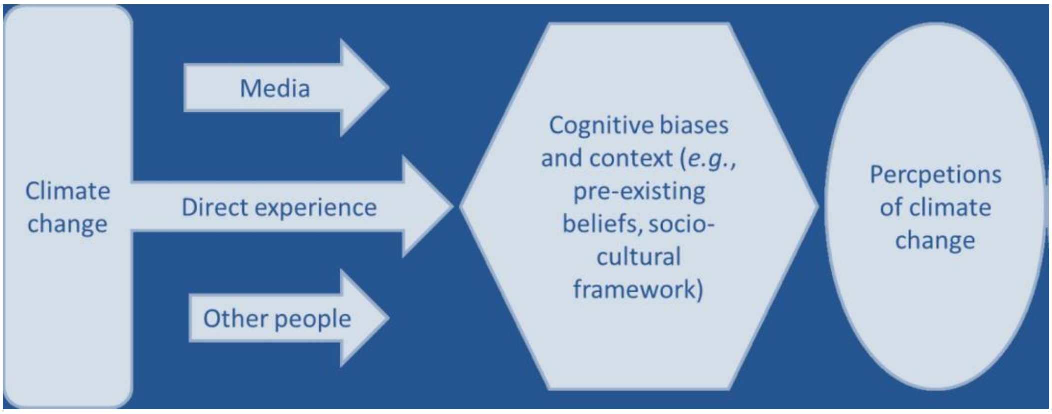

Fig 2.2: A model of the way people perceive climate change (Kuivanen, 2015)

Experience shapes up farmer's views to climate change in the sense that farmers who would have been farming in an area for more years are more aware and alert of the changes around them compared to those with fewer years of farming experience. According to Pahl et al (2015), experience risk perception relies on extreme climatic events that they still remember at their back of their mind to understand the severity of climate change. More so, awareness concerning climate change that is influenced by media and agricultural extension workers from events occurring in distant areas used as examples rather than what is happening at exact places is called description based perceptions.

Hein et al (2019), reiterates that farmers' perceptions can also be influenced by different personal and environmental factors which shows that climatic trends can be misunderstood. Thus the need to always compare smallholder farmer's perceptions to the recorded meteorological data and see if people are perceiving climate change correctly or not. Some of the factors which influence perception include, among other things:-

- Number of years in farming, education level and gender: The assumption being that, more years spent farming and the more learned farmers have much more correct understanding of climate change. Then those who are mainly involved in crop production at a given household be it male or female would perceive climate change more accurately. More-so, an assumption that the more educated household head is the more the probability of a better appreciation and understanding of climate change. This is supported by Ofuoko (2011), who assumes that a unit increase in the number of years of schooling would lead to about 1% increase in chance of appreciation of climate change.
- Primary occupation: High consistency of perception should occur to farmers whose primary occupation is farming.
- Weather information availability and farming teaching involvement: Where farmers have access to weather information and are actively involved in farming trainings the higher is their understanding of climate change. Maddison (2006), argues that farmers perception reveals the farmer's access to information on climate change, exposure to agricultural extension services and farmer to farmer interaction.

CHAPTER 3: Smallholder farmers' perceptions to climate change and weather variability and their access to weather information in uMziwabantu, Ugu District, KwaZulu Natal.

3.1 Abstract

Climate change is a global hazard to farmer's living standards and food availability. This chapter analyses if smallholder farmer understands climate change and weather variability and their access to weather information. In this regard survey data was collected using questionnaires, key informant interviews and focus group discussions. Reliability and validity tests of the questionnaire were done using SPSS (20.0). The results obtained showed that smallholder farmers in uMziwabantu noticed changes in climate in the last 10-15 years and also their major source of weather information was through the radio as well as Indigenous Knowledge System (IKS). This study highlighted that smallholder farmer's livelihood was in a menace due to climate change and weather variability coupled with limited climate information reliability and timeliness.

3.2 Introduction

Climate change has proved to be a global phenomenon and the effects are even worse in Sub-Saharan Africa as more than 95 % of farming practices is rain-fed (Ayandale et al, 2016). The heavy dependence of smallholder farmers on this type of farming has increased their exposure to droughts and floods which significantly reduce yields and increase food insecurity. Additionally, small-scale farmers in SSA are more exposed to climate change and weather variability due to widespread poverty, low infrastructure and technological advancement (Mtambanengwe et al, 2012). Smallholder farmers in uMziwabantu are also not spared from this dilemma brought about by climate variability.

Temperature and rainfall are important factors with immediate impacts on farmer's livelihood and environment. According to Mkonda and He (2017), rising temperature and rainfall variations such as rainfall amount, frequency, beginning as well as ending of a rainy season are key indicators that the climate is changing. Kalungu et al (2013) noted that climate change indirectly affects agriculture by enhancing the distribution of pests and livestock diseases, reducing water availability and increasing the extent of soil erosion.

Farmers' views and understanding about climate change is of much importance as they determine their actions towards the effects so as to minimise the effects (Clarke et al, 2012). However, availability of accurate weather information and proper dissemination thereof to farmers should be timeous and reliable to enhance farmer's coping strategies to climate change. Mtambanegwe et al, (2012) reiterates that when climatic information is at farmer's disposal it enables those to do reasonable decisions pertaining farm management and adaptation decisions in the face of climatic hardships in time. For an example they can shift their farming season activities or change crop types and varieties, timing of major operations and even shifting to livestock production if the rainfall is not reliable for that particular year.

Furthermore, subsistence farmers' awareness to climate variability and weather irregularities enables policy makers to come up with adaptation strategies tailor-made for them to improve livelihoods thereby reducing exposure at area based level (Shuaibu et al, 2014). Issues related to climate change should not take a one size fits all approach as it does not bring effective results thus the need to understand farmer's perceptions at any given area. Amadou et al (2015), suggested that it's imperative to understand farmers perception to climate change as it promotes successful adaptation of the agricultural land-use system. However, effective adaptation relies also on integrating both scientific, local farmer perception and indigenous knowledge system. Most smallholder farmers relies on SAWS for climatic information, and unlike the commercial farmers counterparts, they are poor and cannot afford technological advancements to minimise the effects of climate change.

Gbetiouo & Ringler (2009) noted that in South Africa, KwaZulu Natal suffers the most effects of climate change and variability alongside Limpopo and Eastern Cape. This is because they both have the largest exposure and highest sensitivity. This is coupled by high unemployment rates, HIV prevalence as well as low levels of infrastructure development.

In uMziwabantu subsistence agriculture is undertaken as part of a household's survival strategy and it is mainly done on community land (SDF Review 2015-2016). The most common crop they grow is maize and they are also involved in gardening where they plant cabbages, spinach, tomatoes, carrots and onions.

Aurecon (2016) argued that 20.3% households in uMziwabantu practise crop production, whilst 35.6 % mixed farming. Agriculture and manufacturing sectors are the large contributors to the GDP of the municipality, however, smallholder farming is not sufficiently supported to ensure economic advancement and to improve food availability. Climate change is evidenced with increased temperatures that may result in increased fire frequencies and flood risks in uMziwabantu.

The objectives of this chapter are a) to understand the farmers' views on climate change and its impacts on their livelihood and b) to ascertain farmers' access to weather/ climate information and effectiveness in guiding their agricultural operations in uMziwabantu Local Municipality.

3.3 Study Area

uMziwabantu Local Municipality in Ugu District is located 30˚37'51.7″S latitude and 29˚52′33.7″E longitude (Fig 3.1). It is in the western boundary of Ugu District, which borders the Eastern Cape and KwaZulu Natal. The tribal areas of KwaMachi, KwaJali, kwaMbotho, KwaFodo, Dumisa and Bashawani form about 42 % of uMziwabantu (IDP, 2020). The Municipality is mostly rural and the main economic activities are forestry and plantation that is wattle, gum and pine (Aurecon, 2016).

Umziwabantu has a culturally diverse population, which is dominated by Zulu (88.1 %) speaking people (Stats SA, 2016). According to IDP (2020), it experiences a mean maximum temperature of 25 degrees Celsius in January and a mean minimum temperature of 0.6 degrees Celsius in July with rainfall which is strongly seasonal with an excess of 80% of the rain occurring as thunderstorms during the period of October to March.

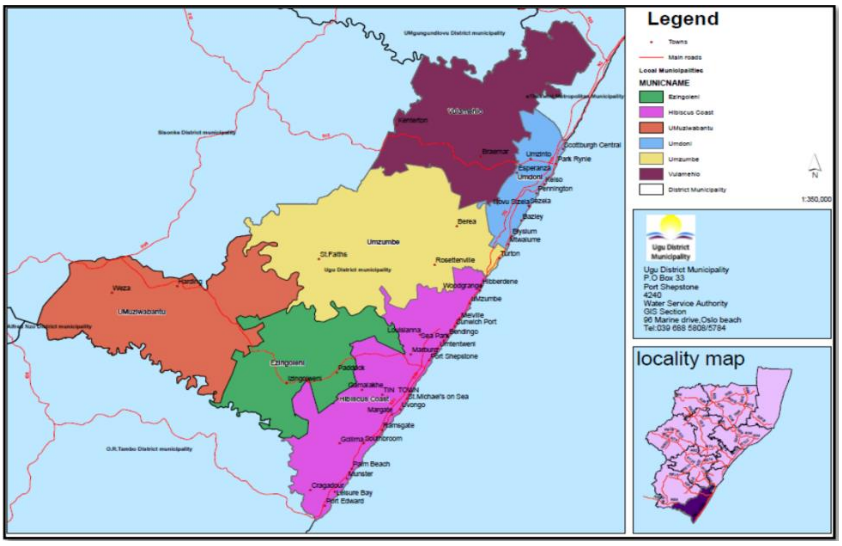

Fig 3.1: Map of the Ugu District showing the location of uMziwabantu (in brick red) Source: (IDP,2020).

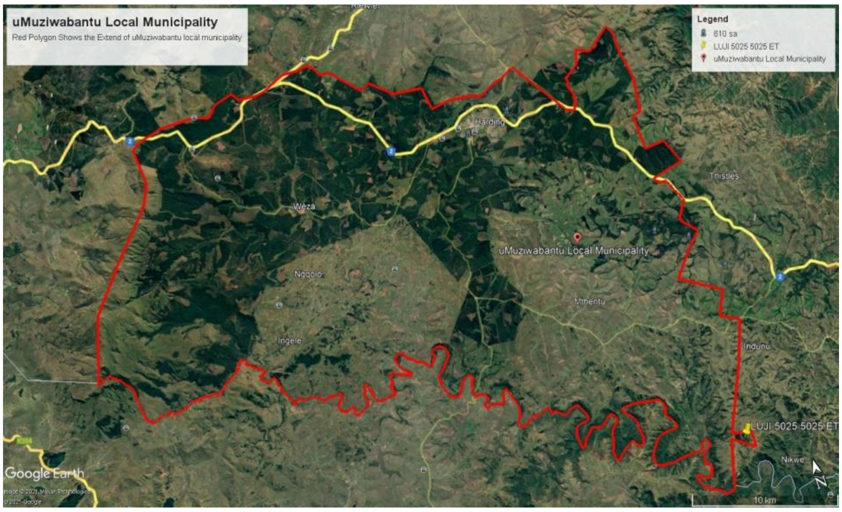

Fig 3.2: Ward boundary of uMziwabantu Local Municipality in Ugu District, KwaZulu-Natal Province. Source: (IDP,2020).

3.4 Primary data collection

Data on demographics, socio-economic livelihood of the households, farmers' views and awareness of climate change and the effects they observed was obtained using structured household questionnaires, Focus Group Discussions (FGDs) and key informant interviews.

A total of 150 small-scale farmers were randomly selected to answer questionnaires. According to Abawi (2013), structured questionnaires are easy to administer, consistent in answers and are easy for data management. The questionnaires were done through face to face interviews with mainly household heads.

Household survey was followed by four FGDs consisting of 10-12 farmers of different age groups and gender. Focus group discussions gives the opportunity to cross check one individual's opinion with other opinions gathered, and in a group set-up members tend to be more open thus interaction can enrich the quality and quantity of information needed (Roopa & Rani, 2012).

Key informant interviews were also conducted so as to have a greater understanding of the issues. According to Abawi (2013), key informant interviews collect information from a wide range of people who have first-hand knowledge about the community. Thirteen key informants were used and they ranged from chiefs, traditional leaders, police officers, nurses and teachers.

3.5 Statistical Analysis

Statistical Package for Social Sciences (SPSS 20.0) was used in analysing the primary data obtained through questionnaires. The target number was 150 small-scale farmers, but after data cleaning and coding 143 farmers were used for data analysis. Descriptive analysis of the household demographic data was done using frequencies. Cross tabulations using farmer's gender and age groups were done where necessary to show variations and to validate the data. Chi-square test was employed for the inferential analysis to determine significant differences between variables.

3.5.1 Validity and reliability of questionnaire data

The validity and reliability of questionnaire data was tested using Cronbach alpha using SPSS (20.0) procedures. Cronbach alpha should be 0.7 to 0.9 (Downing, 2014) indicating that the results are reliable and have a positive internal consistency. Validity refers to the degree in which an instrument measures that which it intends to measure (Bolarinwa, 2018, Pallant, 2011). In this case face validity and construct validity were considered. Face validity involves the experts looking at the items in the questionnaire and agreeing that the concept is worth measuring just by looking at it. Given that the questionnaire was evaluated by the chief investigators at FAO-REOSA, University of Pretoria and NARES, face validity was therefore assumed.

Then construct validity focuses on whether the questions are a representative of the domains that they are supposed to measure (Bolarinwa, 2018), in this case demographics were crucial in understanding the nature of the community and this was shown in the form of graphs.

Deniz and Alsaffar (2013), describe reliability as a degree to which the results obtained from a questionnaire can be reproduced or repeated. In other words it measures uniformity, correctness and repeatability of a research. A commonly used measure of reliability is internal consistency which tests consistency among variables in a summated scale. From the questionnaire reliability was tested on the sections on access to information with a Cronbach alpha of 0.803, use of indigenous knowledge systems (0.845) and farmers' perception on long term climatic and environmental change (0.609).

3.6 Demographics

Table 3.1 shows the demographic attributes of the household heads in uMziwabantu as reported by the respondents.

Table 3.1: Demographic characteristic of household heads in uMziwabantu, KwaZulu-Natal

		%
Gender	Male	37.8
	Female	62.2
	N	143
Read or write	Yes	66.2
	No	33.8
	N	143
Education level	None	28.2
	Primary	45.1
	Secondary	22.5
	Tertiary	4.2
	N	143
Farming status	Full time farmer	36.4
	Part-time farmer	63.6
	N	129

As shown in Table 3.1, more than half (62.2%) of the households were female-headed whilst 37.8% were male- headed. The general picture shown by the results is that there are more female headed household than male headed households. More than half of the household heads (66.2%) were literate, meaning that they could read and write whilst 33.8% are illiterate. Looking at the education levels attained by the household heads, majority however only went up to primary level (45.1%), followed by those who reached secondary level (22.5%). Only 4.2% reached the tertiary level. Of note is that 28.2% did not have any formal education. About 63.6% of the household heads are part time farmers whilst 36.4% were full time farmers. These results show that farming is a part time activity for most households in uMziwabantu.

3.6.1 Age group

The majority of household heads in the sampled households were in the age groups 60-69 years (33.1%) and 50-59 years (27.5%). The least represented age group was 20-29 with 1.4% as shown in Fig 3.3.

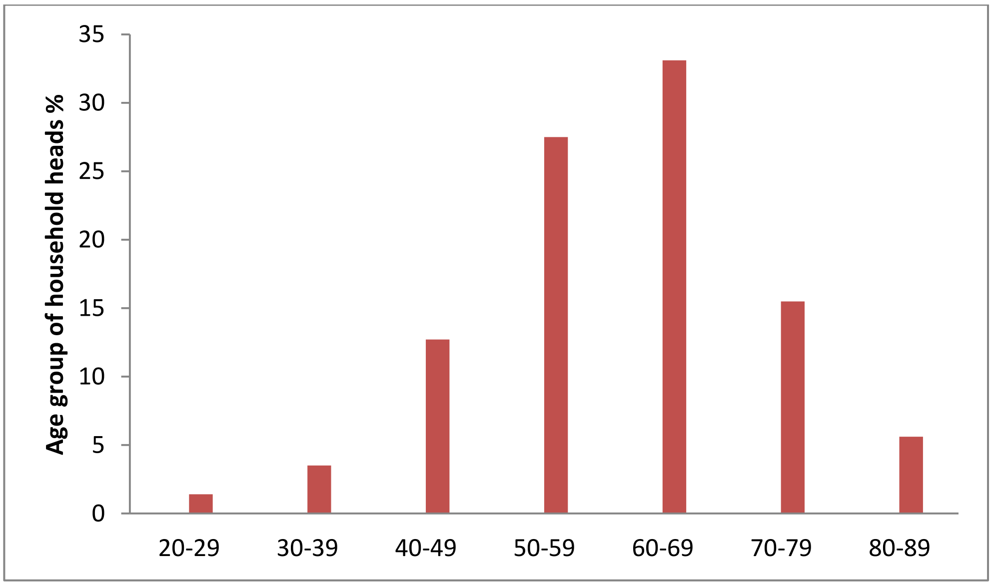

Fig 3.3 Age group of household heads in uMziwabantu, KwaZulu-Natal

3.6.2 Marital status

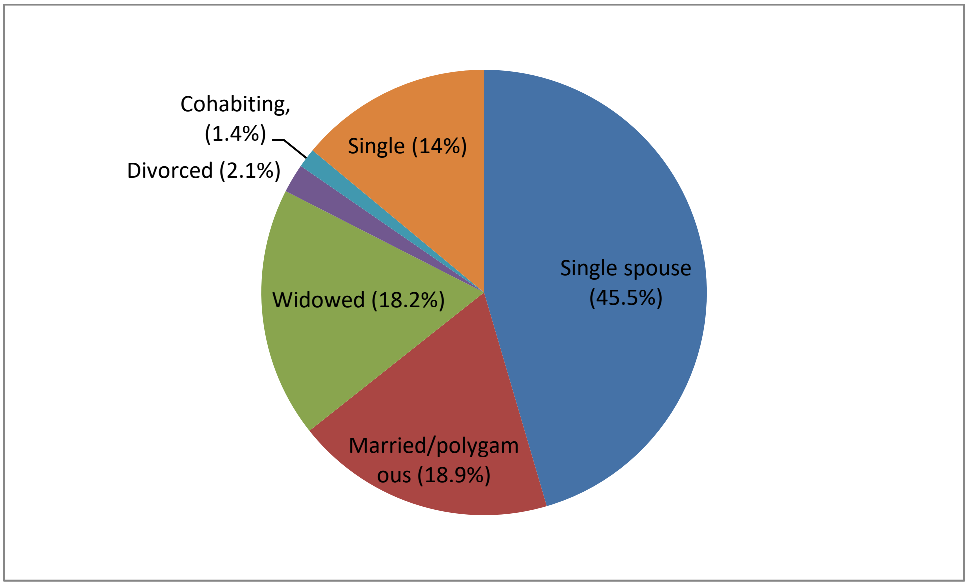

Fig 3.4: Marital status of the head of household in uMziwabantu, KwaZulu-Natal

According to the marital status of the household heads shown in Fig 3.4, 45.5 % of the respondents are married with a single spouse, followed by those who are in polygamous marriages (18.9%) and widowed (18.2%). The rest are either single (14%), separated (2.1%) or cohabiting (1.4%).

3.6.3 The employment status of household heads

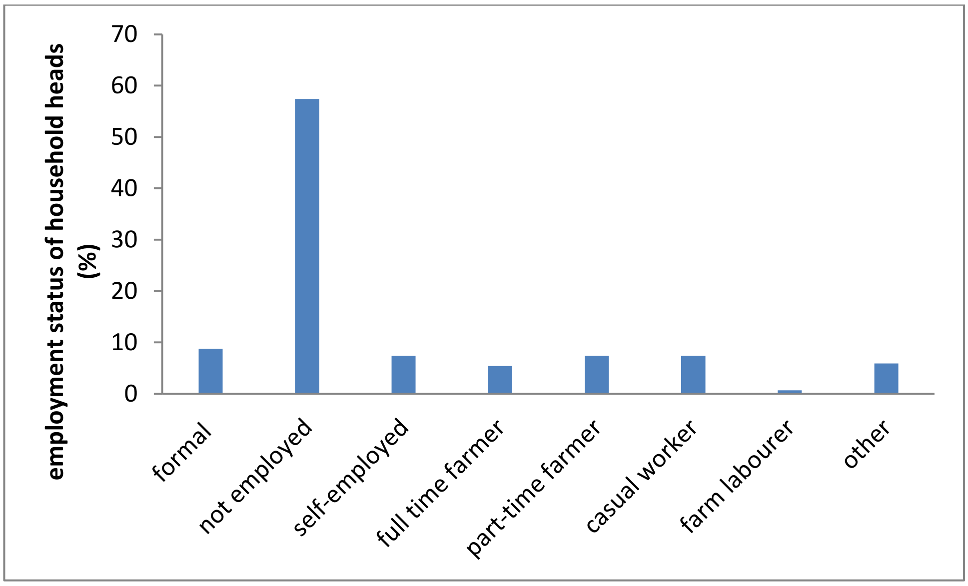

Fig 3.5: Employment status of household head in uMziwabantu, KwaZulu-Natal

As shown in Fig 3.5, majority of the household heads in uMziwabantu were not employed (57.4%). For those who were employed it was mostly formal (8.8%) followed by part time, casual jobs or self- employment with 7.4% respectively.

3.6.4 Household sizes

As shown in Fig 3.6, 52.2 % of the households have between 6-10 people living in the household. Others (37%) however have less than 5 members. Only 10.8% have members above 11. More so in uMziwabantu, majority of the household had at least 2 members fit to work in agriculture related activities. This was followed by households with 1 member fit to work. Other households had up to 10 members.

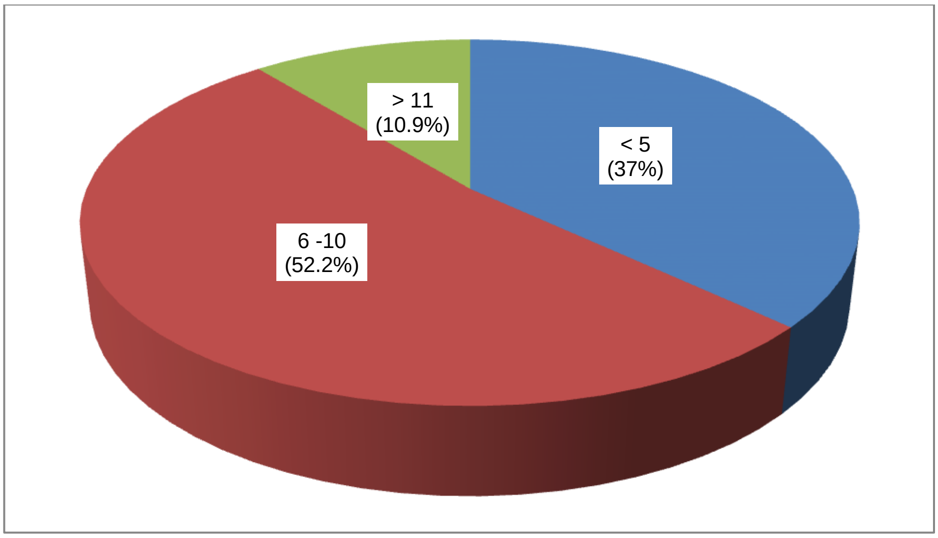

Fig 3.6: Number of people currently living in households in uMziwabantu, KwaZulu-Natal.

3.6.5 Main source of energy/fuel for cooking in the households

In uMziwabantu, the number of household using electricity (45.5%) and fuel wood (49 %) to cook are almost the same as shown in Fig 3.7 below. Only a few households use animal dung, coal/charcoal and other sources of energy to cook.

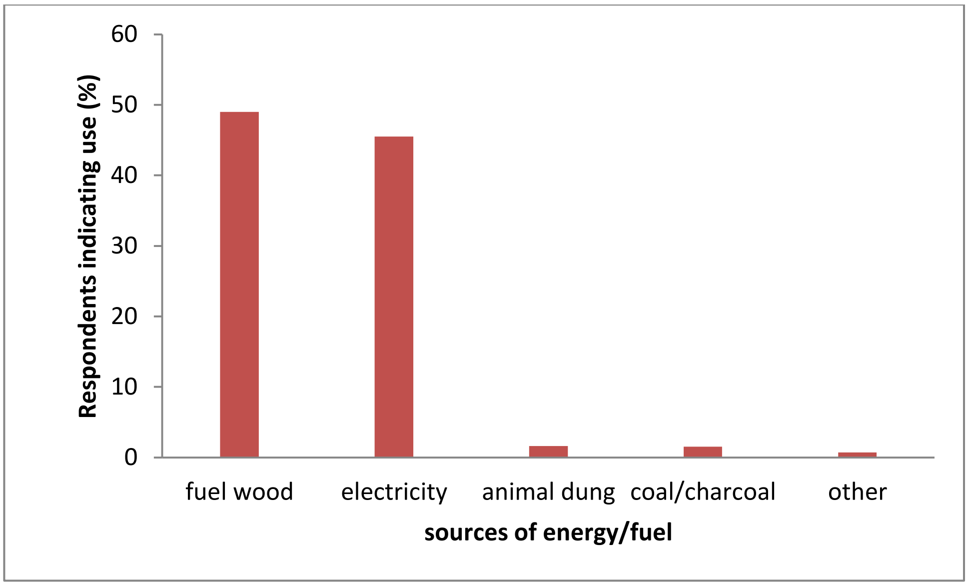

Fig 3.7. Main sources of energy for cooking in households in uMziwabantu, KwaZulu-Natal.

3.6.6 Main sources of household income

In uMziwabantu there were various sources for household income (Fig 3.8). Social cash transfer was reported as the most common cash income source by 21.4% of the sampled households. This was followed by pension (17.3%) and irregular daily/casual labour (11.2%). Other income sources reported were sale of root crops (10.2%), sale of own grown vegetables (8.2%), non-agricultural labour (7.1%), sale of cereals and pulses (5.1%) and private company (5.3%). The least reported sources of income below 5% were government employee, self -employment, remittances and agricultural wage labour.

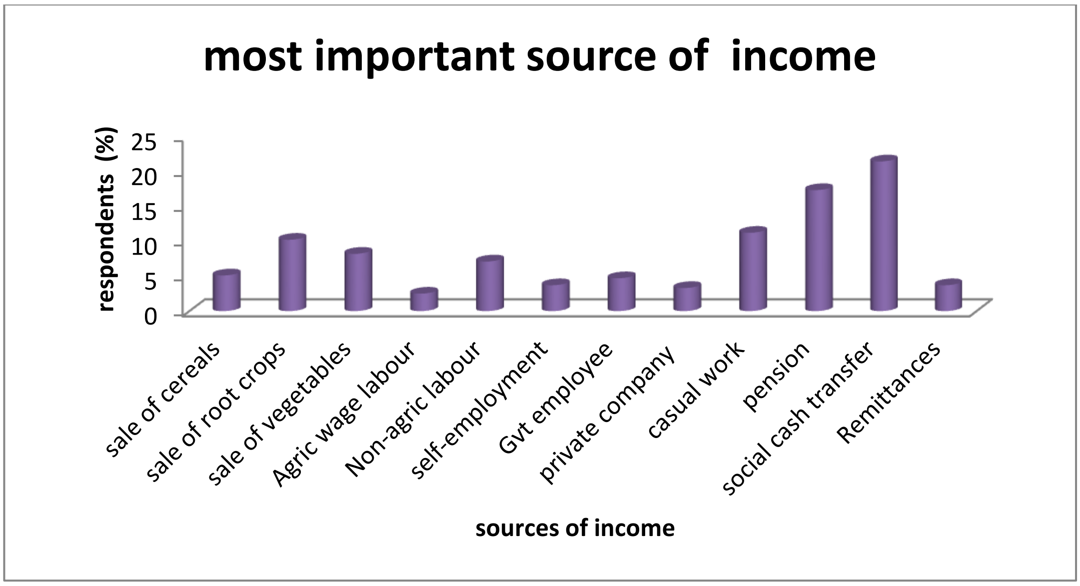

Fig 3.8 Main sources of household income in uMziwabantu, KwaZulu-Natal.

3.6.7 Stability of the most important source of income

The reported income sources were not very stable according to the respondents as shown in Fig 3.9. These sources were either temporal (37.9%), seasonal (17.9%) or erratic (6.3%). Only 37.9% of the respondents had stable/permanent sources of income.

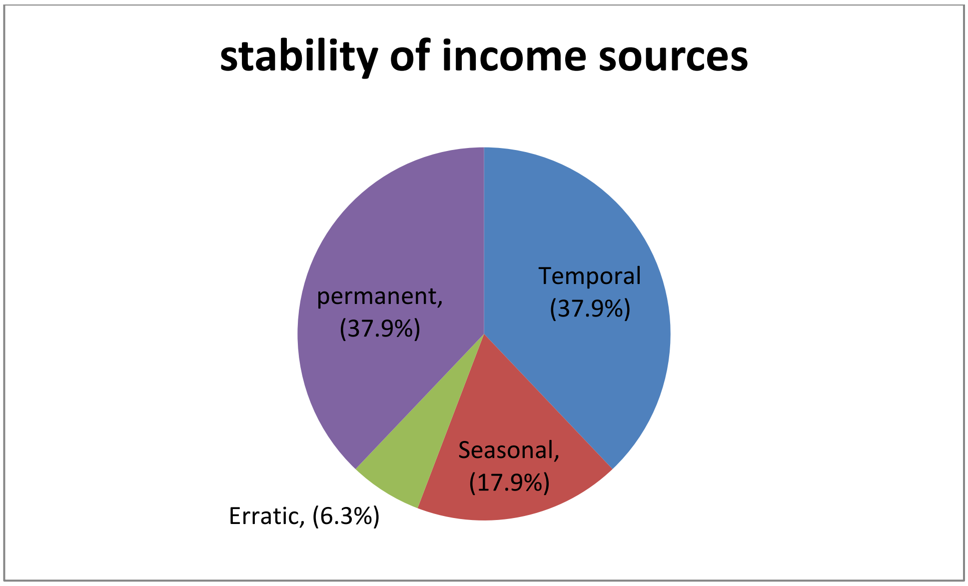

Fig 3.9. Stability of income sources in uMziwabantu, KwaZulu-Natal.

3.7 Livelihood for households

The most common source of livelihood was pension with 45%, followed by government employee with 11.4%. Other livelihood sources identified were agriculture related. These include sale of cereals, sale of root crops, and sale of own grown vegetables (Fig 3.10).

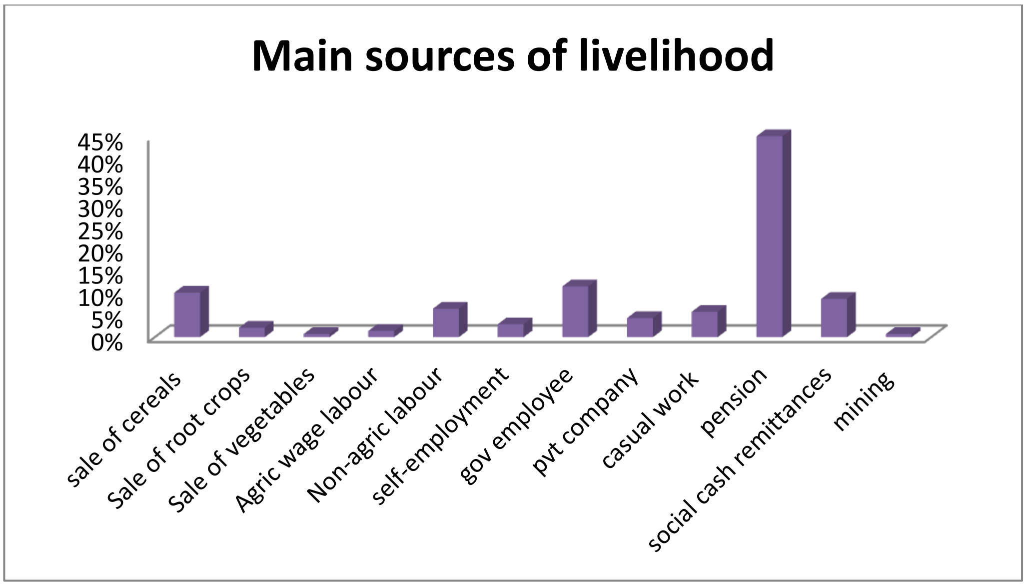

Fig 3.10 Household sources of livelihood in uMziwabantu, KwaZulu-Natal

3.7.1 Household and agricultural assets

In uMziwabantu above 80% of the households own different household assets (Table 3.2) such as fridge, stove, television, satellite dish, cellphone and solar panel. Of these, the most owned assets were television (94.7%) and cellphone (91.9%). Although 82.4% of the household own a hoe, which is a traditional agricultural tool, ownership of other agriculture related assets such as cultivator, plough, oxcart, planter, water pump and tractor is way below 15% as indicated in Table 3.3.

Table 3.2: Household asset ownership in uMziwabantu, Kwazulu-Natal

Asset	Yes %
Fridge	88.5
Sewing machine	14
Stove	85.7
Television	94.7
Satelite dish	20.2
Radio	74
Cellphone	91.9
Solar panel	14
Bicycle	12.9
Car truck	13.8
Bank account	59.6

Table 3.3: Agricultural asset ownership in uMziwabantu, KwaZulu-Natal

Asset	Yes %
Cultivator	12.4
Ox-cart	5.9
Plough	14
Hoe	82.4
Knap sack	12
Planter	3.6
Generator	2.4
Water pump	3.5
Tractor	5.5
Investment saving	25.8
Wheelbarrow	73.1

3.8 Household Coping Strategies

Household coping strategies in uMziwabantu are presented in Fig 3.11, most of the coping strategies are used on a sometimes and often basis. The highest proportion of households sometimes resort to skipping an entire day without eating (71.4%); limiting portion sizes (75%); reducing number of meals (75%); borrowing food from relatives and friends (57.1%) and diverting seed to food consumption. Strategies used on a daily basis included borrowing food from friends; relying on less expensive foods (18.2%); harvesting immature crops (8.3%), reducing adult consumption so children can eat (16.7%) and doing casual labour for food (7.7%).

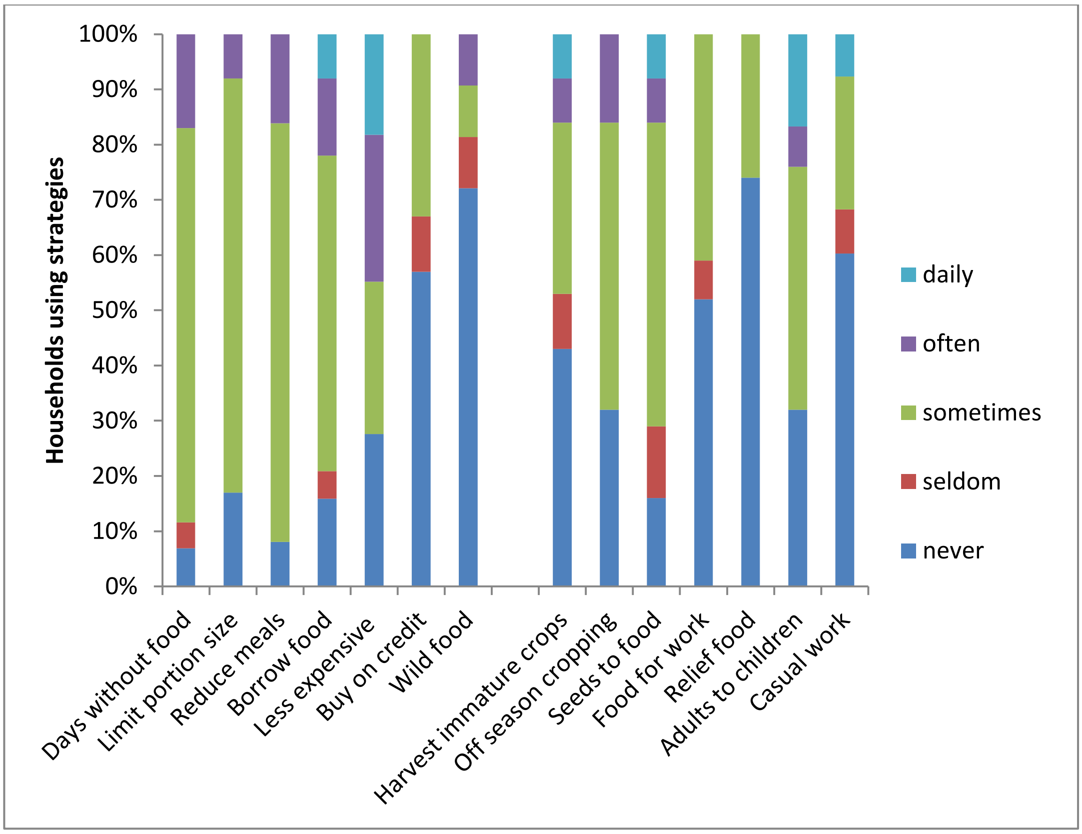

Fig 3.11. Coping strategies used by households in uMziwabantu, KwaZulu-Natal.

3.9 Farmer's access to climate/weather Information

As shown in Table 3.2, majority of smallholder farmers in uMziwabantu indicated that they had access to weather information in general (89.4%), seasonal information (83.6%) and daily information (89.3%). Farmers access to climate/weather information was tallied against gender so since p- value was 0.781 and is bigger than 0.05 the null hypothesis will be accepted which supports that the smallholder farmer's observation on climate and weather variability conformed to the meteorological data observed from SAWS 2005 to 2009. Regardless of gender all the farmers had equal access to climate and weather information.

Table 3.4: Farmers' access to climatic/ weather information in uMziwabantu, KwaZulu-Natal

Climate information n=85	**Frequency**	**% of respondents**	**Sig (2 tailed) P value =.05**
Yes	76	89.4	
Seasonal Information n=55			0.781
Yes	46	83.6	
Daily Information n=56			
Yes	50	89.3	

3.9.1 Main sources of weather information

In uMziwabantu there were various sources of weather/climate forecast information (Fig 3.12). The most common source that was mentioned by the smallholder farmers was radio/television for all categories that is climatic (55.1%), seasonal (44.7%) and daily (51.9%). The second common source for climatic information in general was newspapers with 14.7%, for seasonal and daily weather information it was government extension (13.5%) and (15.6%) respectively. The other sources of information highlighted by the farmers were indigenous knowledge (10.5%), relatives and children (10.5%) and other farmers (7.8%).

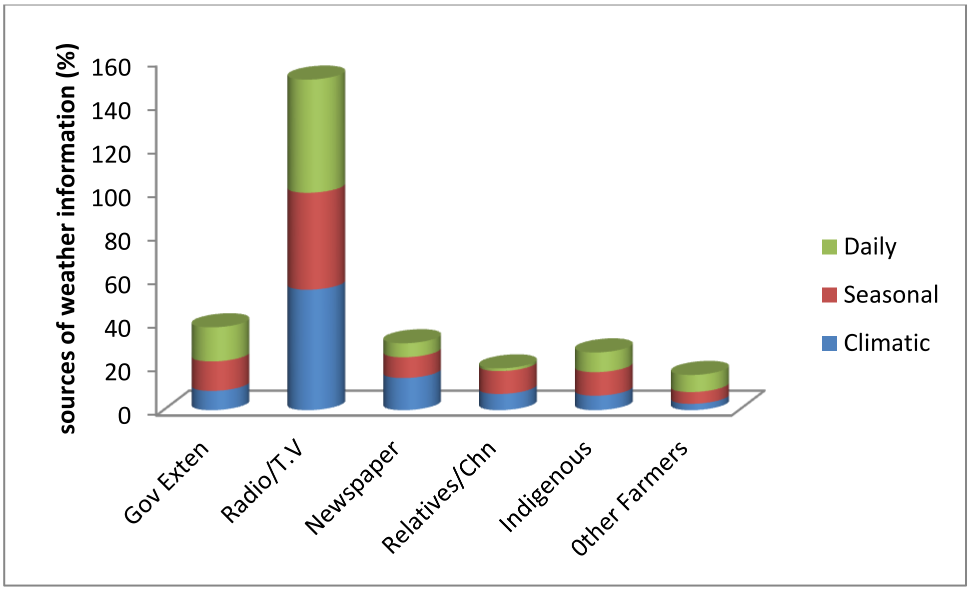

Fig 3.12: Sources of weather forecast information in uMziwabantu, KwaZulu-Natal

3.9.2 Timeliness and reliability of weather sources

Table 3.5 shows the timeliness and reliability of weather information from the sources mentioned in Fig 3.12 above as reported by the respondents.

Table 3.5: Timeliness and reliability of weather sources in uMziwabantu, KwaZulu-Natal

	Good %	Fair %	Poor %	N
Climate info timeliness	63.5	31.5	5.4	74
Climate info reliability	52.1	39.4	8.5	71
Seasonal info timeliness	56.5	28.3	15.2	46
Seasonal info reliability	43.2	43.2	13.6	44
Daily info timeliness	44.7	48.9	6.4	47
Daily info reliability	32.6	60.9	6.5	46

As shown in Table 3.5, 63.5% of farmers indicated that climate information timeliness was good, as well as seasonal information timeliness (56.5%). However, daily information timeliness was ranked fair by the majority of the farmers (48.9%). In terms of reliability, 52.1% of the farmers ranked it fair for climate information. An equal proportion of farmers (43.2%) ranked seasonal information reliability good and fair. When it comes to daily information reliability, majority of the respondents (60.9%) indicated that it was fair.

3.9.3 Indigenous knowledge system usage

In uMziwabantu there were various sources of indigenous knowledge systems (Fig 3.13). Own observation and experience was reported as the most common used by farmers, 41.8% for climatic, 37.8 % for seasonal and 42.8% for daily forecasting. Where farmers would consult a third party for climate forecasting, traditional leaders (14.9%) and community leaders (11.9%) were commonly used. Elders were used for seasonal (17.8%) and daily forecasting (20.8%).

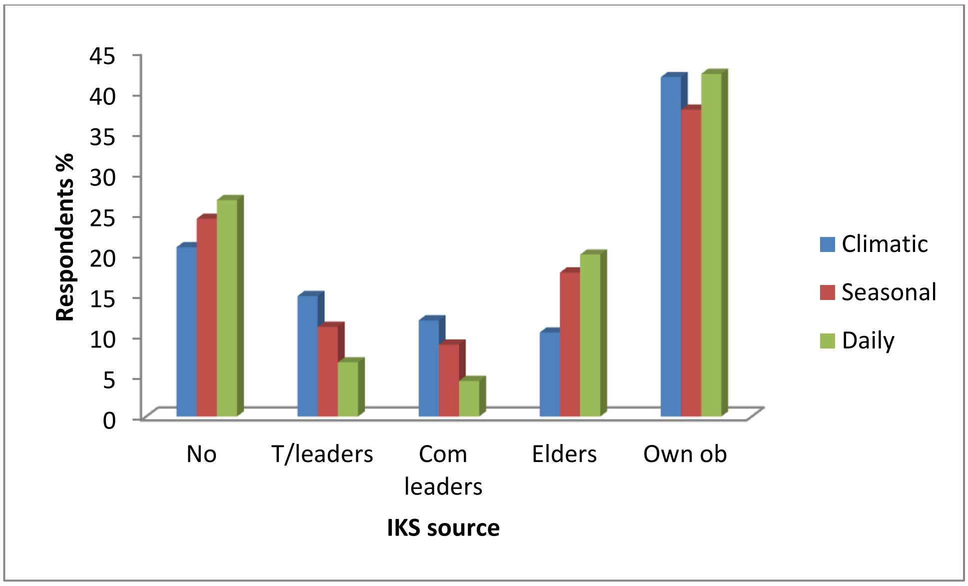

Fig 3.13: Sources of indigenous knowledge system in uMziwabantu, KwaZulu-Natal.

3.9.4 Indigenous Knowledge System Reliability

Most smallholder farmers in uMziwabantu indicated that indigenous knowledge system reliability for climate information was good (45.5%). Seasonal IKS reliability was ranked fair (44.7%) by the farmers and 58.3% ranked daily IKS reliability as fair (Table 3.6). All the values for T tests done to test indigenous knowledge reliability for climatic, seasonal and daily forecast using gender as a grouping were bigger than .05 thus will accept the null hypothesis. Irrespective of household gender small scale farmers indicated that IKS is reliable.

Table 3.6 Reliability of Indigenous Knowledge Systems in uMziwabantu, KwaZulu-Natal

	Frequency	Respondents %	Sig (2 tailed) P- value =.05
climate indigenous knowledge system n=55			0.855
Good	25	45.5	
Fair	23	41.8	
poor	7	12.7	
Seasonal indigenous knowledge system n=38			0.478
Good	15	39.5	
Fair	17	44.7	
poor	6	15.8	
Daily indigenous knowledge system n=36			0.277
Good	10	27.8	
Fair	21	58.3	
Poor	5	13.9	

3.10 Farmers' knowledge and perceptions to climate change and variability

Over 76% of farmers in uMziwabantu showed that they had noticed changes in weather patterns and trends in the years 2005-2019. Out of the respondents interviewed on perception of long term changes in temperature, most farmers (83%) perceived that temperatures have been increasing as shown in figure 3.14 below.

A total of 50% of the smallholder farmers indicated that rainfall has increased as a result of floods and hailstorms. At the same time 34% of the farmers argued that rainfall had decreased as they had observed a lot of droughts. In discussions carried out with key informants, they highlighted that the occurrences of strong winds was becoming more frequent as well. Strong wind coupled with heat stress has increased the spread of veld fires.

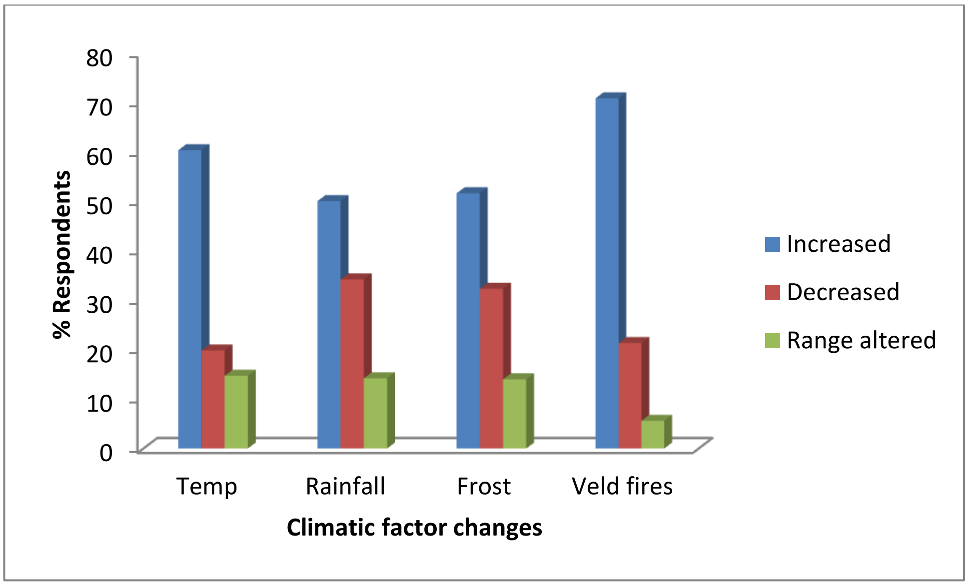

Fig 3.14: Farmers' perceptions to climate change and variability in uMziwabantu KwaZulu-Natal.

3.11: Effects of climate change in uMziwabantu

Smallholder farmers in Ugu District faced frequent risks to their agriculture due to climate change as it impacted on their food security and livelihood. The risks included increased weeds and pests resulting in diseases outbreaks for crops thus lowering crop yields and quality as summarised in Table 3.7.

Farmers also faced challenges with their livestock as high temperatures and erratic rains led to animals' death as there was shortage of grazing lands and water. Also farmers observed changes in rainfall patterns which were said to be characterised with early on-set and cessation of the rainy season, thus impacting the yield outcome.

Table 3.7: Farmers' perceptions of impacts of weather variability in uMziwabantu

Weather Indicator	Observed Impacts
High temperatures	Crop heat stress resulting in low yields
	Increased pests and diseases
Strong winds	Erosion of soils resulting in low fertility.
	Destruction of house roofs
Floods	Destruction of crops, livestock and houses
	Erosion of soils resulting in low fertility.
Drought	Water deficit in crops
	Livestock death due to shortage of grazing lands and water

3.12: Discussion on Farmer’s perception results

3.12.1: Demographics and socio-economic profile in smallholder farming

The study showed that there were more female headed households in uMziwabantu who were involved in small-scale agriculture. According to Ogunlela and Mukhatar (2009), women in Africa contribute greatly in subsistence farming, even though their effort goes by unnoticed.

According to Nhemachena et al (2014), most rural smallholder farming in Southern Africa that is South Africa, Zambia and Zimbabwe is done by women, the main reason being that most males are based in cities. Leaving women having more farming experience and information in agricultural practices in this region as they are the ones involved in the farming.

This general trend has been reported in several countries in the sub region. In Cameroon the current trends in feminization of subsistence farming was mainly due to significant male out migration (Nchu et al, 2019). However it is also imperative not to overlook the work of man in rural agriculture as they are believed to make key farm management decisions even though they might not be hands on (Moyo, 2012 and Ayanlade et al, 2017).

Majority of the smallholder farmers in uMziwabantu had low level of education as most farmers had only completed primary school level. These findings agree with Kangalawe and Lyimo (2013) as they reported that in rural Tanzania subsistence farming was done by females with low levels of education as they had few chances of being employed in other non-farming activities. It is of great importance to observe that in most cases even though the societies were not highly educated, most household heads are generally literate in SSA (Mtambanengwe et al 2012 and Ogalleh et al 2012). As observed also in uMziwabantu Local Municipality.

In most instances education increases the possibility of better appreciation of a lot of things and in this case climate change and weather variability. Ofuoku (2011) estimated that an increase in the number of years of schooling would increase in probability of understanding climate change in Nigeria by 1%. This suggests that education and experience to farming have an impact on knowledge and information to climate change and also possible ways to minimise the effects.

Looking at the assets owned in uMziwabantu, most of the farmers had limited access to machinery and farming equipment and that on its own had a negative impact on food security. Agriculture was said to be their main source of livelihood and with the threat posed by climate change it was becoming difficult for people to sustain themselves. According to Tibesigwa and Visser (2015), the strategy of using smallholder farming to promote food security continues to look bleak in South Africa with the advent of climate change.

This is further confounded by higher vulnerability to food security in female-headed households in rural South Africa as comparison to the male-headed urban households. The fact that in most developing regions female headed rural households are among the poorest of the poor highlights the plight of these farmers to fight the effects of climate change (FAO, 2014).

3.12.2 Household Coping Strategies employed by smallholder farmers

Shaibu et al (2014), describes coping strategies as confirmed reaction to a dilemma and in most cases they are short term responses. In uMziwabantu, in a bid to deal with household food insecurity, they resorted to skipping meals, limiting portion sizes and borrowing from relatives and friends among other things.

It is crucial to note that household coping strategies and livelihood activities are different depending on culture and market opportunities within a village (Berman et al, 2014). This means that household coping strategies are not a one size fit all as they depend with the place and socio-economic features. He further suggested that in Uganda household coping strategies included selling assets, withdrawal of savings, consuming seeds and selling of livestock among other things.

In SSA, most households resorts to sharing food, informal cash or in-kind loans and sending children to relatives so as to survive stresses from climate change (Shaibu et al 2014). In some cases people engage in strategies with negative results on the health, productivity and psychological development of children and family at large. For an example, some farmers would sell farm lands, perennial crops, farm equipment and household assets. The question then becomes how sustainable these strategies are?

3.12.3 Climate change and environmental change perceptions

Farmers in uMziwabantu perceived an increase in temperature as well as unprecedented extreme events in the form of floods and heat waves. Additionally these farmers witnessed increased occurrences of veld fires. This conformed to the studies conducted by Mtambanegwe et al (2012), Ogalleh et al (2012) and Bryan et al (2013). However, changes in precipitation are commonly difficult to discover compared to temperature as rainfall is highly variable from time to time.

Davies-Reddy and Vincent (2017), suggested that the outbreak of fire is connected to high temperatures and high wind speed as they determine the nature and intensity of the fire. More so human activities like land clearing, inadequate land management skills and increased spread of invasive alien plants have strong controlling effects on fire regimes in South Africa.

It is evident that most smallholder farmers were aware and conscious of climate change and its effects. According to Adebayo et al (2015), awareness of climate change helps farmers to plan their activities and reduces risks and uncertainties associated with farming. However, there is need to verify farmer's level of awareness with meteorological data so as to ascertain if their perceptions reflect the collected empirical data. It is possible that individuals might think that they are aware of climate change when they would actually be having a wrong interpretation of events (Mudombi et al, 2014).

3.12.4 Sources of information and the use of IKS

Ronald et al (2015), suggested that without knowledge and proper communication channels to acquire, analyse and share information, small producers remain far behind the global market. The use of climate information in agriculture sector enhances farming productivity as it helps the farmers to make the right choices about the crops to plant and the market as well. This is supported by Onyango et al (2012) that skilful seasonal climate forecasts can help not only to reduce climatic uncertainty but livelihood risks to farmers if forecast is accurately communicated, understood and integrated into the decision process.

In uMziwabantu, radio/television was the main source of climate/weather forecast information as a lot of farmers owned this asset. The use of radio as a major device to broadcast climate/weather information is similar with reports from other SSA countries (Narisi et al, 2017, Gyampoh and Asante, 2011 and Rusinga et al, 2014). In Tanzania the major sources of information used by farmers were radio, agricultural extension officers, neighbours and farmer's experience (Kangalawe and Lyimo, 2013), which corresponds well with sources mentioned in uMziwabantu.

According to Narisi et al, (2018), although the radio can be listened to by many people at once, it is largely a one way form of communication as it does not provide opportunities for farmers to ask questions and get localised guidance from the source of the information. Therefore, there is need to use other channels of information dissemination which promotes face to face interaction at a local scale.

In uMziwabantu, smallholder farmers showed that they also incorporated the use of indigenous knowledge system alongside meteorological data. In agreement Narisi et al, (2018) reported that smallholder farmers in most parts of SSA and the world at large access climate/ weather forecast from both meteorological forecasts and indigenous knowledge. Normally people are better able to adopt new ideas when they can be seen in the context of existing practices, thus using these two knowledge systems could potentially improve understanding of uncertainties in farm management. Onyango et al (2012), agreed that it is ideal to integrate scientific forecast as well as traditional understanding of the farmer as it strengthens the trust of the farmer in using the available forecast.

However, reports from Jiri et al (2016) and Nganzi et al (2015) indicated that indigenous knowledge based forecasts have also been altered by climate change thereby questioning its reliability.

The results from uMziwabantu ranked radio usage for climate/weather forecast information and the use of IKS on average fair in terms of reliability. Whereas other studies by Jost et al (2016), indicated that most farmers perceived reliability of climatic information received through the radio low due to that it was received at a big area and yet farming activities are shaped by climatic conditions in specific locations. More so, information from the radio is not specific to the decision-making frame and needs of most smallholder farmers as sometimes the kind of information they would receive at household level would not indicate onset and cessation of rains, drought forecast and pest and disease outbreak in time.

3.12.5 Implications of climate change on Agriculture

Results from the uMziwabantu showed that agricultural productivity levels declined due to droughts, strong winds and in some cases floods as well as heat stress. Soil fertility was mentioned to have deteriorated, maybe due to continuous cropping of the same piece of land with minimal fertiliser application.

These results concurred with the findings in Tanzania as well and most countries in Southern Africa. Kangalawe and Lyimo (2013) cited that in Tanzania livestock diseases became more frequent with climate extremes and forage productivity and probability declined as plant composition changed due to increase in temperatures and rainfall. More so in Lesotho crop infestation with pests and diseases have led to increased cost of food making it difficult for ordinary people to have access to nutritious food (Mutarira et al, 2013).

Implications of climate change are hitting hard most SSA countries since crop production is based on natural rainfall. In Southern Africa yields have been reduced by up to 40% across all crop types (Knox et al, 2012). The effects of climate change have resulted in serious consequences on household food security.

3.12.6 Conclusion

This chapter showed that small-scale farmers in uMziwabantu were aware and conscious of rainfall and temperature changes occurring as a result of climate change. The main common source of weather forecast information accessible to most smallholder farmers was radio/television. IKS mainly from own observations and consultation of elders shaped the perceptions of smallholder farmers. The perceived changes by the farmers had an impact on their livelihood and food security. This goes on to show that smallholder farming has suffered at the hands of climate change.

Chapter 4: Analysis of temperature and rainfall variability and comparison to smallholder farmer perceptions in uMziwabantu Local Municipality.

4.1 Introduction

According to Singh et al, (2018), meteorological information is sorted data and evidence/ knowledge about the atmosphere-ocean interaction over short and long time periods that would provide input for climate models and direct adaptation options. Livelihoods in Sub-Saharan Africa (SSA) are agro-based with majority being subsistence farmers who depend on rain-fed agriculture. Rainfall and temperature are the main determinants in smallholder farming.

Seasonal weather/climate forecasts if properly analysed and accurately communicated in a way that is easily understood by farmers can help reduce their livelihood risks by incorporating such details in the decision making process (Onyango et al, 2012). At household level climatological information influences farming decisions such as land preparation, planting dates; seed varieties risk management and pest and disease management. In most case though small-scale farmers have acquired climate forecast data, the majority do not understand climate forecast as they are normally presented in a manner that shows uncertainties which is difficult to comprehend without guidance (Narisi et al, 2018). Thus they end up using local knowledge system in order to determine the planting time, however IKS reliability has been affected by climate change. This gives rise to the need for meteorological information to be conveyed to smallholder farmers in a way that it will be useful for operational decisions at a local scale. Extension officers will likely play a key role in the data interpretation so that information is easily understood by farmers.

Masinde et al, (2012), acknowledged that though most countries in SSA give regular weather/climate forecasts particularly daily and seasonal forecasts, there is an information gap with regards to extent this information is useful to smallholder farmers. Thus, the need to monitor usefulness of the information to smallholder farmers.

In this chapter the objective was to study the variability of temperature and rainfall in uMziwabantu Local Municipality, Ugu District and later compare the smallholder farmer perceptions to meteorological evidence from SAWS.

4.2 Materials and methods

To validate the community survey data on climate change and weather patterns with actual weather data recorded for uMziwabantu Local Municipality, climatological data for Margate weather station (closest to uMziwabantu) was obtained from SAWS. This was done to ascertain whether smallholder farmers' knowledge of climate change and weather variability corresponded to the meteorological records. Daily rainfall and temperature data (minimum and maximum) for the period 2005-2019 was used to compare with the findings from the smallholder farmer's survey.

An anomaly index was used to analyse rainfall and temperature trends in uMziwabantu from 2005-2019, Rainfall Anomaly Index (RAI) and Temperature Anomaly Index (TAI) respectively. Plotted graphs showing trends from RAI and TAI were then compared to the responses from the small-scale farmers. The formulae are detailed below:-

$$RAI = +2\left(\frac{\mathrm{R} - \mathrm{MR}}{\mathrm{MH5} - \mathrm{MR}}\right)$$

Where R is the total rainfall (mm/year), MR is the mean rainfall (mm/year), and M_{H5} is the mean of the 5 highest values of rainfall (mm/year) and

$$TAI = +2\left(\frac{T - \mathrm{MT}}{\mathrm{MH5} - \mathrm{MT}}\right)$$

Where T is the annual average temperature in a specific year (˚C), MT is the 15 -year mean of the annual average temperature (˚C), and M_{H5} is the mean of the 5 highest values of annual average temperature (˚C).

4.3 Results from meteorological data

4.3.1: Annual temperature and rainfall variability in uMziwabantu

As shown in Figure 4.1 wet years occurred in 2006, 2007, 2008, 2009, 2011, 2012, 2013, 2016 and 2017. The wettest year was 2012 with an annual total of 1857mm, whereas dry years occurred in 2005, 2010, 2013, 2014, 2015, 2018 and 2019. The driest was 2014 with an annual total of 661 mm. This result can be further explained by the El Niño and La Niña conditions in South Africa The result may imply that the years with lower than normal rainfall are also characterised by late onset and early cessation of the rainy season (Ayanlade et al 2016).

Fig 4.2 shows the mean yearly maximum and minimum temperatures for uMziwabantu. Highest maximum temperature was recorded in 2019 with an average of 24.7˚C. Lowest maximum temperature was in 2009 with an average of 23.4˚C. Additionally minimum temperature has been above normal from 2005 to 2015 with the lowest being in 2017 with a mean of 14.9˚ C and highest in 2008 with a mean of 18 ˚C

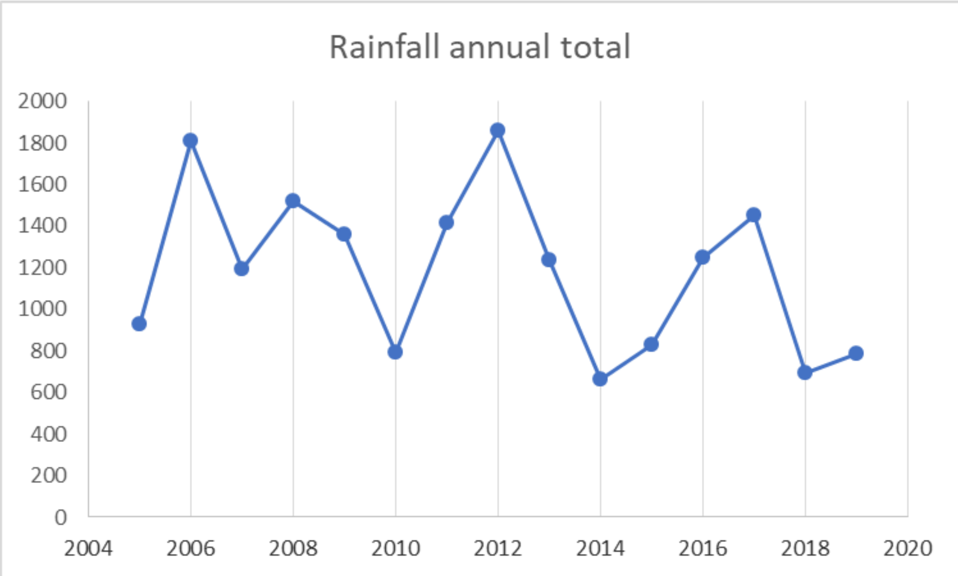

Fig 4.1 Annual rainfall deviations of uMziwabantu Local Municipality, Ugu District

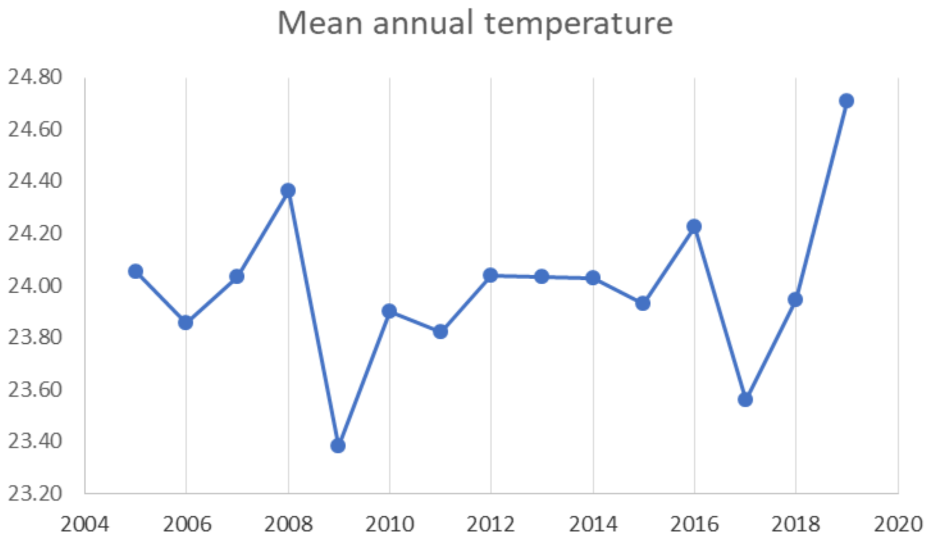

Figure 4.2: Annual mean maximum temperature of uMziwabantu Local Municipality

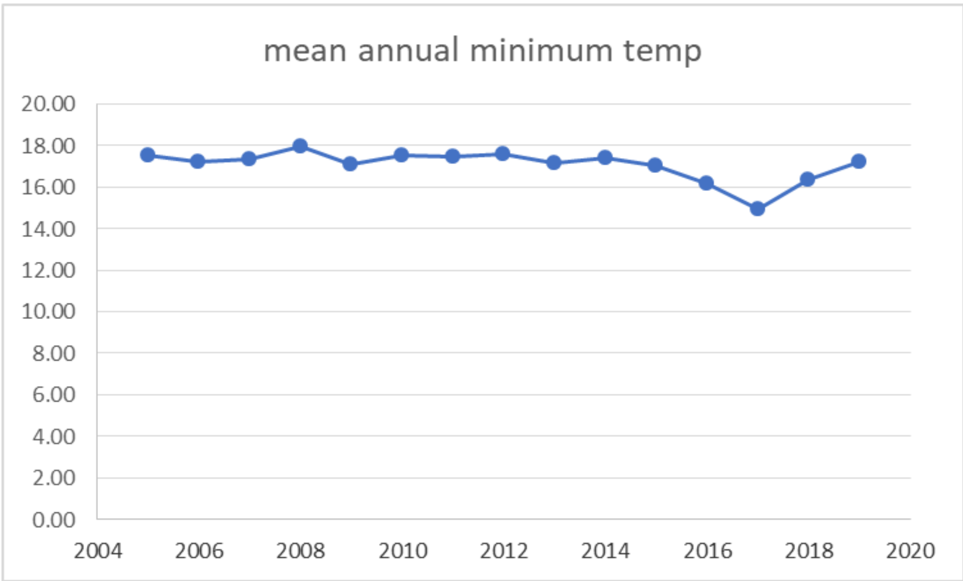

Fig 4.3: Annual mean minimum temperature for uMziwabantu Local Municipality, Ugu District.

4.3.2: Analysis of Rainfall Anomaly Index (RAI)

The distribution of rainfall was analysed by the Rainfall Anomaly Index (RAI). Those above zero show positive anomalies of the rainfall recorded for that particular year from 2005 to 2019 and those beneath zero have a negative amount of the rainfall. Four out of 15 years experienced below normal rainfall.

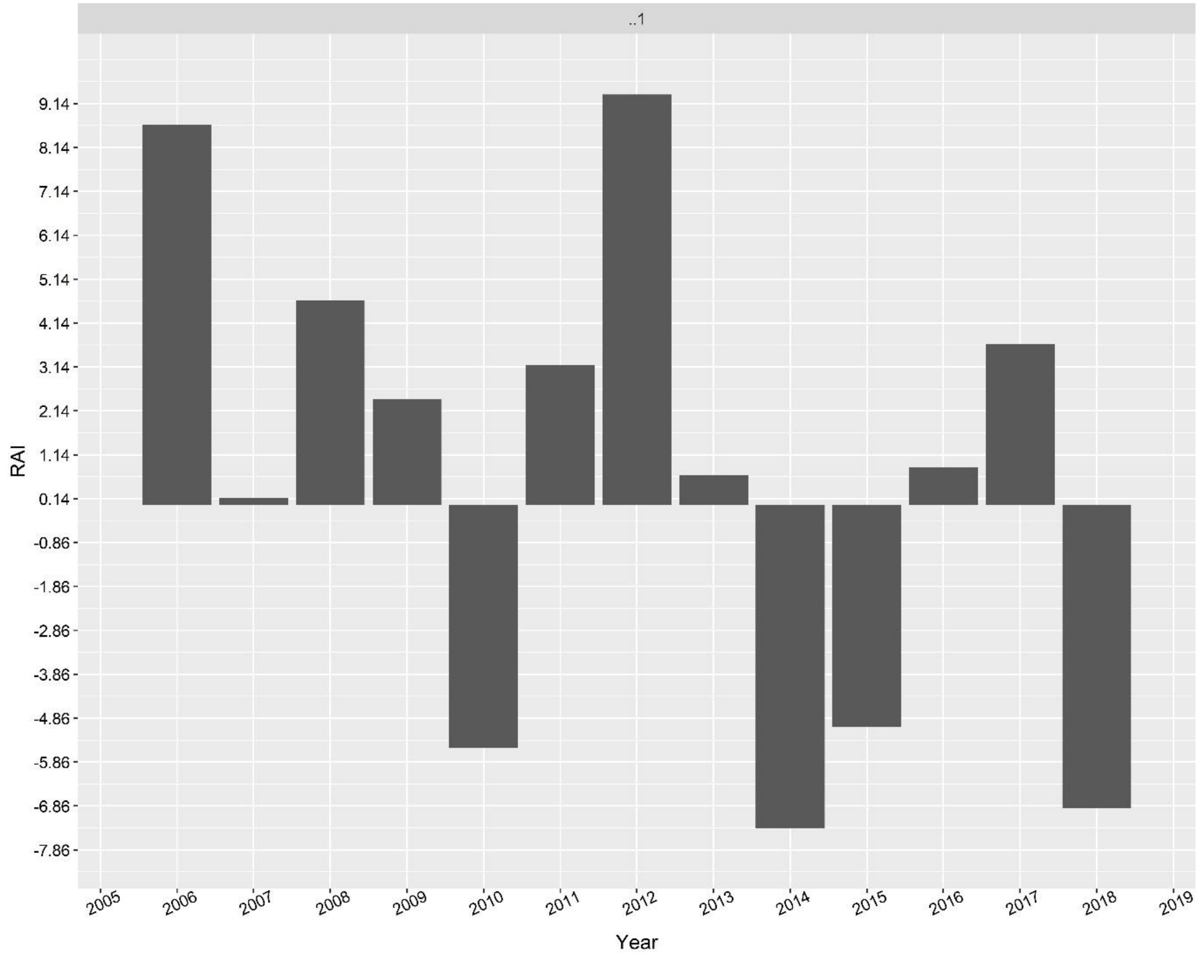

Fig 4.4: Rainfall anomaly index for UMziwabantu Local Municipality, KwaZulu Natal

4.3.3: Analysis of Temperature Anomaly Index (TAI)

Figure 4.5 shows the Temperature Anomaly Index (TAI) and there is noticeable positive variability throughout the study period (2005-2019) mostly above the red line which shows the 2 year moving average.

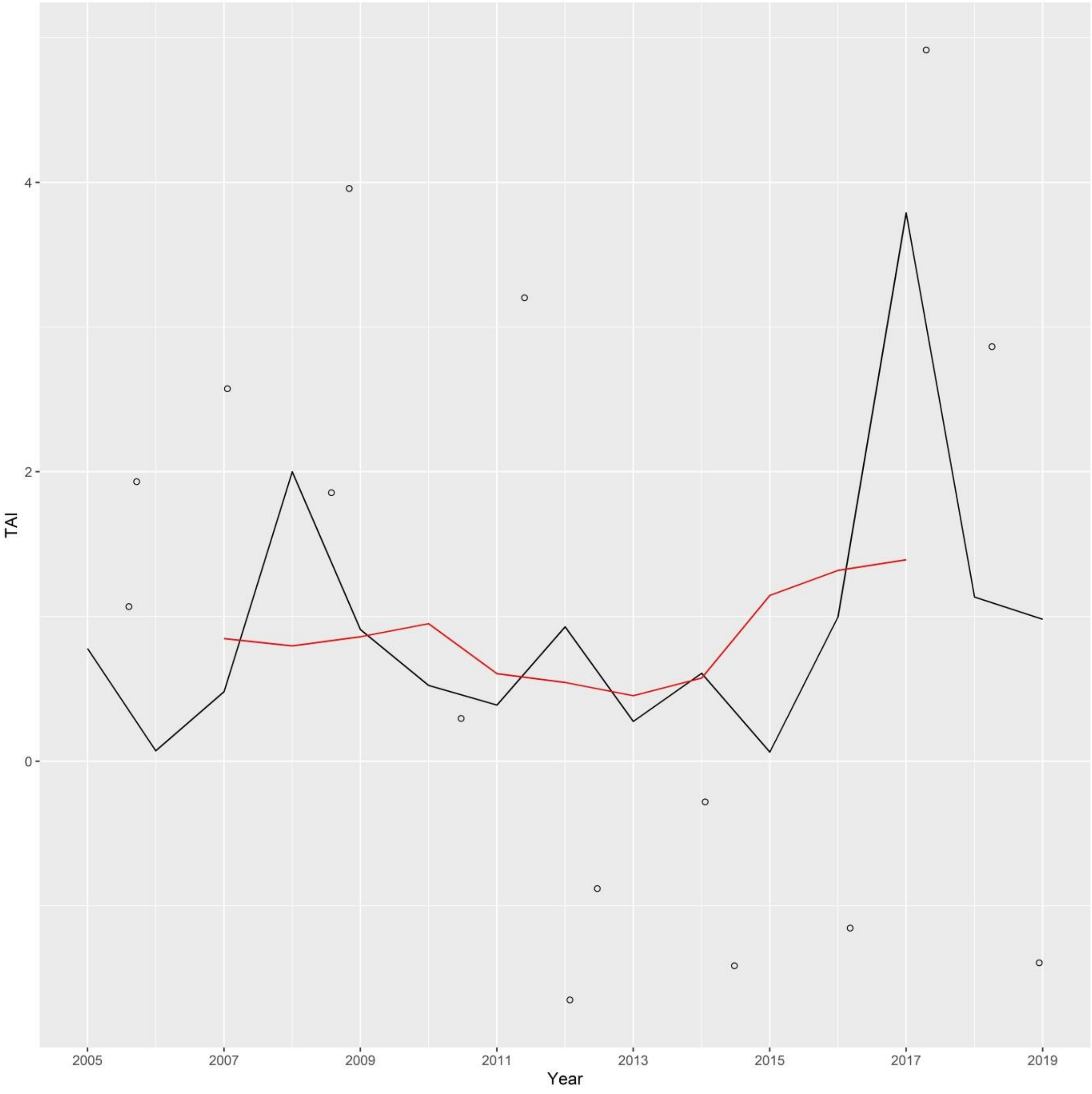

Fig 4.5 Temperature Anomaly index for uMziwabantu Local Municipality, Ugu District KwaZulu Natal.

4.3.4: Onset and cessation of rainfall

Early growing season as shown in Fig 4.6 is from October to December and it is indicated in red colour on the graph, whilst the late growing season is from January to March and is represented with the colour blue. Late growing season received below normal rainfall between 2009 -2011 as well as 2014 – 2016. The period 2014 to 2016 proved to be the shortest and most difficult farming season as there was also below normal rainfall in the early growing season. Generally, when the late growing season received normal rains, the early growing season would receive less rainfall, which practically could make it difficult for the smallholder farmers to thrive well in the farming seasons.

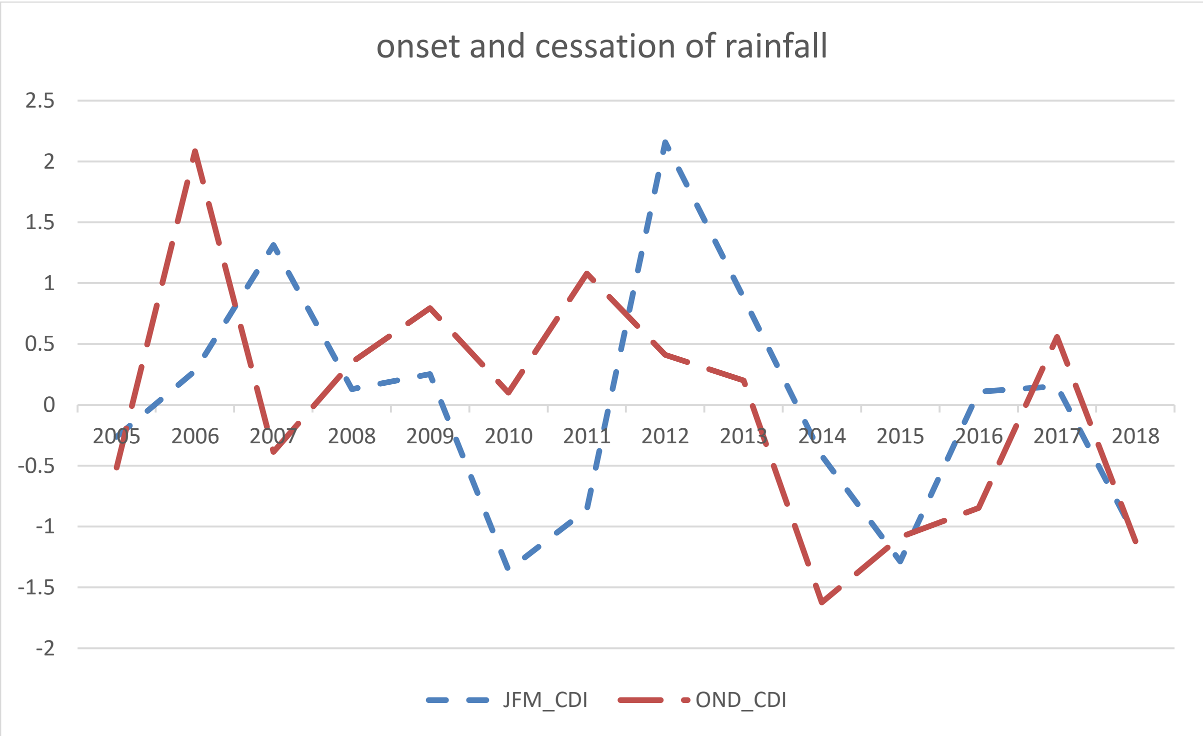

Fig 4.6: Onset and cessation of rainfall in uMziwabantu Local Municipality, KwaZulu Natal

4.4 Comparison of meteorological data and farmers' perception to climate variability

The study basically tried to compare smallholder farmers' perceptions and observations with historical meteorological trends in uMziwabantu, Ugu District, KwaZulu Natal. A total of 83% of smallholder farmers in uMziwabantu perceived an increase in temperature as shown in Fig 3.14, this corresponds with meteorological data looking at trends from 2005 to 2019 even though there are years like 2009 and 2017 where there was a sharp decrease in temperature.

In terms of rainfall, 50% of small holder farmers indicated that rainfall had increased coupled with floods and drought in some years. This is supported by the fluctuations shown in Fig 4.1 of rainfall trends, where the years 2006, 2011, 2012 received a lot of rains, and 2010, 2014 and 2018 were the dry years characterised with droughts. For both rainfall and temperature, the farmers' observations were consistent with the meteorological records. Hence smallholder farmers can accurately perceive climate variability as well as its impacts on their livelihood.

4.5: Discussion on meteorological data

4.5.1: Temperature variations

In general the study shows that temperatures have been increasing in uMziwabantu Local Municipality, this corresponds with other surveys done in South Africa by (Warburton et al 2005, New et al 2006 and Kusangaya et al, 2014) as they pointed out that 23 out of 26 weather stations assessed showed an upward trend in annual maximum temperature over the period 1961-2000. This analysis was both from observed temperature records and remote sensing.

This temperature increase has also been observed also in SSA where annual temperature has been rising with particularly higher degrees Celsius in Namibia and Angola (Kusangaya et al, 2014). This goes on to show that temperatures have been increasing in most parts of Africa although in some countries they have been experiencing high summer temperatures and very low winter temperatures.

4.5.2: Rainfall variations

In uMziwabantu, 50% of small holder farmers indicated that rainfall was increasing then 34% said that rainfall had decreased and the rest agreed that range had been altered, this gives a picture that most smallholder farmers were seeing an increase in rainfall amounts as they highlighted that there was occurrences of floods coupled with drought in uMziwabantu. This is showing an element of the two extremes depending with the year.

Kruger and Nxumalo (2017) suggested that generally in South Africa there is an increasing trend in annual precipitation totals over the southern side mostly higher than 5 mm per decade compared to other places. However, drier conditions are witnessed in the northern parts of the country especially in the Limpopo Province.

According to Mosase and Ahiablame (2018), Limpopo Province has water scarcity problems due to frequent extreme seasonality which could be attributed to El Nino-Southern Oscillation (ENSO) events and interaction with oceanic climates from both Atlantic and Indian Ocean that render rainfall unreliability in the basin.

Rainfall trends are mixed in Southern Africa on model data sets and that is why it is imperative to understand year to year and place to place changes in rainfall characteristics and also planting seasons so as to curb the adverse effects of climate change (Ambrosino et al, 2014). Rainfall in Zambia also showed an increasing trend except in the smaller section in the Northern Province which showed precipitation reduction, some parts of Southern Africa showed a total decline of -0.6 mm/day and even large inter annual variations for example Zimbabwe showed high inter-annual variability (Jury, 2012). In Malawi based on 42 weather stations, rainfall has been decreasing annually, seasonally and monthly at 5% significance level (Ngondondo et al, 2011).

Besides the ENSO phenomenon, ITCZ also determines rainfall variation in Southern Africa. According to Davies (2011), ITCZ is characterised by high radiation activity around the equator which results in high rainfall in several countries within the equatorial regions in summer when its position shifts into the Southern Hemisphere. He further noted that this condition is overpowered by the Botswana Upper High Influence (BUHI) which occurs from time to time and contributes to drought conditions in Botswana and Namibia.

4.5.3: Length of a growing season

In this study both meteorological data and smallholder farmer's perceptions confirmed that seasonal timing had changed. The ability to establish properly the beginning and the ending of the rainy season is of great importance as it determines the farmer's plan of action. In South Africa there is no agreement on the timing of seasons, even SAWS acknowledges that there is no official nomination and clarity of the rainy season as classification using precipitation patterns is complicated due to the high variability of rainfall routines (Van Der Walt and Pritchett, 2020).

Knowing onset and cessation of rainfall at any particular locality is important as it determines when to start planting and in the long run affects crop yields. In most cases farmers integrate indigenous knowledge systems and meteorological information to determine planting seasons.

4.6 Conclusion

UMziwabantu Local Municipality is characterised by inter-annual variations in terms of temperature and rainfall. Meteorological data showed that temperature was slightly increasing as well as rainfall even though there were fluctuations and variations in terms of droughts and flooding in some years. Generally the starting and the ending of rain seasons had changed due to climate change giving challenges to smallholder farmers in terms of adaptation.

Chapter 5: Conclusion, Recommendations and Future work

5.1 General Discussion

Small-scale farming is the back-bone of livelihood for a lot of people in uMziwabantu Local Municipality. However this kind of farming is highly susceptible to weather variations and long term changes, thus affecting livelihood and farming practices of small-scale farmers who rely on rainfall for water in KwaZulu-Natal.

Main focus of the study was to find out smallholder farmers' understanding of climate change and weather variability in relation to meteorological evidence from SAWS. Most farmers observed an increasing trend in temperature as well as rainfall. In the end it all concurred with meteorological data from SAWS, which showed that minimum and maximum temperature was increasing. Rainfall was also increasing as indicated that only four years out of the fifteen years of the study period experienced below normal rainfall. Also an alteration in the beginning and ending of the summer season was observed in uMziwabantu, therefore knowing exactly the length of the growing season was a yearly headache and it impacted the yields. In the end of the study we can safely accept the null hypothesis that stated that smallholder farmer's observation on climate change and weather variability conformed to the meteorological data observed from SAWS from 2005-2019.

Farmers in uMziwabantu used radio/television as their major source of climate and weather updates. However this is a one way form of communication as one cannot ask questions where they do not understand. Thus the farmers ended up incorporating indigenous knowledge systems through own observation and experience so as to make sense of the changes around them. However, own observation and experience have been distorted by climate change and weather irregularity which gives rise to the need for both IKS and scientific evidence to work hand in glove.

Climate change impacted on the livelihoods of smallholder farmers in uMziwabantu such that they had household coping strategies. These included portion size rationing, reduce number of meals and skipping meals among other things. Some of these strategies had lasting effects on their health and the general wellbeing of their families. It is important therefore to increase awareness on effects of weather changes so as to come up with sustainable household coping strategies.

5.2: Conclusion

Climate change is an unfortunate truth that has crippled sustainability and availability of food in smallholder farming hence the need to pop up with adaptive measures to deal with the effects. Key findings of this research included-:

- Smallholder farmers in uMziwabantu are knowledgeable of the changes clouding them regardless of gender and age.
- Their perception of this change in terms of rainfall and temperature variability matched meteorological evidence from SAWS.

In a nutshell, smallholder farmers' perceptions to climate change should be considered before coming up with any adaptive strategies , in fact they should be part of the decision making process pertaining to the improvement of their livelihood. Taking farmers perceptions into consideration could open up ways in which smallholder farming could be improved amidst this plight so in order to minimise the effects of climate change.

5.3: Recommendations and future work

The following recommendations were done:-

- There should be improved communication of weather updates for exact location, as seen that the weather station that was used was from Margate which is 82, 5 kilometres via N2 to uMziwabantu. The information should be timeous so as to facilitate decision making in terms of planting dates and management strategies.
- Due to modern technology advancement, besides radios there is need to consider mobile phones as an easier method to disseminate weather and climate information to smallholder farmers as most of them have access to them.
- Extension officers should bring forth practical guidance about farming. More so they should explain to farmers the meaning of the weather information they

receive from SAWS, integrating IKS at the same time allowing farmers to ask questions and further explanation where they do not understand.

- Government should improve smallholder farmers' livelihood by increasing their access to credit or helping aid in years when they are hit hard by the effects of weather and climate variability so as to improve their household coping strategies.

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