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# Public perceptions of climate change: A rural case study of Motupa community in Limpopo province, South Africa

Happy M. Tirivangasi \*, Shaun N. Makwala, Sejabaledi A. Rankoana

*Department of Sociology and Anthropology, University of Limpopo, Private Bag X1106, Sovenga 0727, South Africa*

## Abstract

This study examined the perceptions of the Motupa community in Limpopo Province, South Africa, regarding the economic impact of climate change on their livelihood patterns. The study used focus group discussions and semi-structured data collection methods to obtain the perceptions of 42 participants aged between 45 and 90 years. The findings indicate that climate change has had a significant impact on the rural environment, affecting water resources, subsistence agriculture, economic activities, farming, livestock, forest, and soil. The study population shows high levels of vulnerability to climate change due to low adaptive capacity, leading to poor production, crop and livestock failure, food insecurity, poverty, malnutrition, diseases, and viruses. The main causes of climate change identified by the community members are the increase in temperatures and unpredictable rainfall patterns. The economic activities of the community are also affected, resulting in livelihood vulnerability. This study highlights the urgent need for climate change adaptation measures to be developed for the Motupa community and other rural areas in South Africa.

**Keywords:** Climate change; Rural; Livelihood vulnerability, Public perceptions, Rural livelihoods, Southern Africa

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\* Corresponding author. *E-mail address:* [happy.tirivangasi@ul.ac.za](mailto:happy.tirivangasi@ul.ac.za)

## 1. Introduction

During the past century, human activities have released large amounts of carbon dioxide and other greenhouse gases into the atmosphere, which results in climate change (IPCC, 2012). Climate change may be due to natural internal processes or external forces such as modulations of the solar cycle, volcanic eruptions, persistent anthropogenic changes in the composition of the atmosphere or land use, and harmful human activities that affect weather conditions directly or indirectly (Sango and Godwell, 2015). Rankomise (2015), is of the view that climate change implies the long-term average of the individual weather conditions that communities experience every day. Climate change has become a complex concept to define or understand due to the rapid change in daily weather conditions in South Africa (IPCC, 2012). The IPCC (2012) reports that climate change is a key concern in Africa, where annual temperatures have increased by 1.5 times above the observed global average of 0.65 °C over the past five decades. These changes are ongoing because the 2013 South African Long Term Adaptation Scenarios and the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) proposed that climate change from 1986–2005 would not have the same effect as the changes of 2018–2100 (Kahsay and Hansena, 2016).

In South Africa, Seager (2008) and Nyahunda and Tirivangasi (2022) observe that climate change is one of the major challenges confronting the South African people and their government. Ziervogel et al. (2014) add that South Africa faces major changes in its climate. However, the annual average temperatures have increased in the past three years, and extreme rainfall events have increased in frequency, which may cause both positive and negative effects of climate change. Limpopo Province was worst affected by drought in the past years, when dams were only 50% full, compared with 84% in the late nineties (Schulze, 2010; Tirivangasi et al., 2021). The members of local communities are also aware of these changing climatic conditions and their threats to human livelihood patterns (Rankoana, 2016). The perceptions of climate change by the members of rural communities are based on observations of variations in rapid changes in temperature and rainfall patterns (Gandure et al., 2011).

Scientists studying climate variation have diverted their attention to the understanding of climate change by community members because they realized that the impacts of climate change are mostly felt by local communities as their livelihoods are climate sensitive. Perception involves a process of identification, organization, and interpretation. In light of this, this study aims to explore the perceptions of Motupa community members in South Africa on climate change and its economic impact on their livelihood patterns. The study described the perceptions of Motupa community members about climate change and further examined the impact of climate change on subsistence economies.

## 2. Literature review

### 2.1. The conceptualization climate change

Climate change can be understood in simple terms as variations in global climate which fall outside of its regular patterns (Hulme, 2017). These variations include changes in rainfall, wind, and ocean wave patterns, as well as rises in mean global temperature and mean sea level (Nobre, 2008). Despite the development of a scientific consensus regarding the role of mankind in climate change, non-scientific media outlets have

repeatedly denied or diminished the importance of this phenomenon (Oreskes, 2004; Cook et al., 2013). Vieira and Bazzo (2007) highlighted how sensationalist accounts of catastrophic future scenarios in the media have influenced public perception of the issue. Moreover, Somerville and Hassol (2011), observed a positive correlation between the increase in the strength of evidence for anthropogenic climate change and the increase in the number of people among the general public that reject these scientific findings, especially in the USA. In spite of this, climate change is a global and complex issue where different scholars explain it in various ways and in terms of their experiences. According to the IPCC (2012), stated that during the past century, human activities have released large amounts of carbon dioxide and other greenhouse gases into the atmosphere which results in climate change. Sango and Godwell (2014) expressed that climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, persistent anthropogenic changes in the composition of the atmosphere or in land use, and activities that human engage in daily being harmful to weather conditions either directly or indirectly. In addition, Sango and Godwell (2015) argue that internal and external forces such as air pollution caused by industries and gas emissions from cars can cause climate change.

Rankomise (2015) is of the view that climate change implies the long-term average of the individual weather conditions that communities experience every day. Climate change has become a complex concept to define or understand due to the rapid change in daily weather conditions in South Africa. The impact of climate change and life-threatening weather events has undermined improvement in poverty alleviation and food insecurity globally, nationally, provincially, and locally (Intergovernmental Panel on Climate Change (IPCC), 2012).

Sociologist observed that in order to understand and respond to climate change there is a need to develop two kinds of imagination: to see the relationships between human actions and their impacts on earth's biophysical system (ecological imagination) and to see the relationships within society that make up this environmentally damaging social structure (sociological imagination) (Norgaard, 2018). Furthermore, the application of both sociological and ecological imagination allows the understanding of four key problems on unpredictable climate change. Firstly, will understand the question why climate change is happening, secondly, how we are being impacted, thirdly, why we have failed to successfully respond so far, and lastly, how we might be able to effectively do so (Norgaard, 2018; Nyahunda and Tirivangasi, 2021). These will be able to make the rural communities to engage in developing the policies and coping strategies on climate change as Krantz (2001) at sustainable livelihood approach (SLA) theory that people that are facing the problem are supposed to be the one to come with the prevention strategies to achieve the positive response towards the problem.

## 2.2. Climate change in South Africa

Climate change research in South Africa is no longer seen purely as an environmental problem, but also as a growing problem (Madzwamuse, 2010). Most rural communities in South Africa rely on subsistence economic activities to enhance their livelihood sustainability. To understand climate change as an evolving problem, many studies have showed evidence about the impacts of increasing temperatures, increased flooding, changes in rainy seasons and changes in winds on many aspects of broader economic development, such as water availability, food security, housing and infrastructure (Ziervogel et al., 2014). It is observed that changing weather conditions will further impact rural community livelihood patterns because temperature is ever changing.

Observed rates and modelled projections indicate that warming over southern Africa is happening at twice the global rate (Department of Environmental Affairs, Republic of South Africa, 2017). Unless concerted international action is taken to reduce greenhouse gas emissions, temperatures may rise more than 4°C over the southern African interior by 2100, with increases of more than 6°C over large the western, central and northern parts of the country, which have faced several years of droughts (Kapwata et al., 2018). Relative to a 1981–2000 base period, the probability of summer heat waves over South Africa has increased by over 3.5-fold (Lyon, 2009). Impacts of heat waves differ from the more insidious, but no less harmful, rises in heat that increasingly cause heat-related symptoms during Summer, but also in Spring and Autumn in some parts of the country (Kapwata et al., 2018). As temperatures rise, the levels of risk from occupational heat may increase from 'low risk' to 'moderate or high risk', especially in the mining, agriculture and outdoor service sectors (Kjellstrom et al., 2014). A seminal study in the mid-20th century of > 200,000 underground miners in South Africa reported a mortality rate of 3.3 deaths/year/1000 miners if the temperature exceeded 34 °C, compared to 0.7 deaths/year/1000 miners when temperatures were between 31 and 33 °C (Wyndham, 1965). Outdoor workers in Upington, one of the hottest parts of the country, frequently experience heat-related effects, including sunburn, sleeplessness, exhaustion and reduced productivity (Mathee et al., 2010). At the time of the study, few, if any, measures had been taken to reduce these effects.

Hummel (2015) and the IPCC (2012) argued that it is important for human communities to determine their survival through indigenous knowledge that they have experienced during the change of seasons in their economic activities and practices such as crop production, livestock and other traditional plants. Climate change as a factor of life is particularly a threat to low income rural communities whose livelihoods heavily depend on rain-fed subsistence agriculture like the Balobedu community. Furthermore, South Africa has high levels of poverty and inequality, which hinder the development of the country 's economy at provincial levels (Hummel, 2015). The unpredictable rainfall and increase in temperature results in low production which affects the livelihood of community members. Most rural communities still characterized by trade exchange in order to improve their economic activities and maintain their social capital.

Rankoana (2016), emphasises that most rural areas depend on agricultural farming, which almost entirely count on rainfall for their production. Communities acknowledge that rainfall amounts decreased over the past years, and the overall temperatures have also increased. Madzwamuse (2010) supports the statement above by emphasising that the meteorological data claimed that such changes have reduced agricultural productivity, particularly by prolonged drought, inadequate and uneven distribution of rainfall, as well as unpredictable onset and ending of rains. Schulze (2010), explains that stressors such as crop diseases and pests, low soil fertility and inadequate extension services were reported to contribute to the decline in agricultural productivity and re-occurrence of food insecurity. Moreover, the IPCC (2012) adds that some African countries have already faced semi-arid conditions that make agricultural production challenging. Consequently, climate change has reduced the length of growing seasons as well as force large areas of marginal agricultural potential out of production (Roncoli, et al., 2002). For example, food production assessment indicates that domestic food production has already declined by 10% in several Sub-Saharan countries. Furthermore, Schulze (2010) argues that Statistics South Africa (2009) projected that a decrease in crops in some countries will be as much as 50% by 2020, with small-scale farmers being the most affected. Therefore, the ecosystems, land use and livelihoods of local communities are among aspects influenced by climate change and variability (Schulze, 2010). Ncube et al. (2016) argue that in South Africa, millions of people living in rural areas are amongst the

poorest and the most vulnerable with have low capacity for resilience to cope with disaster risks. Most developing countries are increasingly vulnerable to disasters.

Food and Agriculture Organisation (FAO) (2007), details that the current interventions recognise different types of impact of climate change disasters on people's livelihoods, especially in rural households. To identify households and livelihoods that are vulnerable to climate change has become a key input for targeting, monitoring, and evaluating adaptation policies (Rose, 2015). According to Ncube et al. (2016), climate change is a global externality that negatively affects households, communities and the broader economy. Furthermore, the potential of climate change to destabilise economies and public finances is real and can no longer be ignored. In addition, Bewket (2012) states that climate change is associated with many of the natural disasters in South Africa and can lead to widespread of food and water insecurity. Furthermore, the dependence of climate sensitive economic sectors such as agriculture makes South Africa vulnerable to climate change. The Financial and Fiscal Commission (FFC) (2012) posits that the effect of climate change on agricultural output will directly affect rural communities through less income and reduced employment. This will have effect on both the rural economies and food security in most rural areas. Moreover, rural households are more vulnerable because they lack knowledge about the means of adaptation to climate change. FFC (2012) further indicates that financial and physical resources are limited, and these scarce resources are targeted in the most vulnerability communities. In South Africa, a number of studies have analysed vulnerability at the household level but have scarcely examined the dimensions of vulnerability within these households (Ncube et al., 2016).

### 2.3. Climate change in Limpopo Province

According to Dube and Phiri (2013), Limpopo Province is one of South Africa's richest agricultural areas, whose major produce is vegetables and fruits. The subtropical climate enjoyed by much of the province gives rise to the cultivation of vegetables, tea, coffee and fruits, especially tropical fruits. Agricultural farming makes a major contribution to the economy because it is used to produce wheat, millet, maize, and groundnuts (Maponya and Mpandeli, 2013; Nyahunda and Tirivangasi. 2022). Livestock farming includes goats, pigs, chickens, cattle ranching and game with abundance of orchards with various sub-tropical fruits and nuts forming the basis of a thriving agro-industrial sector, which contributes to the growth of the economy in Limpopo Province (Maponya and Mpandeli, 2012). Statistics South Africa (2009) estimates that 3 million farmers in South Africa practise subsistence agriculture primarily to meet their family sustainability and improve rural poverty. Furthermore, the current unpredictable climate condition in Limpopo Province could phase worse results on their economic activities. Ncube et al. (2016) supports Statistics South Africa (2009) by stating that due to low income, lower technological and capital stocks, households are predicted to have limited options to adapt to changing weather patterns like drought. Drought is a serious problem in the province considering that it is in a semi-arid area with low, unreliable rainfall.

Roncoli et al. (2002), further hold that the impact of lower rainfall has negatively affected the agricultural sector, resulting in decreases in agricultural activities, loss of livestock, shortage of drinking water, low yields and shortage of seeds for subsequent cultivation. Schulze (2010) adds that the challenges of draught which the province is facing from time to time leads to reduced grazing, and reduced water for livestock and irrigation, which negatively affect the agricultural sector. Limpopo Province was worst affected by drought in the past years where dams were only 50% full, compared with 84% in the late nineties (Schulze, 2010).

Getu (2015), states that the agricultural sector has been seen as an important source of livelihood for Limpopo Province rural areas. Due to extreme weather changes such as drought, it will be difficult for rural communities to adapt to current change. In addition, Maponya and Mpandeli (2012) attest that it is distressing because in some parts of communities, farmers have already been forced to sell their livestock as a result of drought conditions. Moreover, Kumsa and Jones (2010) show that this will turn to serious challenge for agriculture and will result in insufficient or shortage of food (food scarcity), not only in Limpopo Province, but also in South Africa as a whole. This will be caused by the geographical locality of Limpopo Province situated at the northern part of South Africa, which is characterised by many fields that are vulnerable to climate change (Getu, 2015).

Tshiala and Olwoch (2010) argue that climate is a primary element of agricultural productivity, and as such, influences the types of vegetation that can grow in a given location. Tshiala and Olwoch (2010) cited Maponya and Mpandeli (2012) stating that the tropical regions in the developing sphere are particularly vulnerable to potential damage from environmental changes. This will be because large areas of these regions are covered by poor soils, which have already made much of the land unusable for agriculture. Small-scale farmers, who are predominant in the province, have little capital and will not be able to pursue new strategies that will be required to adapt to the change in climate (Tshiala and Olwoch, 2010). Limpopo is one of the developing provinces in South Africa and is predominantly vulnerable to the impact of climate change, partly because of its exposure to extreme weather events and sensitive economies (Kahsay and Hansena, 2016). According to Mokhem and Janse van Vuuren (2015), Limpopo has a high number of rural dwellers who are dependent on natural resources. Communities in Limpopo region may have a greater ability to adapt to long-term changes in climate such as increased seasonal temperature and altered patterns of precipitation.

Limpopo Province is characterised by deep rural areas where subsistence agriculture is a major economic activity for survival. Furthermore, the community smallholder farmers rely on rainfall for cultivation in order to increase production to enable them to trade their goods (Bruckner, 2012). Limpopo Province is also the breadbasket and agricultural engine of South Africa (Sango, 2013). The data represented above illustrate that Limpopo is one of the provinces in South Africa that has a bigger role to play in the economy. Although climate changes affect the agricultural activity as is the primary activity amongst the communities and surrounding farmers, many farmers use their indigenous knowledge to adapt to climate change (Mapaure, et al., 2011). Most farmers rely on cultural indigenous knowledge on ploughing, putting manure, irrigation and preserve seeds for the next season to adapt to current climate change.

The Financial and Fiscal Commission (FFC) (2012; 2013) estimates that 33% of households in Limpopo Province are considered agricultural households. Moreover, Limpopo Province covers 16% homes of South Africa's agricultural households. Despite the above statement, the agriculture sector contributed 3% to the province's annual average Gross Domestic Product (GDP) in 2012 (FFC, 2012; 2013). It is noted that in the Limpopo Green Economy Plan, agriculture is a key sector for the province's subsistence economy because it is a source of food security, is a creator of employment, sustainability and trade exchange, and contributor of exports to other provinces (FFC, 2012; 2013). Mokhem and Janse van Vuuren (2015) argue that the recent rapid changes in weather condition in Limpopo Province poses a threat to smallholder farmers and households' livelihood. Many families depend on subsistence agriculture and animal production for socioeconomic activities and for survival. Dube and Phiri (2013) attest that some smallholder farmers are able to create employment, due to lack of rainfall and high rate of drought, they are forced to reduce people from work and

will not employ again. The rapid change of weather condition in South Africa accelerates food prices due to the high inflation rate. This puts more threat to the government as well.

Tshiala and Olwoch (2010) stated that the South African agricultural sector is traditionally a large employer in the economy. However, the contribution of agriculture to total employment has declined from 30% in 1971 to 13% of the economically active population in South Africa in 2000. Tshiala and Olwoch (2010) further cited the Department of Environmental Affairs Notice of 2010 (2010) that commercial farms provide estimated six million households with employment and their educational needs for the development of rural communities. There are also 240,000 small farmers who provide livelihood to more than one million of their family members and occasional employment to another 500,000 people (Tshiala and Olwoch, 2010). Blignaut et al. (2009) indicate that the ongoing changes in climatic conditions have an adverse effect on agricultural production in Limpopo Province. The impact of climate change felt predominantly by farmers through changes in the timing, frequency and intensity of rainfall events, drought and irregular rainfall is a result of these changes in climatic conditions. Subsistence agriculture is the mainstay of rural economies in Limpopo Province. The importance of agriculture cannot be overemphasised from a food security perspective (Blignaut et al., 2009).

The historical changes in rainfall and temperature changes in South Africa and Limpopo Province agricultural production constrain the livelihoods of people and government to cope with strategies of adapting to climate change (Kumsa and Jones, 2010). Mokhem and Janse van Vuuren (2015) further argue that South Africa was forced to import maize as a result of drought that destroyed crops and infertile soil in most farmers' land. Furthermore, FAO (2003) shows that drought has damaged crops in different provinces, which comprised 64% of output in 2014. The local price of white maize has risen by 27% in Johannesburg this year, and that of yellow maize, used mainly as animal feed, by 13% as the Crop Estimates Committee predicts the smallest harvest since 2007 (FAO, 2003).

#### 2.4. Climate change as perceived by local communities

Perceptions of climate change and its threats to rural communities are among the major challenges faced by scholars, analysts and scientists on research in South Africa. The perceptions of climate change by rural communities are centred on observations of variations in rapid changes in temperature and rainfall patterns (Rankoana, 2016). Gandure et al. (2011) attested that communities are aware of the rapid climatic change condition and its impacts on people's livelihood. However, it is reported that rural communities' experiences sever challenges of scarcity of rainfall, which affects their subsistence economic activities within the community (Gandure et al., 2011). Gandure et al. (2011), observed changes in rainfall and temperature patterns are supported by explanations of a drastic increase in temperatures, with negative impacts on the livelihood patterns of rural communities. This type of understanding of climate change is crucial in planning adaptation and mitigation measures to address the effects of increased temperature and scarce rainfall for sustainable livelihood (Nath and Bhagirath, 2011).

Mapaure et al. (2011) attest that about 60% of people in developing countries living in rural areas depend on subsistence crop production, which is recently characterised by low productivity and instability as a result of marginal and erratic rainfall, low soil and ambient temperature below the minimum temperature of 10 °C. For this reason, subsistence farmers are vulnerable to the impacts of climate change, increased temperature and drought, which are among recent prevalent stressors that rural communities have to cope with (Dube and Phiri, 2013). It is becoming clear that the realisation of development goals would be seriously hampered by a

decrease of suitable areas for maize, cotton, and sorghum suitable by 2080 (IPCC, 2013). Drought and global warming are also expected to exacerbate declining agricultural outputs, further compromising economic growth and stability, employment levels, food security, demand for other goods and poverty reduction (Maponya and Mpandeli, 2013; Nath and Bhagirath, 2011). Foremost climate hazards, excessive heat, diseases, depletion of biodiversity and water scarcity threaten the livelihoods of communities that depend on subsistence crop production. Furthermore, there is a remarkable ecological variability as a result of persistent drought which results in decreased water resources and production (IPCC, 2013), threatening the livelihoods of rural communities.

### 3. Methods

#### 3.1. Study location

The study is based on fieldwork conducted between July 2017 and December 2017 among the Balobedu tribe of Motupa community under Greater Tzaneen Municipality in Mopani District of Limpopo Province, South Africa. Motupa community is located in Greater Tzaneen Municipality, which has a total area of 5.46 km<sup>2</sup> with a population of about 6954 (1274.05 per km<sup>2</sup>). Greater Tzaneen Municipality is located south of Modjadjiskloof and south of Trichardtsdal (47km). The municipal boundaries form an irregular, inverted T-Shape, which results in certain developmental implications for the Municipality, and more specifically, the distance to markets creates difficulties in respect of service provision, and constraints to implementing development vision or strategy. The municipality comprises 425 rural villages, concentrated mainly in the south-east, and north-west, of the study area. Almost 80% of households reside in these rural villages and are characterised by extensive and intensive farming activities (commercial timber, cash crops, tropical and citrus fruit production). Motupa community is a mountainous, inaccessible terrain in the west and south, and un-even topography (gentle slopes) to the north and east. The area is an exceptional natural beauty, with considerable untapped tourism potential. In addition, a large area of land is in private ownership, ranging from smallholdings to extensive farms, used mainly for commercial farming activities. Equally, a large area of land is in the ownership of the state, and under the custodianship of six traditional authorities.

Motupa is situated between 29° C 52'E to 31° C 52'E longitude and 23° C 0'S to 24° C 38'S latitude, with 31° C E as the central meridian (Statistics South Africa, 2011). Motupa area lies in a semi-arid climate type with an annual average rainfall of approximately 403 mm. It has a daily average temperature of between 18° C, 17.7° C and 8.1° C, 9° C (Statistics South Africa, 2011). Summer rainfalls occur between October and April, followed by a dry winter season. Motupa community is inhabited by Balobedu ba Ga-Modjadji, 89% of which mostly speak Khelobedu dialect of Sepedi language. The area is characterised by lowland and mountains, while environmental challenges are inadequate sanitation systems, erratic rainfall, drought and lack of water supply and the community is negatively affected by the current experienced drought (Rankoana, 2016; Rankomise, 2015). The temperature at the area rises unpredictably daily and affects the pattern of rainfall seasons.

The households are distributed in the area between Kubjana and Mopje along Relela village main road. The community falls within the summer rainfall region of Limpopo Province. Motupa community households comprises 1644 (301.20 per km<sup>2</sup>) with a total gender of 3713 females and 3241 males. This illustrates that females outnumber males as they comprise 53.39% of the population. It is noted that the Community Survey



2016 concluded that the population stands at 6950. The slow growth may be attributed to various factors such as migration, birth and death rates (Greater Tzaneen Municipality Integrated Development Plan [IDP], 2018). The Statistic South Africa Census 2011 demonstrated that most males of Motupa community households are heads of families rather than women. Fewer households are headed by orphans (10-15 years) and older people (90-112 years). Most community members practise subsistence agriculture where they cultivate at their home-gardens, fields and farms.

### 3.2. Study design

The researchers adopted a qualitative research design for this study designed to understand the perceptions of climate change by the members of a rural community in Limpopo Province, South Africa.

### 3.3. Participants

Population was made up of all indigenous inhabitants of Motupa community study. Purposive sampling method was used to selected community members above 50 years, and on the basis of their period of residence in the community. The 50 and above age group usually consist of household heads and people who are more aware of the Motupa community. The researchers noted that most of the participants had lived most of their lives in the area. Further, the researcher excluded people who had migrated to the area after South Africa had attained democratic rule, because they are recent settlers. This type of sampling technique provided in-depth information about the community perceptions on climate change. However, equal gender representation was ensured by having 21 males and 21 females.

### 3.4. Data collection

Semi-structured interviews were conducted to collect data. The interview questions were open-ended, and validity of the questions was ensured by developing questions that captured information about the participants' perceptions on climate change. Face-to-face interviews were conducted for about 2 hours per interview. Field notes were recorded manually and later transcribed to allow data analysis process.

### 3.5. Data analysis

Thematic content analysis was used to analyse the data. The method was used to identify, analyse and report patterns within data. Analysis of data started with familiarisation with the responses and implications from the participants' point of view. This process enabled coding, where the data were scored by counting the number of times a particular theme was expressed. Coding was followed by the development of themes and sub-themes. Lastly the researcher contextualised and interpreted the data to determine how far the research problem was addressed. The last step was report writing and follow up meeting with the groups to share and verify the study findings to ensure that the findings represent the participants' views. Data were organized into different themes and sub-themes derived from the responses about the perceptions of climate change.

## 4. Results and discussion

The results of the study indicated that the respondents reported remarkable environmental changes on the increase of temperatures in the community. 80% of the respondents acknowledged that rapid environmental change has been caused by current climate change. The community members argued that the increase in temperature patterns coupled with unpredictable rainfall, which is responsible for prolonged drought and excessive heat, threatens their livelihood pattern. Eighty-five percent of participants reported:

*“The years between 2005 and 2015 were marked by drought, where we did not even cultivate subsistence crops because there was no rainfall”. (Participant 19, Age:72, Male).*

This means that during the years 2005 through to 2015, the community's socio-economic activities declined drastically because the community experienced less rainfall. The respondents observed that drought affected the community livelihood. The results of the study found that Thapane dam is the main water supplier for the community, subsistence farmers and the surrounding communities. The water is commonly used for household consumption and for watering gardens. The respondents stated that the current water status of Thapane dam is unstable due to climate change. Thapane community dam is the largest dam that supplies more than 14 surrounding villages in Bolobedu South. These results are consistent with a study conducted by Rankoana (2018) which reviewed that most rural people in Limpopo had noticed changing patterns in temperature variations since 1993, and 91% identified temperature variations as a major indication of changing weather patterns. The long-term change in temperatures are responsible for excessively hot and dry summers in the province.

The respondents explained that through current drought experienced lately, the water decreased in high volume due to lack of rainfall. They indicated that they are suffering because of unpredictable climate condition, and it is hard to adapt to this change, especially in rural areas. The results of the study showed that because of the current decrease in water level at the community dam, few households have drilled boreholes in their homes. Although they have drilled the boreholes for their household purposes, they also sell the water to other community members at R1 for 20 litres and R2 for 25 Litres or water. This is a threat to households, especially those who are vulnerable and live in abject poverty in the community. Majority of respondents indicated their livelihood is threatened and vulnerable for survival with the current rapid climate change.

The majority of the participants acknowledged that they buy water to do all house chores because the dam and rivers are dry due to unpredictable rainfall. One of the respondents stated that:

*“I do not afford to buy water; therefore, I rely on Municipality Water Trucks that bring water once a week which after three days it starts to have moved things. We are lacking water at Ga-Motupa. Some ages ago we used to fetch water from the dam and some of us used to dig wells. However, by the time we reach October seasonally, the wells will be dry forcing us to rely on municipality water which is unreliable... may be that is what you call the effects of climate change... The timing of rainfall in recent years has occurred between late November and January rather than September and December. And far worse the amounts of rainfall we are receiving is less” (Participant 07, Age:84, Female).*

The community 's livelihood is threatened by unclean water that delivered by municipality truck because after three days they are not healthy to drink. In addition, it is the responsibility of both the community and the municipality to ensure that the health of community members is safe. 90% of the respondents explained that they understand the erratic changing weather condition which is beyond their control. The study observation shows that the impact of climate change affects community subsistence farming and households' social economic activities. The respondents designated that although it is hard to cope with the current changing climate condition, they are trying to use indigenous knowledge to adapt to current climate change. Fewer respondents, specifically those who own farms, indicated that they are mostly using their indigenous knowledge to measure the amount of rainfall per month and year. They confirmed that they are using the sky to predict weather changes using indigenous knowledge that they have learned from each other. Twenty-two participants stated that:

*“The change in weather condition causes disease on our plants, as our vegetables will have small worms and not growing well... due to insufficiencies in water levels in the soil our plants becoming more susceptible to diseases and pests” (Participant 13, Age: 65, Female).*

These indicators are the results of increases in temperature and unpredictable rainfall which influence shifts in seasons. Subsistence farmers observed that due to increases in temperature, they have experienced dry seasons which brought different viruses and diseases to their crops. Furthermore, they observed that they are experiencing high crop wastage due to increases in high temperatures. These indicators threaten the effectiveness of the livelihood and economic activities of Motupa community members. One participant had this to say:

*“The issue of water is stress because the government refuse with water dam. They say their law does not allow borehole to be drilled inside the dam. Therefore, I bought machine to pump water straight from the dam and government said we are stealing they will fine us, but what will we do? That is some of the challenges we are currently facing” (Participant 28, Age: 65, Female).*

The results of the study illustrated that most community members practising subsistence agriculture, and who are cultivating in their home gardens use water from the community dam to irrigate their vegetables. This indicates that the decline in water levels in the community dam threatens the livelihood pattern of the community and their subsistence economy.

The study results are derived from a sample of 42 participants from Motupa community in Limpopo Province, South Africa. The community is one of the rural areas in the Eastern part of the province, which still depend on rain-fed resources such as subsistence crop and livestock farming. The community participants acknowledged and observed changing weather condition. The study observed that rainfall has become scarce, and temperatures increased to become hotter in summer and warm in winter. The perceptions of climate change by rural communities are largely based on variations in temperature and rainfall patterns (Jianchu et al., 2007). Local communities perceive climate change in the form of decreased snowfall, temperature rise and late onset of monsoon.

The observed change in rainfall and temperature patterns is supported by annotations of drastic increase in temperatures with negative impacts on the livelihood patterns of rural communities (Chikosi et al, 2018).

Mugambiwa (2018) supports these observations by showing that climate change and its negative impacts are mostly felt by poor and rural communities whose livelihoods are dependent upon favourable climatic conditions. The perceptions of climate change and its threats to rural communities are among the major challenges faced by the members of local communities in South Africa (Dube and Phiri, 2013). The IPCC (2014) members of rural communities are aware of changing climatic conditions and the resulting impact of increased temperature and drought, which are among recent prevalent stressors that rural communities have to cope with.

Rankomise (2015) observes that there is a remarkable ecological variability as a result of persistent drought which results in decreased water resources and production (IPCC, 2013), threatening the livelihoods of rural communities. Gandure et al. (2011), observed changes in rainfall and temperature patterns are supported by explanations of a drastic increase in temperatures, with negative impacts on the livelihood patterns of rural communities. This type of understanding of climate change is crucial in planning adaptation and mitigation measures to address the effects of increased temperature and scarce rainfall for sustainable livelihood (Nath and Bhagirath, 2011). However, it is reported that rural communities' experiences severe challenges of scarcity of rainfall, which affects their subsistence economic activities within the community (Gandure et al., 2011). Analyses of change in climatic conditions in South Africa show that, the country's average temperature is likely to increase by 1-3°C, with the interior experiencing the greatest increase (Kruger and Sekele, 2013), while the temperature analysis for Limpopo Province provides a noticeable increase of 0.12°C per decade in the mean annual temperature for the 30 catchments, over the 50-year period.

The researchers have validated the community's perception of rainfall and temperature variation by analyzing the existing literature. Warming trends over the eastern and southern parts of Limpopo Province, as reported by SAWS (2015), and supported by the work of Kruger and Shongwe (2004), DEA (2011), and DST (2010), validate the participants' perceptions of rising temperatures as a sign of changing weather patterns. Tshiala (2011), Kruger and Sekele (2013), and Rankoana (2018) found that seasonal temperature trends for Limpopo Province over the past 50 years have been inconsistent. The researchers have validated the community's perception of rainfall and temperature variation by analyzing the existing literature. Warming trends over the eastern and southern parts of Limpopo Province, as reported by SAWS (2015), and supported by the work of Kruger and Shongwe (2004), DEA (2011), and DST (2010), validate the participants' perceptions of rising temperatures as a sign of changing weather patterns. Tshiala (2011), Kruger and Sekele (2013), and Rankoana (2018) found that seasonal temperature trends for Limpopo Province over the past 50 years have been inconsistent.

## 5. Conclusion

This article analyses the perceptions of climate change among the indigenous population of Limpopo Province, South Africa. The results reveal that local residents perceive a changing climate as a result of erratic precipitation and rising temperatures. The correlation between these observations and the meteorological temperature and precipitation statistics for the province of Limpopo, which indicate decreasing precipitation and rising temperatures, is strong. According to the scientific literature, temperatures will continue to rise over the next two decades. This study provides evidence to support the claim that decreased precipitation and rising temperatures are responsible for the deterioration of the indigenous community's subsistence food

production and the depletion of water resources, as well as posing serious threats to biodiversity and human health. Together, the unpredictability of precipitation and the effects of rising temperatures intensify pre-existing difficulties in delivering basic services and sustaining livelihoods. These factors also increase communities' susceptibility to extreme weather disasters such as droughts and floods. Considering this, the researchers propose the establishment of community disaster and resilience committees, which will aid in educating communities about climate change and implementing new adaptation techniques. A rural community's perceptions of climate change contribute to the need to assess its understanding of climate change, mitigation, and adaptation methods. The researchers note that doing a study on climate change adaptation across South Africa will help in discovering ways that enable communities to be resistant to climate changes and preserve subsistence crop production and human livelihoods. Further study findings may be useful in the development of sustainable adaptation policies to aid rural communities vulnerable to the effects of climate change. Yet, these community activities may be used to inform adaptation and climate change coping policies.

## References

- Bewket, W. (2012), "Climate Change Perceptions and Adaptive Responses of Smallholder Farmers in Central Highlands of Ethiopia", *International Journal Environment Study*, Vol. 69 No. 3, pp. 507-523.
- Blignaut, J., Ueckermann, L. and Aronson, J. (2009), "Agriculture Production's Sensitivity to Changes in Climate in South Africa", *South African Journal of Science*, Vol. 105 No. 61, pp. 15-27.
- Bruckner, M. (2012), "Climate Change Vulnerability and the Identification of Least Developed Countries (LDCs)". Available at: <https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/CDP-bp-2012-15.pdf>. (Accessed 20 September 2020).
- Chikosi, E. S., Mugambiwa, S.S., Tirivangasi, H.M. and Rankoana, S.A. (2018), "Climate change and variability perceptions in Ga-Dikgale community in Limpopo Province, South Africa", *International Journal of Climate Change Strategies and Management*, Vol. 11 No. 3, pp. 392-405.
- Cook, J., Nuccitelli, D., Green, S.A., Richardson, M., Winkler, B., Painting, R., Way, R., Jacobs, P. and Skuce, A. (2013), "Quantifying the consensus on anthropogenic global warming in the scientific literature", *Environmental research letters*, Vol. 8 No. 2, pp. 1-7.
- Department of Environmental Affairs, Republic of South Africa, (2017), "Draft: South Africa's Third National Communication under the United Nations Framework Convention on Climate Change". Available at: [https://www.environment.gov.za/sites/default/files/reports/draftsouthafricas3rdnationalcommunication\\_unfccc2017.pdf](https://www.environment.gov.za/sites/default/files/reports/draftsouthafricas3rdnationalcommunication_unfccc2017.pdf). (Accessed 20 September 2020).
- Department of Environmental Affairs, Republic of South Africa, (2011), "South Africa's National Communication under United Nations Framework Convention on Climate Change". Available at: [https://unfccc.int/sites/default/files/resource/South%20African%20TNC%20Report%20%20to%20the%20UNFCCC\\_31%20Aug.pdf](https://unfccc.int/sites/default/files/resource/South%20African%20TNC%20Report%20%20to%20the%20UNFCCC_31%20Aug.pdf). (Accessed 20 September 2020).
- Department of Science and Technology (DST), "Republic of South Africa, (2010)" *South African risk and vulnerability atlas*. Available at: [http://www.rvatlas.org/download/sarva\\_atlas](http://www.rvatlas.org/download/sarva_atlas). (Accessed 20 September 2020).

- Dube, T. and Phiri, K. (2013), "Rural livelihoods under stress: The impact of climate change on livelihoods in South Western Zimbabwe", *American International Journal of Contemporary Research*, Vol.3 No. 5, pp. 11-25.
- Financial and Fiscal Commission, Republic of South Africa (2012), "Annual Submission of the Division of Revenue, Midrand", Available at: [https://www.gov.za/sites/default/files/gcis\\_document/201409/financial-and-fiscal-commission-2012-2013-technical-report-30.pdf](https://www.gov.za/sites/default/files/gcis_document/201409/financial-and-fiscal-commission-2012-2013-technical-report-30.pdf). (Accessed 20 July 2020).
- Food and Agriculture Organisation. (2003), "Responding to Agricultural and Food Insecurity Challenges Mobilizing Africa to Implement Nepad Programmes, Conference of Ministers of Agriculture of the African Union", Available at: <https://www.fao.org/3/AD120E/AD120E00.htm>. (Accessed 20 July 2020).
- Food and Agriculture Organization (FAO) (2007), "Adaptation to climate change in Agriculture, Forestry and Fisheries: Perspective, Framework and Priorities", available at: <https://www.fao.org/documents/card/en/c/1be37c69-0147-44ea-af0b-d1487e223962/>. (Accessed 22 July 2020).
- Gandure, S., Walker, S. and Botha, J.J. (2011), "Farmers' Perceptions of Adaptation to Climate Change and Water Stress in a South African Rural Community", *Environmental Development*, Vol. 5, pp. 39-53.
- Getu, A. (2015), "The Effects of Climate Change on Livestock Production, Current Situation and Future Consideration", *International Journal Agriculture Science*, Vol. 5 No. 3, pp. 494-499.
- Greater Tzaneen Municipality Integrated Development Plan (IDP) (2018), "Final IDP 2022-2023", Accessed at: [http://www.greatertzaneen.gov.za/documents/idp/FINAL%20IDP%20APPROVED%202022-23\\_080622.pdf](http://www.greatertzaneen.gov.za/documents/idp/FINAL%20IDP%20APPROVED%202022-23_080622.pdf). (Accessed 20 September 2020).
- Hulme, M. (2017), "Climate change, concept of. International Encyclopedia of Geography: People, the Earth", *Environment and Technology*, pp.1-6.
- Hummel, D. (2015), "Climate Change, Land degradation and Migration in Mali and Senegal-some policy implications, Migration and Development", *Institute of social-ecological research, hamburger Allee*, Vol. 45, pp. 60486.
- Intergovernmental Panel on Climate Change (IPCC) (2012), *In Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation in a Special Report of Working Groups I and II of the IPCC*. Cambridge: Cambridge University Press.
- Intergovernmental Panel on Climate Change (IPCC) (2013), *The Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.
- Intergovernmental Panel on Climate Change (IPCC) (2014), "Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change", available at: <https://www.ipcc.ch/report/ar5/syr/>.(Accessed 20 July 2020).
- Jianchu, X., Shrestha, A.R.U.N., Vaidya, R.A.M.E.S.H.A.N.A.N.D.A., Eriksson, M. and Hewitt, K. (2007), *The melting Himalayas*. International Centre for Integrated Mountain Development (ICIMOD), Nepal.
- Kahsay, G.A. and Hansena, L.G. (2016), "The Effect of Climate change and adaptation policy on agricultural production in Eastern Africa", *Ecological Economics*, Vol. 121, pp. 56-64.

- Kapwata, T., Gebreslasie, M.T., Mathee, A. and Wright, C.Y. (2018), "Current and potential future seasonal trends of indoor dwelling temperature and likely health risks in rural Southern Africa", *International Journal of Environmental Research and Public Health*, Vol. 15 No. 5, p. 952.
- Kjellstrom, T., Lemke, B., Hyatt, O. and Otto, M. (2014), "Climate change and occupational health: A South African perspective", *South African Medical Journal*, Vol. 104 No. 8, pp. 586-586.
- Krantz, L. (2001), "The Sustainable Livelihood Approach to Poverty Reduction", *SIDA. Division for Policy and Socio-Economic Analysis*, Vol. 44, pp. 1-38.
- Kruger, A.C. and Sekele, S. (2013), "Trends in extreme temperature indices in South Africa: 1962–2009", *International Journal of Climatology*, Vol.33 No.3, pp. 661-676.
- Kruger, A.C. and Sekele, S.S. (2012), "Temperature trends in south africa: 1960–2003", *International Journal of Climatology: A Journal of the Royal Meteorological Society*, Vol. 24 No. 15, pp. 1929-1945.
- Kumsa, A. and Jones, J.F. (2010), "Climate Change and Human Security in Africa", *International Journal Sustainable Development, World Ecol*, Vol. 17 No. 6, pp. 453-461.
- Lyon, B. (2009), "Southern Africa summer drought and heat waves: observations and coupled model behavior", *Journal of Climate*, Vol. 22, pp. 6033-6046.
- Madzwamuse, M. (2010), *Climate Change Vulnerability and Adaptation Preparedness in South Africa*, Heinrich Böll Stiftung, Cape Town.
- Madzwamuse, M. (2014), *Climate Change Vulnerability and Adaptation Preparedness in South Africa*. Cape Town: Heinrich Boll Foundation.
- Mapaure, I., Mhango, D. and Mulenga, K. (2011), *Mitigation and Adaptation Strategies to Climate Change*. Namibia: John Meinert Printing, Windhoek, Namibia.
- Maponya, P. and Mpandeli, S. (2012), "Impact of drought on food scarcity in Limpopo province, South Africa", *African Journal of Agricultural Research*, Vol. 7 No. 37, pp. 5270-5277.
- Maponya, P. and Mpandeli, S. (2013), "Perceptions of Farmers on Climate Change and Adaptation in Limpopo Province of South Africa", *Journal of Human Ecology*, Vol. 42, pp. 283-288.
- Mathee, A., Oba, J. and Rose, A. (2010), "Climate change impacts on working people (the HOTHAPS initiative): Findings of the South African pilot study", *Glob. Health Act*, Vol. 3, pp. 5612.
- Mokhem, T. and Janse van Vuuren, A. (2015), "Drought Forces SA to Buy More Maize from Zambia". Available at: <http://dlvr.it/BPzrvn>. (Accessed 20 July 2020).
- 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*, Vol. 10 No.1, pp. 1-9.
- Nath, P.K. and Bhagirath, B.A. (2011), "Critical Review of Impact of and Adaptation to Climate Change in Developed and Developing Economies", *Environmental Development. Sustainability*, Vol. 13, pp. 141-162.
- Ncube, M., Madubula, N., Ngwenya, H., Zinyengere, N., Zhou, L., Francis, J., Mthunzi, T., Oliver, C. and Madzivhandila, T. (2016), "Climate Change, Household Vulnerability and Smart Agriculture: The Case of two South African Provinces", *Journal of Disaster Risk Studies*, Vol. 8 No.2, pp. 1-14.

- Nobre, C.A. (2008), "Mudanças Climáticas Globais e o Brasil: por que devemos nos preocupar", *Boletim SMET*, Vol. 31 No. 1, pp. 7-11.
- Norgaard, K.M. (2018), "The sociological imagination in a time of climate change", *Elsevier B.V*, Vol. 163, pp. 171-176.
- Nyahunda L. and Tirivangasi H.M. (2021), "Interdisciplinary Approach to Climate Change: Intersecting Environmental Social Work and Sociology in Climate Change Interventions from an Afrocentric Perspective", in: Leal Filho W., Luetz J., Ayal D. (eds), *Handbook of Climate Change Management*, Springer, Cham.
- Nyahunda, L. and Tirivangasi, H.M. (2021), "Barriers to Effective Climate Change Management in Zimbabwe's Rural Communities", in: Oguge, N., Ayal, D., Adeleke, L., da Silva, I. (eds), *African Handbook of Climate Change Adaptation*, Springer, Cham.
- Nyahunda, L. and Tirivangasi, H.M. (2022), "Adaptation strategies employed by rural women in the face of climate change impacts in Vhembe district, Limpopo province, South Africa", *Management of Environmental Quality: An International Journal*, Vol. 33 No. 4, pp. 1061-1075.
- Oreskes, N. (2004), "The scientific consensus on climate change", *Science*, Vol. 306 No. 5, pp. 1686-1686.
- Rankoana, S.A. (2016), "Perceptions of climate change and the potential for adaptation in a rural community in Limpopo Province, South Africa", *Sustainability*, Vol. 8 No. 8, pp. 672.
- Rankomise, A. O. (2015), "Climate Change in Zimbabwe", Available at: [www.kas.de/Zimbabwe](http://www.kas.de/Zimbabwe). (Accessed 20 July 2020).
- Roncoli, C., Ingram, K. and Kirshen, P. (2002), "Reading the Rains: Local knowledge and Rainfall Forecasting among Farmers of Burkina Faso", *Society and Natural Resources*, Vol. 15 No. 5, pp. 409-427.
- Rose, R.M. (2015), "The Impact of Climate Change on Human Security in the Sahel Region of Africa", *Donnish Journal of African Studies and Dev*, Vol. 1No. 2, pp. 009-014.
- Sango, I (2013), "An investigation of communal farmers' livelihoods and climate change challenges and opportunities in Makonde rural district of Zimbabwe", available at: [https://uir.unisa.ac.za/bitstream/handle/10500/13507/thesis\\_sango\\_i.pdf;sequence=1](https://uir.unisa.ac.za/bitstream/handle/10500/13507/thesis_sango_i.pdf;sequence=1). (Accessed 26 July 2020).
- Sango, I. and Godwell, N. (2015), "Climate change trends and environmental impacts in the Makonde Communal Lands, Zimbabwe", *South African Journal of Science*, Vol. 111 No. 7-8, pp. 1-6.
- Schulze, R. E. (2010), *Atlas of Climate Change and the South African Agricultural Sector: A 2010 Perspective*, Department of Agriculture, Forestry and Fisheries, Republic of South Africa, Pretoria.
- Seager, T.P. (2008), "The Sustainability Spectrum and the Science of Sustainability", *Business Strategy and the Environment*, Vol. 17 No. 17, pp. 444-453.
- Somerville, R.C. (2012), "Communicating the science of climate change", *Phys. Today*, Vol. 64 No. 10, pp. 48.
- Somerville R.C. and Hassol, S.J. (2011), "Enhancing the communication of climate change science", In: AGU Fall Meeting Abstracts, pp. GC24A-02. Accessed at: <https://ui.adsabs.harvard.edu/abs/2011AGUFMGC24A..02S/abstract>. (Accessed 24 July 2020).



- South African Weather Services (SAWS) (2015), *Annual Rainfall, Min/Max Temperature*, South African Weather Services, Pretoria.
- Statistics South Africa (2009), "Mid-Year Population Estimates. Statistical Release P0302", Available at: <http://www.statssa.gov.za/publications/P0302/P03022009.pdf>. (Accessed 20 July 2020).
- Statistics South Africa (2011), "Statistics South Africa Formal census", Accessed at: [https://www.statssa.gov.za/?page\\_id=3839](https://www.statssa.gov.za/?page_id=3839). (Accessed 26 July 2020).
- Tirivangasi, H.M., Rankoana, S.A. and Nyahunda, L. (2021), "Climate change impacts and effects on health system: A challenge towards achievement of sustainable development goal 3 in South Africa", *Technium Soc. Sci. J.*, Vol. 26, pp. 950.
- Tshiala M.F. (2011), "Analysis of temperature trends over Limpopo Province, South Africa", *J. Geogr. Geol.*, Vol. 3, pp. 13-21.
- Tshiala, M.F. and Olwoch, J.M. (2010), "Impact of Climate Variability on Tomato Production in Limpopo Province, South Africa", *African Journal of Agricultural Research*, Vol. 5 No. 21, pp. 2945-2951.
- Vieira, K. R. C. F. and Bazzo, W. A. (2007), "Discussões acerca do aquecimento global: uma proposta CTS para abordar esse tema controverso em sala de aula", *Ciência & Ensino*, Vol. 1, pp. 1-12.
- Wyndham, C.H. (1965), "A survey of the causal factors in heat stroke and of their prevention in the gold mining industry", *J. S. Afr. Inst. Min. Metall*, Vol. 66, pp. 125-156.
- Ziervogel, G., New, M. and Van Garderem, A.M. (2014), "Climate Change Impacts and Adaptation in South Africa." *WIREs Climate Change*, Vol. 5, pp. 605-620.