EFFECTS OF SUBSISTENCE FARMERS' KNOWLEDGE AND PERCEPTIONS ON CLIMATE CHANGE ADAPTATION USING ASSETS: A CASE STUDY OF WARD 24, POLOKWANE LOCAL MUNICIPALITY.

by

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Abstract

Climate change is one of the biggest threats confronting humanity in the 21st century. There has been an increase in global average temperatures by about 0.85°C between 1880 and 2012. In South Africa, mean annual temperatures have increased by at least 1.5 times the observed global average over the last 50 years. Climate change is thus already a measurable reality in the country where it is negatively impacting on water resources, biodiversity, ecosystems, health and food security. Subsistence farmers especially, are envisaged to be facing challenges from climate change due to their limited knowledge, assets and financial resources. Little, however, is known about the adaptation process involving subsistence farmers. This study thus sought to assess the effects of subsistence farmers' knowledge and perceptions on climate change adaptation and the role played by assets in enhancing farmers' adaptive capacity.

To collect data, the study used quantitative and qualitative research approaches which consisted of a questionnaire survey as well as in-depth interviews. Data was collected from 148 households in Ward 24 of Polokwane Local Municipality. Survey results indicate that 58% of the farmers were engaged in crop farming only, 3% in livestock farming only and 39% in mixed farming. Generally, subsistence farmers had knowledge of climate change. Their knowledge and perceptions were in line with current scientific observations on climatic and environmental changes in the country. Even though some farmers were adapting to climate change, the majority were hindered from adaptation by lack of financial resources. Assets played a significant role in climate change adaptation as households possessing different assets were using these assets to enhance their adaptive capacity and reduce their vulnerability.

The study concludes that farmers' adaptation strategies to climate in the ward was primarily influenced by the knowledge and perceptions that the farmers had on climate change. Additionally, possession of household assets played a central role in the adaptation process. The more assets that a household possessed, the more adaptive and resilient to climate change that the household was likely to be. Given this conclusion, the study recommends deploying agricultural extension officers in the study area to provide more information on climate change regarding causes, effects and the range of adaptation strategies available. Improved farming approaches should be instituted to enhance farming output, which will enable farmers to buy assets that are central to the adaptation process. Poverty alleviation programmes should also be introduced to reduce poverty and enhance the subsistence farmers' capacity to adapt and secure their livelihoods.

Declaration

I declare that this report is my own work and where I used other people ‘s work I have acknowledged their work. This report is submitted in partial fulfilment of the degree of Master of Science in Environmental and Resource Studies at the University of Limpopo and has not been submitted before for any degree or examination at any other university.

Signature ……

(Miss W.A. Mhlanga)

Date ……

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Dedication

To the memory of my late father, Enough Mhlanga. You left fingerprints of hard work, motivation and success in our lives. Gone, but not forgotten!

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Acronyms

UNFCC	-	United Nations Framework Convention on Climate Change
SWC	-	Soil Water Conservation
CC	-	Climate change
IPCC	-	Intergovernmental Panel on Climate Change
UNDP	-	United Nations Development Programme
FAO	-	Food and Agriculture Organisation
US	-	United States
CO2	-	Carbon dioxide
CH4	-	Methane
N2O	-	Nitrogen oxide
USD	-	United States Dollar
NCAR	-	National Centre for Atmospheric Research
SADC	-	Southern Africa Development Community
AGRA	-	Alliance for a Green Revolution in Africa
SSA	-	Sub Saharan Africa
StatsSA	-	Statistics South Africa
NGOs	-	Non-Governmental Organisations
SPSS	-	Statistical Packages for Social Sciences

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CHAPTER 1: INTRODUCTON

1.1 Background

Climate change is one of the biggest threats confronting humanity in the 21st century (Papworth *et al*., 2014). According to the United Nations Framework Convention on Climate Change (UNFCCC) (2011), climate change refers to those changes that can be attributed directly or indirectly to human activities which change the composition of the global atmosphere and which change is in addition to natural climate variability observed over compatible periods of time. These direct and indirect human actions range from agricultural activities such as cattle ranching, deforestation, mining activities, and combustion of fuel by vehicles, to rapid population increases (Markham, 2009).

Global average and ocean temperatures data indicate a warming of 0.85°C between 1880 and 2012 with the period 1983 to 2012 being the warmest 30-year period in the last 1400 years (IPCC, 2014). In South Africa the mean annual temperatures in the country have increased by at least 1.5 times the observed global average over the last 50 years (Ziervogel *et al*, 2014). In addition, climate data analyzed from 26 weather stations across the country also show an increase in average temperature of about 0.13°C per decade between 1960 and 2003 (Kruger & Shongwe, 2004).

At global level, changes in climate are causing significant impacts on natural and human systems and livelihoods as well as creating food insecurity and heightening water stress, especially in developing countries (Nelson, *et al*., 2009). The consequences of human induced climate change are thus without question. Evidence of climate change include changes in precipitation amounts, increase in global air and ocean temperatures, increases in the intensity of heat waves and tropical cyclones, increases in the frequency and duration of droughts, widespread melting of ice and snow and rising global sea levels (IPCC, 2014 & Hulme, 2009). In October 1998, over 18000 people were killed and thousands of homes were destroyed by hurricane Mitch over Central America, especially in Honduras and Nicaragua. (World Neighbours, 2000). By the time the hurricane subsided, it had impacted 6.4 million people, the most vulnerable being those farming and living in hillsides near riverbanks in Honduras (World Neighbors, 2000).

The IPCC has identified environmental and ecological ecosystems that are especially vulnerable to climate change and increases in overall temperature. The majority of these ecosystems are often found on the African continent. These include Mediterranean-type ecosystems, tropical rainforests, costal mangroves and salt marshes, coral reefs, water resources in the dry tropics, lowland agricultural systems and low-lying coastal systems. The Horn of Africa is a typical example, where severe drought due to failing rains in two successive years led to a widespread famine in 2011. The famine caused a severe food crisis across Somalia, Djibouti, Ethiopia and Kenya, threatening the livelihoods of close to 9.5 million people (IPCC, 2012).

In South Africa, climate change is already a measurable reality (Government of South Africa, 2011) as it is negatively impacting on the country's water resources, biodiversity, ecosystems and health as well as food security (Ziervogel *et al.*, 2014; Thompson, Matamale & Kharidza, 2012). Given South Africa's high levels of poverty and inequality, climate change impacts pose critical challenges to national development (Ziervogel *et al.*, 2014). This is especially true in the Limpopo province, which is a province generally classified as a climate change hotspot because of its exposure to extreme weather events (Levey & Jury, 1996; Tennant & Hewitson, 2002). The impact of climate change in the province is also worsened by the fact that the province is underdeveloped (Polokwane Local Municipality, 2014). In 2009, for example, the province had a poverty gap of 44.4%, up from 36.8% in 2006 (National Development Agency, 2014).

Whereas climate change is bound to affect everyone in the province, communal farmers are especially vulnerable due to their increased dependence on rain-fed agriculture which is highly sensitive to any changes in climate (Jordaan, Sakulski & Jordaan, 2013). Limpopo province has three distinct climatic regions: The Lowveld region characterized by semi-arid climate, the middle and Highveld that is considered semi-arid and the escarpment that experiences sub-humid climate (Limpopo Department of Agriculture, 2008). The semi-arid nature of the province thus adds more pressure on farmers due to its influence on rainfall amounts and erratic seasonal rainfall distribution. High temperatures that are characteristic of arid areas also increase evapotranspiration rates in the province, negatively impacting on the water available for plants. As the IPCC (2014), points out, climate change is amplifying existing risks and creating new threats for natural and human systems. These risks are, however, unevenly distributed, affecting disadvantaged rural communities such as those in Limpopo more because

of their high levels of poverty which reduces their ability to cope (National Development Agency, 2014).

Communal farmers in Limpopo province depend on rain for their crops and animals (Manderson, *et al*., 2016). Any significant changes in climate thus threaten food production and general livelihoods of these subsistence farmers. Most farmers in the province are poor and have little financial resources to aid them in confronting the climate change challenges (Deressa, *et al*., 2011). The only way that these communal farmers may overcome the climate change predicament is through adaptation to the various threats and challenges that threaten their viability and existence. Such adaptation is essential for their livelihoods and survival.

Adaptation refers to the adjustment in natural and human systems in response to the impacts of climate change that are already happening while at the same time preparing for future impacts, which moderates harm or exploits beneficial opportunities (UNFCCC, 2007). The process of adaption involves changes in the processes, structures and practices to moderate potential damages or benefit from opportunities associated with climate change. Adaptation is considered to be successful if it reduces vulnerability to existing climate variability while also building within communities the potential to anticipate and react to further climate changes in the future (Davoudi *et al.*, 2009).

Communal farmers across the world adapt to climate change in a variety of ways: crop diversification, increasing farm sizes, engaging in non-farm secondary jobs and rural-urban migration, irrigation and the increased use of fertilizers (Erickson *et al.*, 2007; World bank, 2011; Tubiello & van der Velder, 2010; Dumenu & Obeng, 2016). The adoption of these strategies however, depends on the knowledge that farmers have of climate change, the skills and technologies that they possess and most importantly, the assets that they have in their possession (Cifdaloz *et al.*, 2010).

Assets are defined as a stock of financial, human, natural or social resources that can be acquired, developed, improved and transferred across generations (Ford Foundation, 2004). Asset adaptation therefore refers to the means and ways that farmers use assets in their possession to anticipate and deal with challenges brought by climate change (Tawodzera, 2012). This study analyses climate change adaptation through assets by communal farmers in Ward 24 village of Polokwane Local Municipality. It seeks to assess the knowledge that communal farmers have on climate change in Ward 24, identify the assets they possess and

determine how these households are using the assets in the adaptation process to overcome detrimental effects of climate change.

1.2 Problem statement

Climate change poses critical development challenges to Limpopo province. This is because the province is a major climate change hotspot (National Development Agency, 2014). Subsistence farmers in the province are vulnerable to climate change because of their dependence on rain-fed agriculture which is sensitive to climate changes (Government of South Africa, 2011). Ward 24 of Polokwane Local Municipality is affected by climate change which is evidenced by persistent droughts in the Ward (Polokwane Local Municipality, 2014). The farmers are generally unable to confront climate change challenges because of high poverty levels and limited skills (StatsSA, 2014). The only alternative is for these farmers to adapt. However, it has been argued that successful adaptation to climate change depends largely on the farmers' knowledge, skills, technologies, as well as the assets they have in their possession (Cifdaloz *et al.*, 2010). While most studies on adaptation to climate change have focused on large scale farming operations (Seo *et al.*, 2005; Maddison, 2007) little is known regarding the adaptive capacity of subsistence households and how assets can play a central role in the adaptation process. This study therefore assesses the effects of the farmers' knowledge and perceptions on climate change adaptation and ascertains the role of assets in the adaptation process.

1.3 Significance of the study

This study intends to generate a body of knowledge on subsistence farmers' knowledge and perceptions on climate change as well as their adaptation using assets. Such knowledge will enable policy makers, local authorities and planners to understand how subsistence farmers are impacted on by climate change and how they are responding and adapting in order to lessen the negative impacts of the phenomenon. The study is important given that the livelihoods of most subsistence farmers are almost exclusively dependent on rain-fed agriculture. Understanding how successful adaptation can be achieved will go a long way in enabling different stakeholders to proactively capacitate subsistence farmers so that they can successfully confront climate change challenges. Successful adaptation will also protect rural livelihoods and increase food security which is currently under threat. Finally, the findings from the study will also provide recommendations on how subsistence farmers may be able to respond better to specific challenges such as floods and droughts.

1.4 Study aim

The aim of this study is to assess the effects of subsistence farmers' knowledge and perceptions on climate change adaptation and ascertain the role played by assets in enhancing the capacity of farmers to adapt to climate change in Ward 24 of Polokwane Local Municipality.

1.5 Study objectives

The objectives of the study are to:

1. Examine the effects of subsistence farmers' knowledge and perceptions on climate change adaptation in Ward 24.
2. Determine adaptation strategies being used by farmers to reduce the negative impacts of climate change in the ward.
3. Assess the role played by assets in enhancing households' adaptive capacity to climate change.

1.6 Organisation of the dissertation

This research is organized into five chapters. Chapter One gives the background to the study, outlines the research problem as well as the research aim and objectives and study significance. The chapter concludes by detailing the way in which the dissertation is organised.

Chapter Two presents the literature review which outlines climate change trends globally, regionally and locally in terms of the causes of global warming, as well as in the vulnerability of the African continent and impacts on agriculture. Furthermore, the literature discusses the vulnerability of subsistence farmers, how they adapt to climate change and the role played by assets in enhancing households' adaptive capacity. A conceptual framework of the study is also provided.

Chapter Three presents the study area and the methodology. It explains the sampling techniques used and gives a brief description of how the quantitative and qualitative data required in the study was collected. The chapter also explains issues of validity and reliability of the collected data, ethical considerations as well as the study limitations.

Chapter Four presents the results of the study. It starts by detailing the socio-economic and farming characteristics of Ward 24. It then discusses the subsistence farmers' knowledge and

perceptions on climate change, the adaptation strategies used and challenges faced in the adaption process. The chapter also deliberates on the effects of subsistence farmers' knowledge and perceptions on adaption as well as the role of their assets in enhancing their adaptive capacity.

Chapter Five synthesizes the findings of the study. It then summarises the study's contributions to the field of climate change adaptation which demonstrate that the possession of assets plays a crucial role in the climate change adaptation for subsistence farmers. Lastly, the chapter makes recommendations on how to improve subsistence farmers' adaptive capacity to climate change. The next chapter provides a literature review on climate change and adaptation at different scales: from the global to the local.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The brief discussion in Chapter One indicates, without doubt, that climate change is an undeniable threat to humanity because of its impact on global weather events and patterns and the consequent negative impact on subsistence livelihoods anchored on farming. This chapter therefore provides an expanded review of literature on climate change definition, perceptions, causes, impacts and adaptation strategies, as well as relevant trends from global to the local level.

2.2 Definition and perceptions of climate change

Climate includes temperature, rainfall, wind and other weather conditions over a larger region and on a longer time frame unlike weather. On the other hand, change is the act or a process through which something becomes different. In lame man's language, climate change is the alteration of weather conditions in a huge area over a long period of time. Hence, this concept is usually referred to as the concept of global climate change. According to the UNDP (2009), climate change is a scientifically proven phenomenon that includes any change in the climate, whether due to its natural variability or because of human activity. UNFCCC (2011) defines climate change as change which is attributed directly or indirectly to human activities that alter the composite on of the global atmosphere and which are in addition to natural climate variability observed over comparable time periods. The global climate is changing and this is basically because of increased global warming mainly resulting from human activities (Egbule, 2014).

The question which arises is are people aware of this global change in climate? If so, how do they perceive and understand it. Perception is the process of attaining awareness or understanding of a phenomenon including climate change (Seyoum, 2015). According to (Tripathi & Mishra 2016, p, 196), "the role of the human perception is one of the most important questions. If we understood how a human perceives and operates information, we would more precisely make the future forecasts and increase our efficiency". Studying the way people perceive various environmental phenomena is very critical in the formulation of decisions about environmental phenomena. Many studies have been done regarding climate change perception across the globe e.g (Vedwan & Rhodes, 2001; Akponipke *et al*, 2010; Ogelleh *et al*, 2012; Babatolu & Akinnubi, 2016 and Nguyen *et al*, 2017).

The exploration of perceptions of climate change involves two vital steps: the detection of climate change and determining its significance versus other stressors (Tripathi & Mishra, 2016). Recent studies from Western India into rural people's belief and understanding of climate change suggested that most respondents detected changes in the climate, but they did not understand the scientific concept of climate change (Moghariya & Smardon, 2012). Similarly, a study of East Tibetan villages in China found that people were not aware of the global phenomenon of climate change and assumed that the changes were local (Byg & Salick, 2009). Leiserowitz (2006) contended that since the year 2000, numerous public opinion polls had demonstrated that large majorities (92%) of Americans were aware of global warming. In addition, 74% of them argued that climate change was real and already underway. Furthermore, 76% of the total population already viewed climate change as a somewhat very serious problem. A 2004 survey in the UK found that 62% of the respondents described climate change as a "fairly bad thing" or a "very bad thing" (Norton & Leaman, 2004). In the survey by Globescan (2009), 64 per cent of people interviewed considered climate change and global warming as very serious problems and this showed an increase of up to 20 per cent from a 1998 poll.

Maddison (2007) surveyed ten countries in Africa and concluded that a significant number of people believed average temperatures had increased due to climate change. By contrast, almost none believed they had decreased or that the temperature range had altered due to climate change, apart from some respondents in Ethiopia. The results for precipitation showed a similar uniformity of opinion across the ten countries. In six out of ten countries, majority of the people believed rainfall levels had decreased and a change in the timing of the rains. All the above-mentioned examples show the importance of understanding climate change at a local or indigenous level versus the global or scientific understanding about perceptions of climate change.

The other aspect of perceptions of climate change relates to significance that people attach to climatic shocks against other stressors. Studies with coffee producing communities of Mexico (Eakin *et al*., 2005) and Nicaragua (Bacon, 2005) did not show significance to the impacts of climate change on their coffee trees compared to impacts of coffee price changes. In other words, according to South American studies, market forces attracted higher significance over climate change. However, studies in Africa noted that farmers were acutely aware of warmer temperatures and decline in precipitation (Maddison, 2007; Juana *et al*., 2013). Mubaya *et al.*, (2012), for example, found that climate variability was the most critical factor that exacerbated

livelihood insecurity for farmers in Zimbabwe and Zambia. The fact that the above studies presented mixed results is a cause for concern. There is a need for further studies regarding the understanding of climate change and how people perceive it globally.

2.3 Causes/drivers of climate change

2.3.1 The greenhouse effect

There is a scientific consensus that concentration of greenhouse gases in the atmosphere are increasing and this is causing the surface air temperatures to raise leading to climate change (IPCC, 2013). The emission of these gases in mainly caused by natural and human factors. Since the mid – 1800s, scientists have known that that carbon dioxide is the main greenhouse gases of importance to the earth's energy balance (Royal Society & US National Academy of Siences, 2014). Between 1800 and 2012, measurements of carbon dioxide in the atmosphere and in the air trapped in ice reveal that the gas has increased by approximately 40% (Royal Society & US National Academy of Siences, 2014). From the direct measurements of different carbon dioxide forms, human activities are the major cause of carbon dioxide in the atmosphere. However, other gases such as methane and nitrous oxide also contribute to the greenhouse effect caused by humans (IPCC, 2013).

In the scientific realm, different influences on climate have different signatures in climate records which are unique. The observed patterns of surface warming, temperature changes in the atmosphere, increases in ocean heat content, rise in sea level, melting of glaciers and polar ice caps as well as increase in the atmospheric moisture content match the patterns that scientists expect to see due to rising carbon dioxide and other anthropogenic causes of carbon dioxide (IPCC, 2013). For climate to change, it is based on the understanding on how greenhouse gases trap heat.

However, studies on the physics of greenhouse warming and fingerprints/signature studies show that natural causes alone are not enough to explain the recent observed changes in climate (Royal Society & US National Academy of Siences, 2014). These natural causes include variations in the sun's output and in the Earth's orbit around the sun, volcanic eruptions and internal fluctuations such as the El Nino and La Nina (IPCC, 2013). Calculations have been made sing climate models to simulate what would have happened to the global temperatures if only natural factors were influencing climate (IPCC, 2014). This resulted in the simulations yielding little warming or even a slight cooling over the 20th century (Royal Society & US National Academy of Siences, 2014).Only when the models included the anthropogenic

influence on the atmospheric composition are the resulting temperature changes consistent with the observed current trends of climate changes.

To a greater extend, human activities contribute more to climate change by causing changes in the atmosphere in the amounts of greenhouse gases, aerosols and cloudiness (IPCC, 2013). The largest known contribution comes from the combustion of fossil fuels. The gases released from combustion of these fuels affect climate by altering incoming solar radiation and outgoing infrared radiation that are part of the Earth's energy balance (IPCC, 2007). Changing the atmospheric abundance or the properties of these gases and particles can lead to a warming or cooling of the climate system. Since the start of the industrial era to present, the overall effect of human activities on climate change has been a warming influence (IPCC, 2007).

2.3.2 Contribution of greenhouse gases to climate change

Human activities result in emissions of four principal greenhouse gases namely carbon dioxide, methane, nitrous oxide and the halocarbons (a group of gases containing fluorine, chlorine and bromine). These gases accumulate in the atmosphere, causing concentrations to increase with time. Significant increases in these gases have occurred in the industrial era. The emission of these gases is also attributable to natural causes but to a much lesser extent. The figure 2.1 below shows the major causes responsible for the release of these gases.

Table 2.1 Human and Natural causes of climate change

GAS	HUMAN CAUSE	NATURAL CAUSE
Carbon dioxide (CO_2)	CO2 has increased from fossil fuel combustion in transportation, building heating and cooling and the manufacture of cement and other goods. Land uses where land areas can act as a sink absorbing CO_2 from the atmosphere. In the United States, since 1990, managed forests and other lands have absorbed more CO_2 from the atmosphere than they emit.	Naturally, CO2 is released during the decay of plant matter.
Methane (CH4)	Methane contributes to climate change because of human activities related to agriculture, natural gas distribution and landfills.	Methane is also released from natural processed that occur I wetland for example.
Nitrous oxide (N2O)	It is emitted by human activities such as high use of fertilisers and fossil fuel burning.	Natural processes in soils and oceans also release N2O

Halocarbons	Halocarbon gas concentrations have also increased due to human activities. Chlorofluorocarbons, which were used extensively as refrigeration agents and in other industrial processes before their presence in the atmosphere was found to cause stratospheric ozone depletion.	Natural processes which release this gas are close to none.
Aerosols	Human activities such as surface mining and industrial processes have increased dust in the atmosphere. Fossil fuel and biomass burning have increased aerosol containing sulphur compounds, organic compounds and black carbon (soot).	Natural aerosols include mineral dust released from the surface, sea salt aerosols, biogenic emissions from the land and oceans and sulphate and dust aerosols produced by volcanic eruptions.
Ozone	In the troposphere, human activities have increased ozone through the release of gases such as carbon monoxide, hydrocarbons and nitrogen oxide, which chemically react to produce ozone. As mentioned above, halocarbons released by human activities destroy ozone in the stratosphere and have caused the ozone hole over Antarctica.	

(IPCC, 2007)

2.4 Impacts of climate change

Climate change is one of the major challenges of our time and adds considerable stress to our societies and to the environment. From shifting weather patterns that threaten food production to rising sea levels that increase the risk catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale (Cruz *et al*, 2007). However, the impacts of climate change vary from region to region.

2.4.1 Latin America

Latin America contains much of the world's biological diversity, as well as a wide range of ecosystems, climatic regions, topographies and land-use patterns. Mostly vulnerable to climate change are the water, agriculture and health sectors, the Andean glaciers, the Amazon region. The region has already been experiencing climate-related changes with the frequency and intensity of extreme weather events such as droughts and floods (UNFCCC, 2006).

In terms of temperature, Latin America is predicted to have a warming above the global mean. Precipitation, snow and ice is also predicted to decrease in annually in most of Central America and in the southern Andes, although large local variability will be experienced in mountainous areas. There will also be an increase in winter precipitation in Tierra del Fuego. Uncertain rainfall changes over northern South America, including the Amazon forest. These changes in temperature and precipitation patterns will severely affect water resources, agriculture and the health sectors in Latin America (Christensen, *et al*., 2007).

The increase in the number of people experiencing water stress is likely to be 7–77 million by the 2020s (Magrin, *et al*., 2007). Runoff and water supply in many areas is being compromised due to loss and retreat of glaciers and also an experience in water quality reduction in some areas due to an increase in floods and droughts. Latin America is largely facing reductions of crop yields in some areas, although other areas see increases in yields. By the 2050s, 50% of agricultural lands are very likely to be subjected to desertification and salinization in some areas (Christensen, *et al*., 2007). This will result in food insecurity especially in dry areas where agricultural land subject to salinization and erosion reducing crop yields and livestock productivity.

Wildlife and human life is also being impacted due to increases in the intensity of tropical cyclones. Heavy rains and resulting floods, including those associated with tropical cyclones, have resulted in tens of thousands of deaths and severe economic losses and social disruption in the region in recent years, for example in 1998 hurricane Mitch caused 10,000 deaths and severe damage to infrastructure, with Honduras and Nicaragua the worst hit. Northeast Brazil, on the other hand, is particularly affected by drought and its associated socio-economic impacts (Charveriat, 2000).

2.4.2 Asia

Asia is a huge continent which spreads over four climatic zones (boreal, arid and semi-arid, tropical and temperate). Due to climate change, land and ecosystems are being degraded, threatening to undermine food security as well as deterioration in water and air quality. Furthermore, the region is highly subjected to natural hazards, such as the 2004 Indian Ocean Tsunami, the 2005 Pakistan Earthquake, and the 2006 landslides in the Philippines (UNFCCC, 2006).

There is evidence of prominent increases in the intensity and/or frequency of many extreme weather events such as heat waves, tropical cyclones, prolonged dry spells, intense rainfall, tornadoes, snow avalanches, thunderstorms, and severe dust storms in the region (Cruz, *et al*., 2007).This has resulted in tens of millions of people in low-lying coastal areas of south and Southeast Asia affected by sea level rise and an increase in the intensity of tropical cyclones. For example, the extreme weather events in China during 2006 included major storms and flooding in the east and south, as well as heat and drought in central, western and north-eastern regions, killing more than 2700 people and causing USD 20 billion in damages (UNFCCC, 2007).

Predicted rainfall increases over most of Asia, particularly during the summer monsoon, could increase flood-prone areas in East Asia, South Asia and Southeast Asia. In Central and South Asia, crop yields are predicted to fall by up to 30 per cent, creating a very high risk of hunger in several countries (Cruz, *et al*., 2007). The major impacts of climate change on health in this region will be on epidemics of malaria, dengue, and other vector-borne diseases (Martens, *et al*., 1999). The global burden of climate change-attributable diarrhoea and malnutrition are already the largest in the world in Southeast Asian countries including Bangladesh, Bhutan, India, Maldives, Myanmar and Nepal in 2000. Illness and death are expected to increase from diarrhoeal diseases due to drought and flooding, and are also expected from increased amounts of cholera bacteria in coastal waters (UNFCCC, 2006).

2.4.3 Africa

The African continent is already under pressure from climate stresses and is highly vulnerable to the impacts of climate change. Extreme weather events such as floods and droughts can occur in the same area within months of each other. These events can lead to famine and widespread disruption of socio-economic well-being. For example, estimates reported at the African regional workshop on adaptation in Accra, Ghana indicate that one third of African people already live in drought- prone areas and 220 million are exposed to drought each year (UNFCCC, 2006). The overexploitation of land resources including forests, increases in population, desertification and land degradation pose additional threats (UNDP 2006). In the Sahara and Sahel, dust and sand storms have negative impacts on agriculture, infrastructure and health (Balgis, 2006).

Africa is facing an increase in water scarcity and stress with a consequent potential increase of water conflicts as almost all the 50 river basins in Africa are transboundary (De Wit & Jack, 2006). Agricultural production relies mainly on rainfall for irrigation and is being severely compromised in many African countries, especially for subsistence farmers in sub-Saharan Africa. Due to climate change much, agricultural land will be lost, with shorter growing seasons and lower yields. National communications report that climate change will cause a general decline in most of the subsistence crops, e.g. sorghum in Sudan, Ethiopia, Eritrea and Zambia; maize in Ghana; Millet in Sudan; and groundnuts in Gambia. Of the total additional risks towards people is that of hunger and famine due to climate change and it is already a large proportion in Africa (Fischer, *et al*., 2002).

Africa is susceptible to a number of climate sensitive diseases including malaria, tuberculosis and diarrhoea (Guernier, *et al*., 2004). Under climate change, rising temperatures are changing the geographical distribution of vector diseases which are migrating to new areas and higher altitudes. For example, Boko, *et al.* (2007) noted that migration of the malaria mosquito to higher altitudes will expose large numbers of previously unexposed people to infection in the densely populated east African highlands. Future climate variability will also interact with other stresses and susceptibilities such as HIV/AIDS (which is already reducing life expectancy in many African countries) and conflict and war resulting in increased susceptibility and risk to infectious diseases (e.g. cholera and diarrhoea) and malnutrition for adults and children (Harrus & Baneth, 2005)

2.4.4 The impacts of climate change on agriculture in African regions

2.4.4.1 Sahel

The Sahel region has been identified as one of the most vulnerable regions to climate change because of its proximity to the equator. It already experiences high temperatures and low rainfall and this has a negative effect on agriculture due the high reliance of local populations on rain fed agriculture. The high population density and low adaptive capacity exacerbates the vulnerability of farmers in this region (Dube *et al*., 2016). The area has been experiencing droughts over the past decades due to low precipitation rates. Sissoko *et al*. (2011) estimated that between the 1960s and 1990, there was a decline of between 20% and 40% in precipitation in the region. It is also estimated that a systematic water shortage problem is expected to emerge in the Sahel region by the year 2025 as a result of the new climatic trends (Mohamed, 2011). The water shortage will be worsened by the pressure of increasing populations in the region over and above the effects of climate change. Furthermore, Mohamed (2011) projects a

decrease of between 11% and 26% of millet and groundnut production by 2025 due to reduced precipitation and shortened cropping seasons.

2.4.4.2 West Africa

The impacts of climate change in west Africa appear to be generally the same with the rest of the regions (Dube *et al*., 2016). According to a study conducted by Jalloh et al. (2013), climate change poses a great threat to agriculture based livelihoods in the West African region. Model simulations of climate change scenarios predicted that climate change will impact the region through changes in precipitation patterns, increasing extreme weather events and a general shift in farming seasons. The study also projects that increasing temperatures will negatively affect the growth of particular crops including sorghum, while reduced precipitation is also expected to worsen the situation (Jalloh *et al*., 2013). Crop yield losses of between 5% and 25% are projected for the region by 2050 according to simulation models. This reduction in food security is against the backdrop of one of the fastest population growth rates in the world found in West Africa.

2.4.4.3 East Africa

According to Dube *et al*., (2016 p,263), "A study by Oxfam (2008) examined the impact of climate change on the livelihoods of pastoralists in Eastern Africa, focusing on Kenya and Uganda. It found out that notable climatic changes had taken place. It further noted that the length of rainy seasons had been reduced particularly in North Eastern Uganda. The rains that used to fall in the month of March through to August were frequently now starting in April. These findings are comparable with Mubaya *et al*.'s (2012) findings in Southern Africa which showed that the region was getting shorter wet seasons with unpredictable rainfall patterns. This reduction of the amount of rain was negatively impacting on livestock pasture as there was less time for it to mature. The Oxfam study further notes that increasing successive poor rainfall seasons were not giving cattle sufficient time to recover from drought years. The return rate of droughts was increasingly becoming more frequent. Estimates show that drought related shocks used to occur every ten years. However, they were now occurring every five years or less at the time of the study."

2.4.4.4 Southern Africa

The Southern Africa region is generally projected to become hotter and drier as the next decades unfold (Dube *et al*., 2016). Studies have been conducted which already show that rainfall patterns will become unpredictable and unstable (Mubaya *et al*., 2012). Moreover, rainfall seasons have already shown significant signs of shortening, thereby affecting growing

seasons (Mubaya *et al*., 2012). Shackelton & Shackelton (2011) also projected more intense floods and droughts, reduced farm produce and an increase in water scarcity. Additionally, there is expectation (and there is evidence already) that there will be a shortening of the wet season and increased variability of rainfall patterns from season to season (Dube *et al*, 2016). This will greatly affect farming seasons with serious consequences for agricultural production. In their study focussing on Zimbabwe and Zambia, Mubaya *et al*. (2012, p 264) conclude that 'there appears to be an increasing trend towards a late start to the rain season, prolonged mid-season droughts, and shorter growing seasons in Southern Africa.'

2.5 Climate change trends

2.5.1 Global climate change trends

Global climate is changing and this change is apparent across a wide range of observations. The global warming of the past 50 years is primarily due to anthropogenic activities. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally and how sensitive the earth's climate is to those emissions (Sango, 2013). According to the United Nations Framework Convention on Climate Change (UNFCCC, 2007), climate change refers to, "a change of climate that is directly or indirectly attributed to human activities by altering the composition of the global atmosphere, in addition to natural climate variability observed over comparable time periods." Climate change is also defined by a number of factors which include: temperature, precipitation, air pressure, humidity, wind and extreme weather events such as droughts and floods (Sango, 2013).

Globally, the average temperature of the earth's surface has risen by 0.74^{o}C since the late 1800s and it is expected to go up by another 1.8^{o}C to 4^{o}C by the year 2100 if no action is taken (IPCC, 2007). According to the geological time scale, that is a very fast and intense change in such a period (Sango, 2013). Furthermore, if the temperatures do not reach 4^{0}C by 2100 and only increase by 1.8^{0}C, it would be a larger increase in temperature than any century long trend in the last 10000 years. Years between 1950 and 2006 rank among the twelve warmest years in the instrumental record of global surface temperatures since 1850 (Tol, 2005).

Records of increasing temperatures, melting glaciers, reductions in thickness and extent of sea ice, thawing permafrost and rising sea level all provide strong evidence of the recent Arctic warming (Hassol, 2004). The average Arctic temperatures have increased almost twice the global average rate in the past 100 years. Global average sea level rose at an average rate of 1.3m to2.3mm per year during 1993 to 2003. Since then, there has been a decrease in the

glaciers and ice caps contributing about 28% of sea level rise and lose from the polar icecaps contributing the remainder. It has also been observed that in the Arctic, temperatures in winter are rising more rapidly than in summer. In Alaska and Western Canada, winter temperatures have increased as much as 3 - 4^0C in the past 50 years (Fischer, *et al*., 2005).

In addition to the overall increase in temperature, changes in precipitation characteristics have also been observed (Hassol, 2004). Much of the precipitation increase appears to be coming as rain, mostly in winter and to a lesser extent in autumn and spring. The increasing winter rains, which fall on top of existing snow, cause snow to melt faster and when the rainfall is intense it causes flash floods in some areas. These events have significantly increased across much of Arctic (Hassol, 2004). For example, there has been an increase in snow melt by 50% over the past 50 years in Western Russia.

2.5.2 Sub-Saharan climate change trends

Chishakwe (2010) and Archer *et al*., (2010) observed that Sub Saharan Africa has been experiencing a warming trend over the past few decades. Temperatures in the sub region have risen by over 0.50^0C over the last 100 years. Between 1950 and 2000, Namibia for example, experienced warming at a rate of 0.0230^0C per year. The Indian Ocean has also experienced warming of more than 10^0C since 1950. The region has also experienced a downward trend in rainfall (National Centre for Atmospheric Research (IPCC, 2007) for example, between 1988 and 1992; SSA experienced over 15 drought events.

2.5.3 SADC climate change trends

Climate across the SADC region is highly diverse and is driven by a range of distinct climatic systems. Evidence shows that the SADC region has already experienced a decreasing frequency of extremely cold days and increasing frequency of hot days (AGRA, 2014). Rainfall trends are variable but evidence points to an increased inter-annual variability to date, with extremely wet periods and more intense droughts in different countries (AGRA, 2014). In terms of physical climate impacts, the SADC region has experienced a decreasing trend of rainfall since 1950. Regarding temperature, SADC has also experienced upward trends in the annual mean, maximum and minimum temperature over large parts of the region. The most significant warming has taken place in 30 the last two decades (IPCC Africa, 2014).

According to the SADC Climate Change Policy Paper (Lesolle, 2013), "instrumental observations from a number of SADC countries show an increase in temperatures, especially the minimum temperatures. Between 1950 and 2000, Namibia experienced warming at a rate of 0.023ºC per year (DEA, 2016); similarly, Botswana received warming at a rate of 0.017ºC per year. In South Africa, the mean annual temperatures have increased by at least 1.5 times the observed average of 0.65^0C over the past 50 years and extreme rainfall events have increased frequently. Overall, since 1950, the region has also witnessed a downward trend in rainfall. Many reports including the IPCC Fourth Assessment Report (IPCC, 2007) indicate that below-normal rainfall years are becoming more and more frequent.

The potential projected climate changes for the SADC region includes; an overall annual warming, with a greater increase in temperatures in central regions relative to coastal regions and an increase in the number of very hot days with the temperature being greater than 35°C. A general decrease in annual rainfall is being projected over the south-western Cape of South Africa, and parts of Zimbabwe, Mozambique and Zambia. An increase in annual rainfall over south-east South Africa will be seen as well.

2.6 Climate change and agriculture in sub-Saharan Africa

Climate change affects agriculture and agriculture also has an effect on climate change. Reduced rainfall, higher temperatures and increased variability in rainfall patterns reduces crop yields and threaten food security in low-income and agriculture-based economies (Below *et al*, 2012). Therefore, the impact of climate change has detrimental effects to countries that depend on rain fed agriculture as their main source of livelihood, many of which are found in Sub Saharan Africa (AGRA, 2014). In SSA, subsistence farmers are the primary producers of agricultural output for about 80% of all the farms around the region (AGRA, 2014). These farmers often cultivate on small parcels of land which are often degraded and have no access to reliable irrigation.

Most subsistence farmers in this region are classified as being resource poor and they do not have access to affordable inputs and financial credit. The effects of climate change add to these challenges facing subsistence farmers in SSA and it has become a survival challenge for them (Below *et al,* 2012). Climate change impacts are making worse the already tight resources constraints facing subsistence farmers in this region. Furthermore, erratic weather patterns and extreme weather events are decreasing the average yields. Rapid uncertain changes in rainfall and temperature patterns are a threat to food production as mentioned earlier on. Sadly, this

has led to food price shocks, increase in vulnerability of subsistence farmers and accentuate rural poverty (AGRA, 2014).

2.7 Adaptation in the context of climate change

Adaptation in the context of human dimensions of global change usually refers to a process, action or outcome in a system, be it a household, group, region, sector or country, in order for the system to adjust to some changing condition, stress, hazard, risk or opportunity (Seyoum, 2015). Numerous definitions of adaptation are found in climate change literature. IPCC (2007) defines adaptation as the adjustment in natural of human systems in response to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities. Brooks (2003, p8) describes adaptation as "an adjustment in a system's behaviour and characteristics that enhance its ability to cope with external stress." Smit *et al*, (2006, p225) in the climate context refers to adaptation as, "adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts." In all these definitions of adaptation, the most important thing is the ability to adjust and cope when faced with certain stresses, conditions or situations.

Based on their timing adaptations can be anticipatory or reactive, and depending on the degree of spontaneity they can be autonomous or planned (Smit & Wandel, 2006.) Reactive adaptation occurs after the initial impacts of climate change become evident. Whereas, anticipatory occurs before the impacts becomes evident (Brooks, 2003). Planned adaptation is the result of a deliberate policy decision, based on the awareness that conditions have changed or are expected to change. Thus, some form of action is required to maintain a desired state (Brooks, 2003). Autonomous adaptation refers to those actions taken as individuals, communities or institutions to independently adjust to the risk of facing the impacts of climate change.

Adaptation, be it planned or autonomous involves changes in processes, practices and structures to moderate potential damages to benefit from the opportunities associated with climate change. For adaptation to be successful, it must reduce the vulnerability to existing climate variability while simultaneously building within systems the potential to anticipate and react to further changes in climate in the future (Davoudi *et al*, 2009). Adaptation is especially important where systems such as communities have little or no capacity to mitigate climate change impacts (Carlson & McCormick, 2015).

2.8 Farmer adaptation to climate change

Given the growing evidence of climate change in different regions of the world including sub-Saharan (Archer, *et al*., 2010), it is very clear that farmers are vulnerable to the impacts of climate change. Subsistence farmers in Africa are mostly affected by this vulnerability and which has serious consequences on their livelihoods (Sango, 2010). According to Dube *et al.,* (2016) there are three points that make Africa the most vulnerable continent to climate change. "Firstly, the geographical positioning of the African continent gives it one of the warmest climates by virtue of its proximity to the equator. Secondly, most African countries depend on the agricultural sector which is sensitive to climate change. Lastly, the socio-economic gaps in governance, government financing, high rates of poverty and growing populations all expose Africa as a region with high vulnerability to climate change. The only way that these farmers can overcome vulnerability is through adaptation (Dube *et al*., 2016, p.258)." According to Morton (2007), subsistence farming includes activities that are undertaken in a relatively small area with little or no modern, purchased inputs and outputs are mostly directly consumed and with little or no output is send to the market. The term may also be used to describe a form of economy normally found in the rural poor developing countries, that is, a predominantly small-scale farming using family labour supporting livelihoods for majority in such countries (Cornish, 1998).

Adapting to stresses by subsistence farmers in their local environment has existed since time immemorial. Over the centuries, subsistence farmers have drawn on traditional knowledge and historical observations to manage effects of a changing climate and other stresses (Altieri & Koohafkan, 2008). They have used the local knowledge they have and experience they have gone through to cope with such changes over time. Historically, for hundreds of years, these farmers have managed to develop complex agricultural systems, which are adaptive to the local environment using locally tested skills and practices, leading to sustained food security at household and community levels. This has been successful without so much dependence on the influence of support from governments, scientists and researchers (Altieri &Koohafkan 2008).

Although very few, evidence exists in certain parts of the world and it includes the following: "mountain rice terrace systems in Madagascar; multiple cropping systems in Chinampas, Mexico; nomadic and semi-nomadic pastoral systems of the Maasai in Tanzania and Kenya; ancient irrigation, soil and water management systems in Iran, Afghanistan and Mali; and

complex multi-layered home gardens with wild and domesticated plants for foods, medicines, ornamentals and the like in China and India" (Koohafkan & Altieri, 2011).

It is a well-known fact that subsistence farmers across the world undertake farming in lands that are marginal at times, with comparably very small plots, making use of little or no modern technologies for both farming and farm management and using local knowledge (Ndaki, 2014). Such farmers have, over the years, invented good ways of diversifying their farming through crops biodiversity (Altieri & Koohafkan, 2008; Koohafkan &Altieri, 2011). For instance, in West Africa and Latin America alone, more than 40 percent of cassava, 60 percent of maize, and 80 percent of beans are intercropped with other crops thus demonstrating long time knowledge and techniques of local people in their traditional farming activities (Ndaki, 2014). This kind of practice supports soil fertility, food security, crop disease prevention, biodiversity conservation as well as adaptation to climate variability and change. This has occurred ultimately as a result of local inventions and knowledge accumulation for generations (Altieri& Koohafkan, 2008). However, this has generally been a result and response to certain stimuli that in a way forms a base for farmers to make some changes in their production processes, either part or whole in order to probably benefit more or cope with current changes.

Subsistence farmers in Africa have been part of the inventive history of the subsistence farmers in the world at large. As counterparts in other parts of the world, subsistence farmers in Africa have a long-time experience in adapting to various changes that in a way affected their farming activities (Ndaki, 2014). Several strategies that these farmers have been using to adapt to changes in the environment have been mentioned and discussed in literature. Hassan and Nhemachena (2008), for example, mention increased irrigation, multiple cropping and integration of livestock as some of the strategies employed by subsistence farmers in responding to climate stressors in Africa. Paavola (2008) cites extension of cultivation, agricultural intensification, livelihoods diversification as well as migration as the most commonly used adaptation strategies by subsistence farmers in Morogoro, Tanzania. Other examples of strategies include improved farm management and technology use as well as farm financial management (Below, *et al*., 2010) and changing planting dates, changing crop varieties as well as using various locally oriented and invented soil conservation techniques (Acquah, 2011).

However, today, the speed and intensity of change in the environment and climate are overtaking the subsistence farmers' capacity to adapt using the same ways they used to in the

past. Historical averages and local means of forecasting may no longer be a reliable guide for the future production process in the farm. Losses and damages from extreme weather events keep increasing, as the pattern of droughts, floods and storms becomes ever more unpredictable than expected (Ndaki, 2014). Therefore, subsistence farmers' change of their farming practices in the face of environmental and climate change today may not necessarily and entirely support successfully adapt and build resilience towards climate change. How they are coping now and the methods they are using has become a cause for concern.

2.9 Adaptation to climate change by subsistence farmers

It is a prerequisite to understand whether climate is changing or not in order for subsistence farmers to successfully adapt. Researchers have done work on understanding farmers' awareness of climate change, options for adaptation to climate change and the factors influencing choice of adaptation methods to climate change. However, there has been mixed evidence about whether farmers are aware that the climate is changing in their areas. For instance, Ishaya & Abaje (2008) report a lack of awareness and knowledge about climate change by farmers in Jema'a, Nigeria. On the other hand, Deressa *et al*., (2009) reports that 50.6% of the surveyed farmers in the Nile Basin of Ethiopia had observed increasing temperature over the past 20 years and 53% of them had observed decreasing rainfall over the past 20 years. Therefore, in line with the current definition of climate change, the majority of the surveyed Ethiopian farmers had awareness about climate change.

One would expect that farmers who are aware of climate change will take some actions to cushion themselves against its adverse effects. A study from Ethiopia reveals that 58% of farmers who claimed to have observed changes in climate over the past 20 years had responded to it by undertaking some adaptation measure. Several studies report agricultural adaptation measures such as the use of crop varieties, planting trees, soil conservation, changing planting dates, and irrigation as the most used adaptation methods in African countries (Deressa *et al*., 2009 & Bryan *et al*., 2009)

Although there are various measures to adapt, not all farmers will adapt to climate change for various reasons. Quite a number of factors have been put forward to explain the presence or absence of adaptation to climate change. Nhemachena & Hassan (2007) identified the important determinants of adaptation to climate change in South Africa, Zambia and Zimbabwe to be access to credit and extension, and also farmers' awareness about climate change. As

such, that study suggested enhancing access to credit and information about climate and agronomy so as to boost farmer's adaptation to climate change.

Ishaya &Abaje (2008) also found that lack of awareness and knowledge about climate change and adaptation strategies, lack of capital and improved seeds, and lack of water for irrigation played an important role in hindering adaptation to climate change in Jema'a Nigeria. Gbetibouo (2009) proposed that the major driver influencing farmers' adaptation to climate change in Limpopo basin, South Africa, is the way that they formulate their expectations of future climate in dealing with the changing weather patterns. According to that study, the major factor restraining farmers' adaptation to climate change is inadequate access to credit. He argued as well that among other things, the main factors that promote adaptive capacity are farmers' income, the size of the household, farmers' experience, and engaging in non-farm activities.

While analysing farmers' perception of climate change governance and adaptation constraints in the Niger Delta region of Nigeria, Nzeadibe *et al*., (2011) also pointed out that the factors responsible for hindering adaptation to climate change are inadequate information, narrow awareness and knowledge about adaptation methods, and poor government attention to climate change. Deressa *et al*., (2011) also finds that education and gender of the head of the household, size of the household, livestock ownership, availability of credit and environmental temperature significantly influence the presence of farmers' adaptation to climate change.

For those farmers who undertake any adaptation at all, the choice of particular adaptation methods depends on a number of factors including socioeconomic, environmental and institutional factors as well as the economic structure. Thus, the choice of adaptation methods depends on a range of variables which are considered important for the availability, accessibility and affordability of particular adaptation methods. Several studies have identified specific variables which may positively or negatively affect the choice of particular adaptation methods. Deressa *et al*., (2009) concluded that farmers' education, access to extension and credits, climate information, social capital and agro-ecological settings have great influence in farmers' choice of adaptation methods to climate change while financial constraints and lack of information about adaptation methods hinders the farmers' uptake of other adaptation methods.

In analysing options and constraints in adapting to climate change in Ethiopia and South Africa, Bryan *et al*., (2009) insisted on farmers' better understanding of climate change as the way of

reducing its negative impacts. That study found that government farm support, farmers' income, and access to fertile land and credit influence the choice of adaptation methods in South Africa while access to extension and credit, farmers' income and information about climate change influence the choice of adaptation methods in Ethiopia. That study further found that the main barrier to uptake of other adaptation methods in both countries was lack of access to credit.

However, as mentioned earlier, the most important factors for uptake of adaptation to climate change is the availability, accessibility and affordability of adaptation methods to climate change using assets which they have. Therefore, this study will seek to capture information on the adaptation strategies being employed by subsistence farmers in South Africa using Ward 24 of Polokwane local municipality as the case study. The starting point will be identifying what can be perceived as assets from literature. These assets are but not limited to access to credit and extension, farmers' awareness about climate change knowledge about climate change and adaptation strategies, availability of capital and improved seeds, availability of water for irrigation, farmers' income, the size of the household, farmers' experience, engaging in non-farm activities, knowledge about adaptation methods, education and gender of the head of the household, livestock ownership, social capital agro-ecological settings government farm support, access to fertile land.

2.10 The role of assets in enhancing subsistence farmers' household adaptive capacity

Assets are envisaged to play a significant role in enabling households and communities to adapt to the challenges of climate change (Tawodzera, 2012). According to Ford Foundation (2004), assets are defined as a stock of financial, natural, human or social resources that can be acquired, developed, improved and transferred across generations. There are five different types of assets that can aid in the process of adaptation. These include physical, natural, financial, social and human capital. Human capital includes knowledge of climate risks, conservation agriculture skills, good health to enable labour; Social capital includes women's savings and loans groups, farmer-based organisations, traditional welfare and social support institutions; Physical capital includes irrigation infrastructure, seed and grain storage facilities; natural capital includes reliable water sources, productive land, vegetation and trees; and Financial capital includes Micro-insurance, diversified income sources (World bank, 2009).

Asset adaptation refers to the means and ways in which people use assets that they possess to anticipate and deal with the challenges resulting from climate change (Tawodzera, 2012).

Assets are central to the adaptation of subsistence households when it comes to climate change. This is in line with what Bebbington (1999) points out, people with assets have the "capability to act and to be", thus creating agency.

2.11 Conceptual framework on climate change adaptation through assets

Communal farmers in Limpopo province are vulnerable to climate change. In the context of rural agrarian livelihoods, this vulnerability is influenced by exposure to climatic hazards and the underlying sensitivity of the natural resource to such hazards. Hufschmidt (2011) views vulnerability as the conditions determined by physical, social, economic and environmental factors or processes which increase the exposure of a community to the impacts of hazards. Furthermore, vulnerability must always be linked with a specific hazard or set of hazards so that vulnerability and exposure in the context of climate change become inseparable (Blaikie *et al*., 1994). The IPCC (1996) theorizes that the extent to which climate change may damage or harm a system depends not only on a system's sensitivity, but also on its ability to adapt to new climate conditions.

Since Limpopo province has a semi-arid climate, communal farmers are most likely to be exposed to long dry spells which will ultimately expose them to droughts and veld fires. These communities will be much more sensitive to changes in rainfall patterns as they heavily depend on rain-fed agriculture. Sensitivity in this sense means the degree to which a system will respond either negatively or positively to changing climatic conditions (Kelly & Adger, 2000).

The combination of vulnerability and sensitivity will give rise to the potential impacts of natural and human systems (McCathy *et al*., 2001; IPCC, 2007). Crop and livestock production will be affected by increased temperatures, changing precipitation patterns and more frequent and intense weather events. These will have direct effect on crop growth and their need for water, soil fertility, irrigation water supplies and prevalence of pests and diseases (FAO *et al*., 2012). This will result in poor yields which affects food production. Once food production is affected, it also means unsustainable livelihoods for these communal farmers.

The ability to respond to these impacts will determine how vulnerable individuals, households or communities are to climate change and it will also determine their adaptive capacity. In this case, communal farmers can adapt through assets in order to overcome the threats, difficulties and challenges posed by climate change. When people use have these assets and utilize them, they have the capability to be and to act (Bebbington, 1998) thereby enabling them to decide

what to do, when to do it and how to do whatever is necessary for them to sustain their livelihoods through these changes.

2.11.1 Human capital

Human capital refers to investments in education, health and nutrition of individuals (Moser, 1998). Moser (1998) links labour and health status to investment in human capital and argues that health status influences people's capacity to work, whereas skills and education determine the returns from their labour. Therefore, to build a long-term resilience against the dangers of climate change, the duty lies on individuals, families, societies and nations to strengthen human capacity through education; which can help to improve health status and eradicate extreme poverty (Muttarak & Lutz, 2014). The fact that human capital centrally revolves around education, plays a crucial role in ameliorating some of the negative impacts of climate and extreme weather events both directly and indirectly change.

According to Lutz and Skirbekk (2013), formal education is one of the direct key ways through which individuals and families acquire knowledge, competencies and skills that boost their adaptive capacity in the context of climate change. Experts believe that literacy, general life skills and intellectual thinking obtained through education give better understanding and the ability to internalise risk information about weather forecast and warning messages (Muttarak & Lutz, 2014). Moreover, Ishikawa & Ryan (2002) emphasize that formal education equips individuals and families with problem solving skills. Thus, when calamities related to climate change such as droughts or floods occur, educated individuals might be readier to respond and act upon the event than their uneducated counterparts.

Finally, education can promote a reduction in an individual's vulnerability to climate related disasters through increasing socio-economic resources, facilitating access to information and enhancing social capital. Educated societies will therefore have greater economic and institutional capabilities necessary for successful climate change adaptation. In Ward 24, it is envisaged that farmers with higher education levels may be able to adapt more successfully to climate change than the less educated.

2.11.2 Social capital

According to Moser (1998; 2006) social capital is defined as an intangible asset consisting of the rules, norms, obligations, reciprocity and trust embedded in social relations, social structures, society's institutional arrangements as well as the rules and regulations governing formalised social institutions. Social capital predominantly occurs at a micro-institutional level

(in households, families, clans and communities (Apraku, 2015). As part of those strategies aimed at addressing climate change impacts, social capital is relevant in building adaptive capacity at both household and community levels as one of the fundamental conceptual principles (Pelling & High, 2004).

Pelling & High (2004) argue that social capital can be used to address or respond to background climate stress. This can be attained by investing in the youth and children's education to enhance their human and social capitals as a means of boosting familial and societal resilience to future climate risks (Pelling &High, 2004). With individual and collective contributions towards youth education, experts believe that public participation in procedures and processes of collective decision-making towards climate change, resilient policies would be enhanced (Putnam, 1995; Pelling & High, 2004).

Social capital as an asset has three ways in which it can be used to mediate the impacts of climate change (Apraku, 2015). The first way identified is support networks and relationships through trust, values and norms (Szreter & Woolcock, 2004). They argue that the reciprocity embedded in social relations and networks and the trust in the associated norms and values can be helpful in offering assistance to flood, storm, drought and many other forms of climate disaster. The second way as identified by Szreter &Woolcock (2004) is social capital working towards reducing social and economic inequalities through individual and community support systems. They indicate that reduced social and economic inequalities through various support systems can help enrich households' stock of other asset portfolios such as financial or physical capital. The third way according to Szreter& Woolcock (2004) is social capital being a channel through which people can have access to other resources, which were previously lacking. Drawing on the three scenarios, it can be suggested that there is a positive link between social capital and climate change impacts mitigation at individual, household and community levels.

2.11.3 Physical capital

Physical capital refers to the stock of plant, equipment, and other productive resources owned by individuals, community, the business sector or the country itself (Moser, 1998; 2006). In order to engage in effective and sustainable productivity, individuals and communities need physical resources such as, equipment, machinery and other forms of infrastructure for production purposes (Scoones, 1998). Thus, physical capital allows people to develop strategies that can improve their resilience and adaptive mechanisms in the face of various climate change impacts. Dulal *et al*., (2010:12) argue that a group of persons, families, or a

society with no or limited physical capital is at high risk of being severely affected by climate related disasters partly because of weak resilience.

2.11.4 Natural capital

Natural capital refers to the stock of environmentally provided assets such as soil, atmosphere, forests, minerals, water, and wetlands (Moser, 1998; Frayne *et al*., 2012). It complements the contributions of other asset stocks in mediating the vulnerabilities of climate change on the livelihoods of individuals and communities. For instance, rural dwellers in developing countries mainly depend on natural capital for their livelihoods due to low levels of infrastructural development (Dulal *et al*., 2010). The ability to protect the natural capital stock of various communities from depletion and damage can serve as a vital coping and adaptation strategy against climate induced impacts (Dulal *et al*., 2010). For example, the availability and proper utilisation of fertile soils for agricultural purposes; water from rivers, streams and lagoons for irrigation, domestic consumption and fishing for consumption are some of the guaranteed methods for averting food and water insecurity in rural settlements (Traldi *et al*., 2013). Preserving natural resources does not only enrich the natural capital portfolio of local communities but also reduces the depletion of plant and animal species (i.e. ecosystems and biodiversity conservation). Dulal (2010) concludes that individuals and communities with lower natural assets stock are more susceptible to climate change impacts while those with higher endowments are more resilient to climate induced impacts.

2.11.5 Financial capital

According to Moser (1998) financial capital refers to financial resources available to people, such as income, remittances, savings and supplies of credit. Financial capital is critical in combining various types of coping and adaptation strategies available to people. Therefore, it draws together other forms of asset capitals required for successful coping and adaptation strategies in high climate risk areas. Access to financial and credit facilities from wages, remittances, savings, banks and other microfinance institutions improves people's adaptive capacity and reduces their vulnerability levels to climate induced calamities (Dulal *et al*., 2010). Low-income groups in communities are generally slow in responding to, and recovering from climate shocks as their low financial capital status does not allow them to regain their lost livelihoods in as timely as those from affluent communities. Lutz *et al*., (2008) argue that, even though both poor and rich individuals may suffer the same losses due to climatic disasters, victims with relatively well-endowed financial capital are more likely to recover quickly from

such losses than their less endowed counterparts. In a nutshell, individuals and households with higher earnings have more financial capital to subscribe to costly, but effective and efficient disaster precautionary and protective measures and policies, than lower earning households (UNDP, 2007).

Table 2.2 Types of assets

Type of assets	Examples
Human capital	Knowledge of climate risks, conservation agriculture skills, good health to enable labour
Social capital	Women's savings and loans groups, farmer-based organisations, traditional welfare and social support institutions
Physical capital	Irrigation infrastructure, seed and grain storage facilities
Natural capital	Reliable water sources, productive land, vegetation and trees
Financial capital	Micro-insurance, diversified income sources

Source: World Bank 2009

The assumption is that when communal farmers have these assets they will be to adapt to climate change. However, since these farmers do not live in an isotropic plane there are certain external factors which will impact the way they adapt to climate change even if they can have access to these assets. These factors include government policies, political institutions as well as regulatory and legal frameworks.

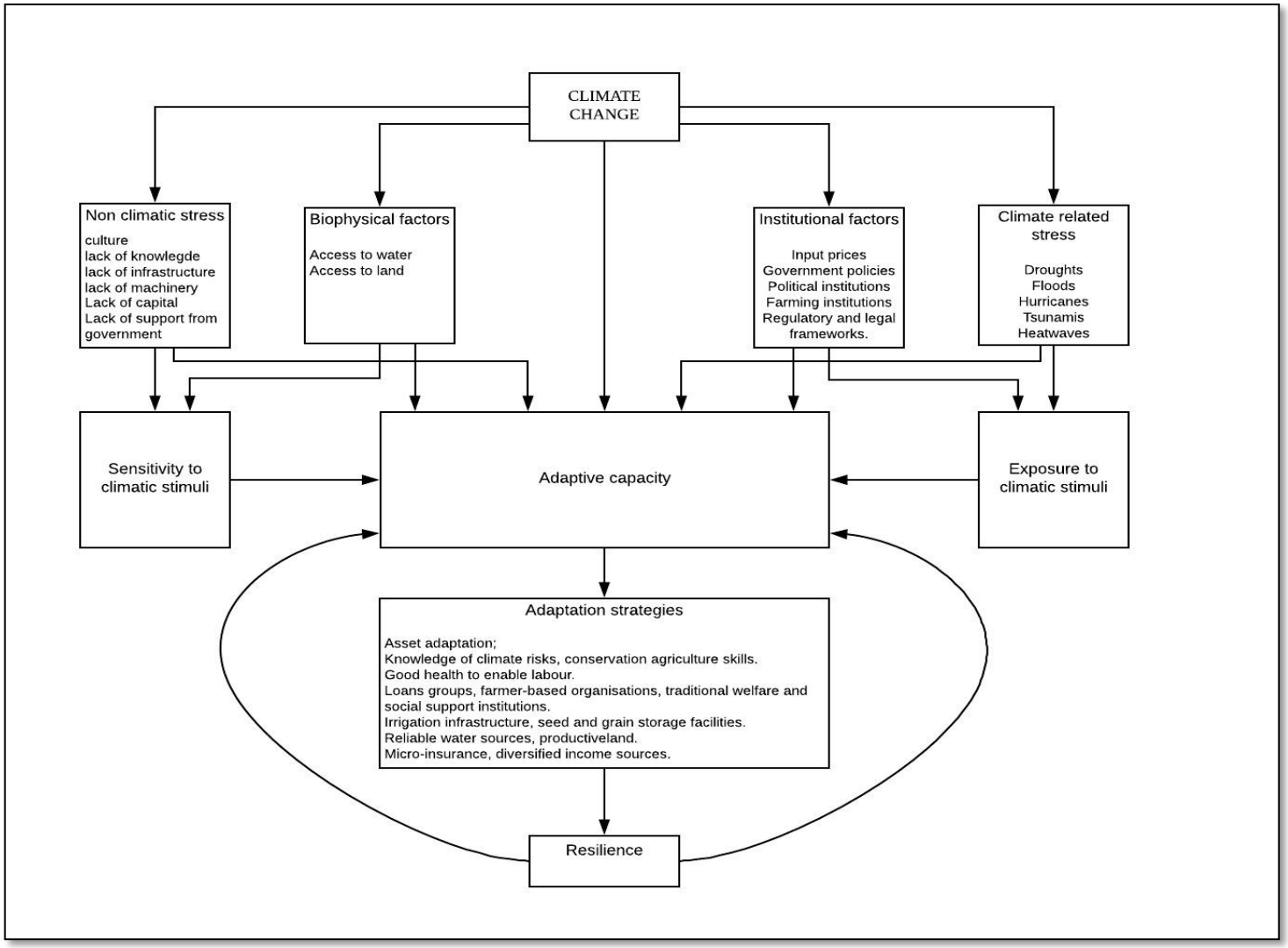

Figure 2.1Conceptual Framework of climate change and asset adaptation by subsistence farmers.

2.12 Conclusion

This chapter has set a theoretical background of the study by contextualising climate change trends across the world, the impacts as well as the adaptation strategies being employed to curb climate change effects. Scientists have provided enough evidence which proves that climate change is a measurable reality and that the earth is warming at an alarming and unprecedented rate. Global, sub Saharan and SADC climate change trends have all shown that temperatures are increasing due to climate change. This has led to impacts such as floods, droughts, high rates of evapotranspiration and temperature increase and these impacts have a direct effect on agriculture and the general livelihoods of subsistence farmers. Various adaptation strategies are used across the world and in some African countries to adapt to climate change. Some of the strategies used by subsistence farmers include crop diversification, livelihood diversification, crop and livestock insurance, change of planting dates, irrigation and intercropping. However, farmers also encounter challenges in using these adaptation strategies and in the end, they fail to adapt. The challenges hindering adaption are basically lack of knowledge, financial assets and appropriate farming technologies and machinery. It has also been shown in the review that the adaptive capacity and resilience of any given community, household or individual also depends on the various assets that they possess and that assets, if well harnessed and utilised, can provide an invaluable relief to households of any given community in the face of climate change impacts. The next chapter elaborates on the methodology used in this study.

CHAPTER 3: METHODOLOGY

This Chapter gives a background on the study area and the methodology used to accomplish the objectives of the study. It elaborates on the sources of data for the research, the sampling procedures employed to collect primary data, and the data analysis methods.

3.1 Study area

The study was conducted in Ward 24 of Polokwane Local Municipality in the Capricorn District. Ward 24 is located 27km east of Polokwane and 10km from the University of Limpopo. The district in which the study area falls is situated in the center of Limpopo Province, sharing its borders with four district municipalities namely: Mopani District and Vhembe District in the eastern quadrant, Sekhukhune District and Waterberg District in the Western quadrant see Figure 3.1 below.

According to census 2011, Ward 24 has a population of 22130 people, 11732 of these being females and 10397 males (Stats SA, 2014). Ward 24 is an agricultural based village with 5582 households in an area of 2.83km^2 (Stats SA, 2014). The villages predominantly engage in smallholder farming systems with low levels of production technology. The size of the average farm holding in the village is approximately 1,5ha (Baloyi, 2011). Production is primarily for subsistence with little or no surplus for sale.

Being in the Polokwane Local Municipality, Ward 24 features a semi-arid climate under the Koppen Climate Classification system. The average maximum temperatures in this area reach range between 21ºC and 22ºC in summer while the minimum average temperatures fall to 11ºC in winter (Baxter, 2010). This area has a dry climate with a summer rainy season and a pronounced dry spell during winter. The average annual rainfall is about 495 milliliters (Baxter, 2010).

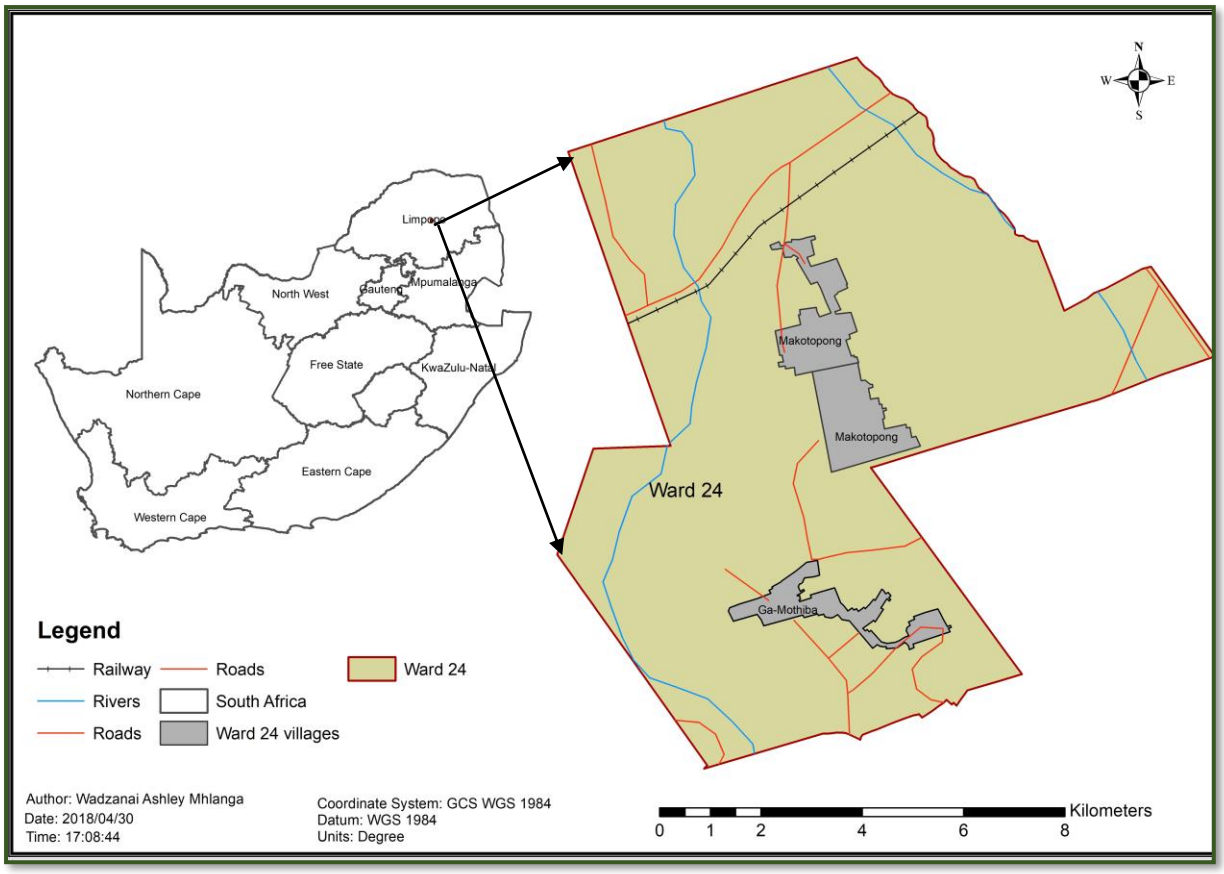

Figure 3.2 Location of Ward 24 in Polokwane Local Municipality, Limpopo province.

3.2 Research design

According to Bryman (2008), a research design relates to the criteria that one can employ when evaluating any academic research. "Bryman (2008, p.31) further states that "a research design provides a framework for the collection and analysis data." To achieve the objectives of the study on farmer adaptation through assets in Ward 24 of the Polokwane local municipality, a case study approach was employed. A case study refers to an in-depth study in which an individual, group or a situation is studied (Yin, 2004). Due to the complexity of the case study approach, large amounts of data will be produced which will be enough to use for data analysis. Researchers from many disciplines use the case study method to build upon theory, to produce new theory, to dispute or challenge theory, to explain situation, to produce a basis to apply solutions to situations, to explore or to describe an object or phenomenon (Soy, 1997). Thus, this study used the case of Ward 24 in the Polokwane local municipality to evaluate the assets that farmers possess and how these assets are helping then to adapt. The detailed qualitative accounts often produced in case studies do more than just establishing the data in real life, but

also help in explaining the complexities of real-life situations which may not be captured through experimental or survey research (Zainal, 2007).

3.3 Secondary data

Secondary data sources were accessed from pamphlets, journals, articles and books on climate change, rural livelihoods, and climate adaptation that were available at the University of Limpopo library and on the internet. These sources aided in reviewing literature on climate change and subsistence farmer adaptation through assets especially at a regional level, to understand how farmers elsewhere have adapted. Other information sources included the Polokwane Local Municipality where information on population of the study area and listing of households in Ward 24 was obtained. The review of literature was also important in generating the conceptual framework for this research. Having a conceptual framework is important as it indicates the direction of the research and the variables to be considered.

3.4 Primary data

Primary data was collected in Ward 24. A mixed methods approach which includes quantitative and qualitative data was used. The use of two data collection methods enabled the researcher to find the best possible information about climate change and asset adaptation by farmers in Ward 24 of the Polokwane local municipality. Furthermore, it is advisable to use more than one method of collecting data to ensure the reliability and validity of results (Zorhabi, 2013). This is in line with Campbell & Friske (1958, p.268) argument:

> *"more than one method data collection should be used as a measure of validation to ensure that any variance reflected is that of the trait and not of the method and that the results obtained are valid not merely a methodological artefact."*

Thus, the mixed methods approach to research generally seems to allow the various strengths from qualitative and quantitative methods to be capitalized upon the weakness that can arise by using only one method (Bryman, 2008).

3.5 Sampling

For this study, a sample survey was used. In a sample survey, only part of the total population is approached for information on the topic under study. A sample is defined as a set of observations taken from the population for the purpose of obtaining information about the population (Kennedy, 2008). To conduct a sample survey, sampling is a pre-requisite.

Sampling is the process of selecting units for inclusion into the study. For instance, selecting only a few people from a bigger population of interest and then studying that sample with the aim of generalizing the results back to the population from which the sample had been selected (Bryman, 2008)

3.5.1 Sampling frame

A sampling frame is the list from which potential respondents are drawn (Kennedy, 2008). In this study, all the households in Ward 24 of Polokwane local municipality constituted the sampling frame. The choice of using the household as a sampling unit was necessitated by the fact that most farming operations are, according to the FAO, made at the household level (FAO, 2008). These decisions directly impact on processes at the farm level regarding farming and adaptation. The total number of households in the two villages of ward 24 was 2699 (Stats SA, 2011) and these households constituted the sampling frame.

3.5.2 Sample size

Sample size refers to the number of households that take part in a survey in a study area. The sample size must be able to represent the entire population. Various statistical procedures have been developed to produce acceptable sample sizes. For this study, the sample size was derived using a formula developed by Glenn (1992). This formula uses 95% confidence level and an error margin of 8%.

$$n = \frac{N}{1 + N(e)2}$$

Where : n = required sample size

N = sampling frame

e = level of precision/ error margin (0.08)

Calculating the sample size for ward 24 of Polokwane Local Municipality

$$n = \frac{2699}{1+2699(0.08)2} = 148 \text{ households}$$

Where: n = necessary sample size for ward 24

N = Estimated population size for ward 24 (2699households)

E = level of precision/ error margin (0.08)

Using this formula, the sample size for Ward 24 was 148 households. This represents 5% of the entire population. The sample size was deemed adequate for this research, because, as Payne (1983, p32) argues, "a survey that involves 5-10% of the entire population is fairly representative of the total units if the population from which the units are selected is less than 10000."

3.6 Sampling methods

3.6.1 Simple random sampling

Simple random sampling was used to select households for inclusion in the sample. This process involved generating 148 random numbers through Microsoft Excel and then using these numbers to select households from the municipality list which was arranged using stand numbers. The selected households thus became the sample for the study.

3.6.2 Purposive sampling

Purposive sampling is a non-probability sampling method where respondents are selected based on their ability to provide information relevant to the research questions (Ritchie and Lewis, 2005). Thus, in this study, key informants were selected based on the fact that they were able to provide information on climate change in general and adaptation processes in Ward 24 in particular. Such information was key to achieving the objectives of the study. These key informants included the village induna and an agricultural extension officer.

3.7 Research tools

3.7.1 The questionnaire

As indicated in section 3.5.2 above, questionnaires were administered to 148 households that were randomly selected from the two villages in Ward 24 of the Polokwane local municipality. The table below shows how questionnaires were distributed in the 2 villages.

Table 3.1 Questionnaire distribution in Ward 24 villages.

Village name	Number of households	Sample from each village	% of total sample
Ga-Mothiba	540	30	20
Makotopong	2159	118	80
Total	2699	148	100

The questionnaire accommodated both open ended and closed ended questions (Appendix A). The choice of closed ended questions was based on the fact that such questions are easy for respondents to answer, and also for ease of data capturing. In addition, answers from different respondents can be easily compared and analyzed statistically (Ursa, 2003). The open-ended questions were used to explain the trends emerging from the quantitative analysis of the collected data. Were necessary, direct quotes from individuals were used in the analysis. The questionnaires gathered demographic information, socio-economic status, knowledge on climate change and the assets that the subsistence farmers have and how they are of use in adapting to climate change. Questionnaires were written in English, however, during the course of the interview they were interpreted in Sepedi which is the local language in Ward 24.

3.7.2 Key informant interviews

Interviews with the key informants were structured to collect information of how subsistence farmers in Ward 24 of the Polokwane Local Municipality were adapting to climate change (Appendix B). The key informants included one agricultural extension officer in Ward 24 and a village chief/induna. The agricultural extension officer is important as an adviser to farmers, aiding famers to make better decisions on how to maintain or increase agricultural production. The extension officer is generally armed with the latest techniques and information related to agriculture and relays this information to farmers and agricultural business. The village chief and/or induna were essential in providing the history of farming in Ward 24 and how climate change has been impacting the farmers.

3.8 Data analysis

Data from closed-ended questionnaires was captured and analyzed using the Statistical Packages for Social Sciences (SPSS) software. Qualitative data from open ended questions was

used to support or explain trends identified in the quantitative component of the research. Quotes from respondents were used in the analysis verbatim.

3.8.1 Descriptive statistics

Descriptive statistics were used to gain insights into the demographic and socioeconomic status of respondents. Frequency distributions and measures of central tendency such as the mean and mode were performed for dependent and independent variables. This was done to analyze the socioeconomic characteristics of the respondents as well as farming operations and the frequencies were displayed in the form of graphs and tables. Cross tabulations were used to analyze the effects of knowledge and perception on climate change adaptation and the type of adaptation strategies used. Cross tabulations were also used to see if there were relationships between the assets that households possessed and their socio-economic status.

3.8.2 Chi square

The chi-square test is used to verify the possible relationship between two categorical variables, where a two-way table is created and the observed counts are compared to the expected counts of the cells. According to Moore & McCabe (2003, p. 624) "the chi-square statistic is a measure of how much the observed cell counts in a two-way table diverge from the expected cell counts." Therefore, the chi-square tests the following hypothesis:

H_o: Row and column variables are independent – there is no relationship

H_a: Row and column variables are not independent – there is a relationship

To get the value of Chi-square, the formula below is used:

$$x^2 = \sum \frac{(O - E)^2}{E}$$

This test was used to verify the relationships that were established from the cross tabulations.

3.8 Limitations of the study

The researcher was born in Zimbabwe and is not fluent in Sepedi which is the main language spoken by the majority of farmers in Ward 24. This was a limitation as some of the interviews were conducted in English which some of the farmers were not very fluent in. To minimize this limitation, a translator was always at hand to help in cases where problems of communication arose.

The nature of the research required subsistence farmers to provide information on how they adapt to climate change impacts that affect their agricultural production which encompassed both crops and livestock production. However, few respondents in the ward owned livestock. In addition, the respondents with intimate knowledge of livestock production were generally difficult to get hold of as they were always out in the pastures with the livestock. Not much information was therefore collected regarding livestock and climate change adaptation.

3.9Ethical considerations

In most researches that involve direct contact or one on one session with the respondents to collect data which includes their personal information, the researcher must account for ethical issues. The researcher sought ethical clearance from the Turfloop Research Ethics Committee before going to the field (Appendix C).

3.9.1 Informed consent

Prior, to conducting the research, the purpose of the study was explained clearly to the respondents and the researcher sought their consent to participate in the study. The respondents were further informed of their right to terminate the interview if they so wished without any repercussions to them.

3.9.2 Confidentiality and anonymity

Respondents were informed of the confidentiality and anonymity of their data, both during the data collection phase as well as during the final write up of the report. None of the data collected is therefore presented in a way that makes it possible to identify the individual origin of the data. Furthermore, the researcher did not discuss the information with anyone outside the research team or collect any personal information that could be traced back to the respondents.

3.9.3 Avoidance of harm

The researcher made all efforts possible to avoid any sort of psychological and physical harm to the respondents. The researcher avoided making any reference to offensive stereotypes, assumptions and other statements considered cruel to the respondents.

3.9.4 Respect

Throughout the data collection phase, the researcher paid due respect to the culture of the respondents and avoided approaching them judgmentally.

3.10 Conclusion

This chapter discussed the methodology that was used in the study. This involved using a case study approach to understand the effects of climate change knowledge and perceptions on farmers adaptation as well as the role played by assets. The chapter also elaborated on the data collection and sampling procedures adopted, data analysis approaches as well as the rationale for the approach which combined both qualitative and quantitative procedures in a climate change adaptation study. Matters of research ethics, especially issues of consent, confidentiality and the avoidance of harm to the research participants were also discussed. The next chapter presents and discusses the results of the data collected using the approaches discussed in this chapter.

CHAPTER FOUR: PRESENTATION AND DISCUSION OF RESULTS

4. Introduction

The previous chapter, Chapter Three, elaborated on the data procedures adopted in the study. This chapter thus presents and discusses the findings resulting from the research. It starts by presenting the demographics, socio-economic and farming characteristics of the respondents. The chapter then focuses on the data that is geared towards meeting the objectives of the study: farmers' knowledge and perceptions on climate change and how this impacts on household adaptation strategies as well as the role of assets in enhancing adaptive capacity of the farmers. Quantitative data from the questionnaire was used to generate frequencies and develop graphs and tables while direct quotes derived from the open-ended questions are used verbatim to support and validate trends from the quantitative data.

4.1 Demographics socio-economic and farming characteristics

This section presents and discusses the demographics, socio-economic and farming characteristics of the respondents. The variables analysed include gender, age, income, family size, educational level, marital status, employment status as well as farming characteristics.

4.1.1 Respondents' relationship to household head

Respondents to the study were household members above the age of 18 who were knowledgeable about household information regarding to farming and adaptation strategies at household level. More than half (61%) of the respondents interviewed were household heads (Table 4.1). A total of 13% and 18% were spouses and children respectively. Only 1% of the respondents were not related to the head of the household.

Table 4.4 Respondents' relationship to household head.

Relationship to the head of the house	**N**	**%**
Head	90	61
Spouse	19	13
Child	26	18
Relative	11	7
Non- relative	2	1
Total	**148**	**100**

(Source: Research survey,2017)

4.1.2 Sex of respondents

Of the total respondents interviewed, 37% were males and 67% were females in both villages (Table 4.1). In this study women were more open to respond than men because most women were found to be home during the time of the survey. In cases where one would find a couple, the husband would ask the wife to take over in answering mainly because women are more familiar with household operations.

Table 4.5 Sex of the respondents

Sex of respondents	N	%
Male	55	37
Female	93	63
Total	**148**	**100**

(Source: Research survey,2017)

4.1.3 Age of respondents

Respondents in the study ranged in age from 19 to 90 years old. The mean age of the respondents was 55.17 years. Most of the respondents (42%) were aged above 65 years. This indicates that Ward 24 was comprised mainly of an ageing population. At the lower end of the age spectrum, only 7% of the respondents reported falling in the 15-24 age group, while the 25-34 age group constituted 14% of the respondents. The predominance of an ageing population in Ward 24 does not augur well for farming, as farming is demanding in terms of labour that the older people may be unable to provide.

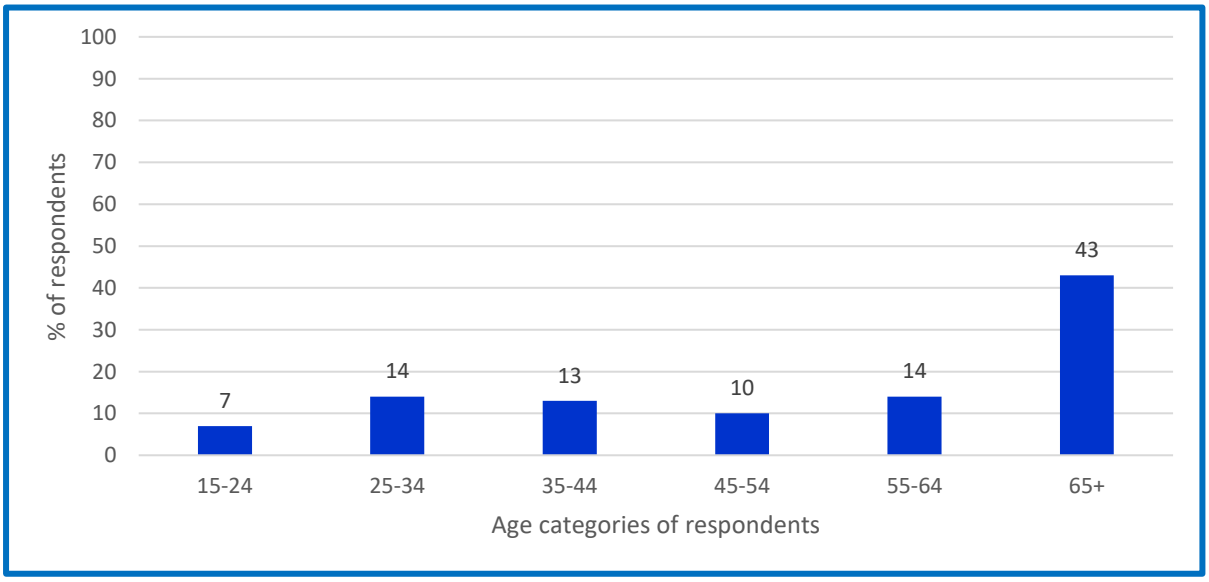

Figure 4.3 Age groups of respondents in Ward 24

(Source: Research Survey,2017)

4.1.8 Marital status

The study sought to record the marital status of respondents. This was deemed important because marital status may also determine the role that one plays in farming operations as well as the decision-making process in farming operations and practices. In addition, marital status is usually used as a measure of the stability of a household, especially as it relates the sharing and exchange of information and transfer of skills regarding farming and adaptation methods. Survey results show that 39% of the respondents were married while 28% were single and 26% were widowed. Only 5% of the respondents reported to have separated with their partners while 2% were divorced and 1% a percent was cohabiting.

4.1.4 Education of respondents

Education has the potential to enhance farming efficiency and knowledge when it comes to agricultural production in both small scale and large-scale farming. Subsistence farmers who are educated are more likely to apply better farming methods and are amenable to embracing new adaptation techniques. Their ability to read, write and listen will also expose them to more information from different media sources, which information may be used to better adapt to the challenges brought about by climate change. Most of the respondents in Ward 24 were literate. This is evidenced by the fact that only 10% of the household heads had no formal schooling (Figure4.4). The majority of the respondents has gone through one educational phase or another: 28% having gone through some secondary education while 20% reported having completed secondary education.

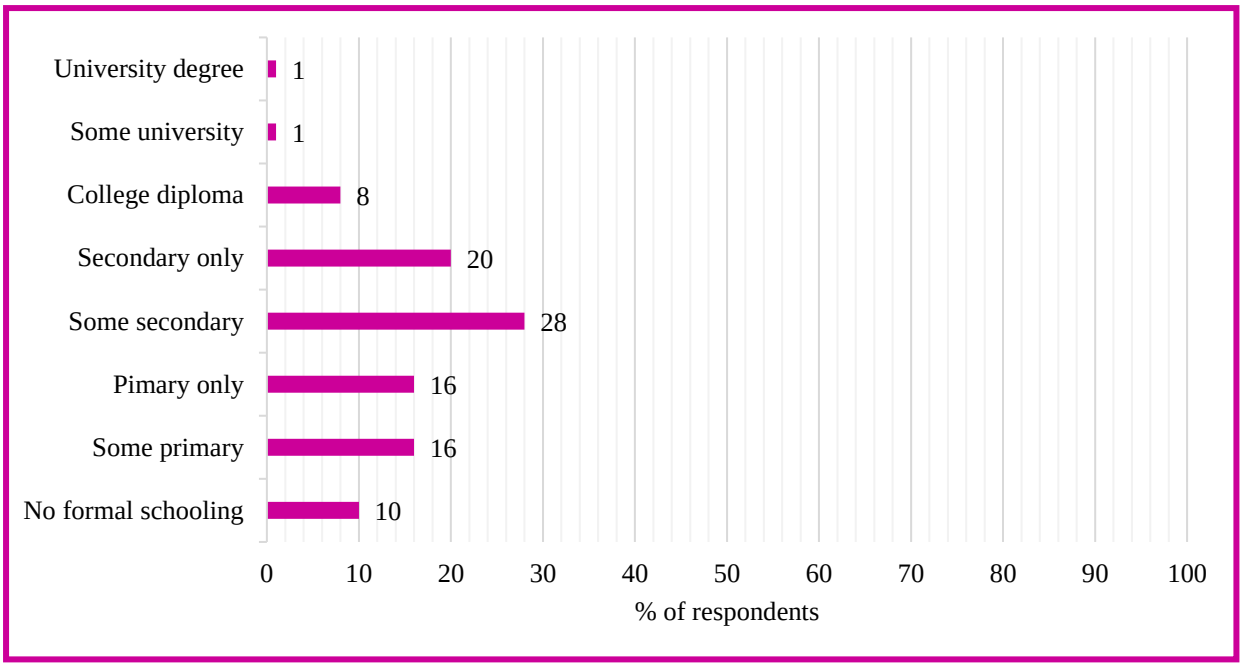

Figure 4.4 Education of respondents

(Source: Research Survey, 2017)

Comparison of literacy level across age groups reveals that most of the younger household respondents were well educated. This is evidenced by the fact that none of the respondents under the age of 24 years reported having no formal education at all. This result was encouraging, given that education has a positive impact on adaptation. Uddin *et al*., (2014) in a study on factors affecting farmer's adaptation strategies in Bangladesh found that the education of young adults impacted positively in enhancing agricultural management and adaptation to climate change.

4.1.5 Household size

The average household size in Ward 24 was 3,16, roughly translating to 3 persons per household. This was above the national household average size in South Africa of 2.2 (ESRI, 2014). The high average household size could be attributed to the fact that the study area was carried out in a village were larger household sizes are common. Most households (42%) in Ward 24 had family sizes ranging between 4-6 people. On the other hand, only 4% of the households had between 11-15 people.

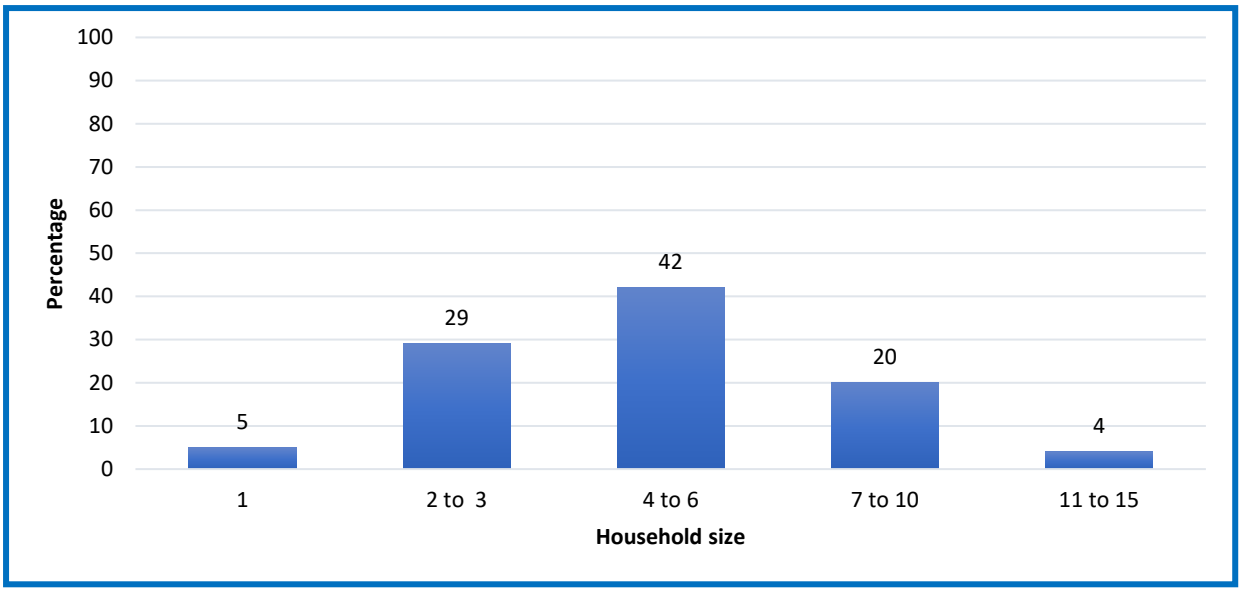

Figure 4.5 Household size

(Source: Research Survey,2017)

4.1.6 Employment status

The study results revealed that 42% and 30% of the respondents were pensioners and unemployed respectively. Such households generally do not have a consistent cash flow as most of them rely on state grants such as the old age, disability and child social grants to survive. Only 7% of the respondents were employed full time, 8% were employed part time, while 13% were self-employed.

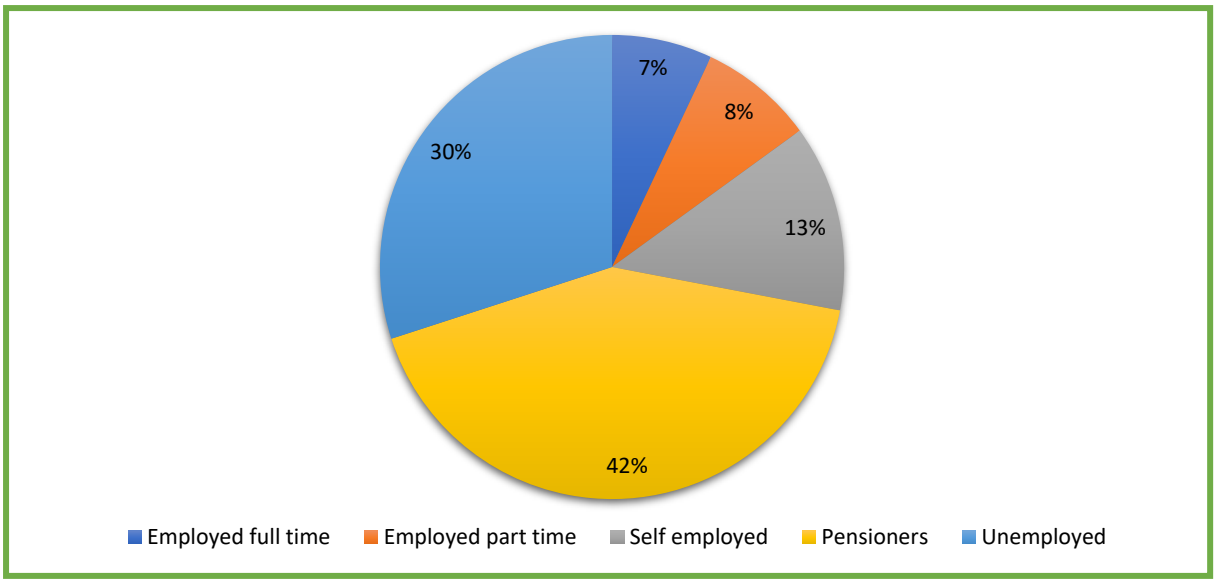

Figure 4.6 Employment status of respondents

(Source: Research Survey,2017)

4.1.7 Annual income sources

The income sources for households in Ward 24 included income from agricultural activities and from other sources: salary, social grants, allowance from children and/or relatives and stokvels. These results reveal that most households were primarily depending on income from sources other than agricultural activities. The annual household income from other sources ranged from R2 400 to R192 000 with the mean annual income being R30 538 (Table 4.6).

Table 4.6 Household annual income levels from other sources

Income levels	**N**	**%**
R100-R2500	7	5
R2600-R5000	4	3
R5100-R8000	1	1
R8100-R15000	13	9
R15000+	118	80
No income	3	2
Refused	2	1
Total	**148**	**100**

(Source: Research Survey, 2017)

More than half (80%) of the households earned R15 000+ per annum. According to table 4.7 most of these respondents are old people who get a monthly old age grant of approximately

R1 600 per month. Nine percent earned between R8100 – R15000 and only 2% of the respondents had no income at all.

Table 4.7 Household annual income from agricultural activities

Income levels	**N**	**%**
R100-R2500	8	5
R2600-R5000	11	7
R5100-R8000	3	2
R8100-R15000	4	3
R15000+	4	3
No income	118	80
Total	**148**	**100**

(Source: Research Survey, 2017)

The survey results reveal that four fifths of the households (80%) had non-agricultural income even though they were farmers. Only a few (20%) were getting any income from their farming activities because their primary reason for farming was to obtain food. Furthermore, only 5% get annual income between R100 and R2500 and 7% also got an income between R2600 and R5000. Those who get an income above R15000 constituted only 3%. The reason for a low agricultural income is basically because most households produce for subsistence and not primarily for selling. Both crop and livestock farmers in the ward mainly produce for subsistence (figure 4.8).

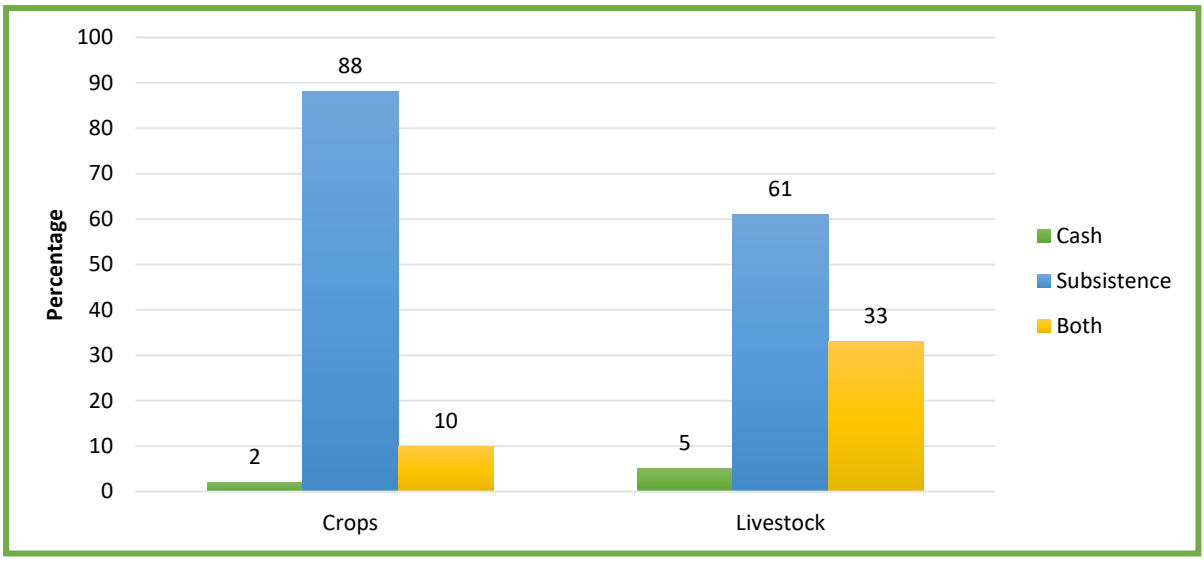

Figure 4.7 The use of crops and livestock at household level

(Source: Research Survey, 2017)

4.1.9 Number of years living in the Ward

Most of the respondents have lived in the ward for considerably longer periods of time. A total of 31% of the respondents had been living in the ward for 31-50 years while 19% had stayed in the ward for 51-70 years. A further 23% had been living in the ward for more than 70 years. These results also reveal that most of the respondents had been born in Ward 24. It was predicted in the survey that living in the ward for a long time might result in the respondents having more knowledge on how the climate of the area has been changing over the years, how it has affected production and the best adaptation methods that are likely to work for that area specifically.

4.1.10 Household coping strategies

Household coping strategies are defined as the mechanisms employed by households when the means of meeting needs are disrupted by one or a combination of factors including drought, low income, high food prices or poor crop production (Kruger *et al*., 2008). It was important in this study to learn about the coping strategies that farmers use when they ever run out of resources during the month. It has been indicated in Section 4.1.6 that 42% and 30% of the respondents were pensioners and unemployed respectively. Such people did not have a consistent source of income and hence were susceptible to running out of food and money to

cover their daily basic needs. As Figure 4.9 shows, 41% of the households reported running out of food and money sometimes during the previous month.

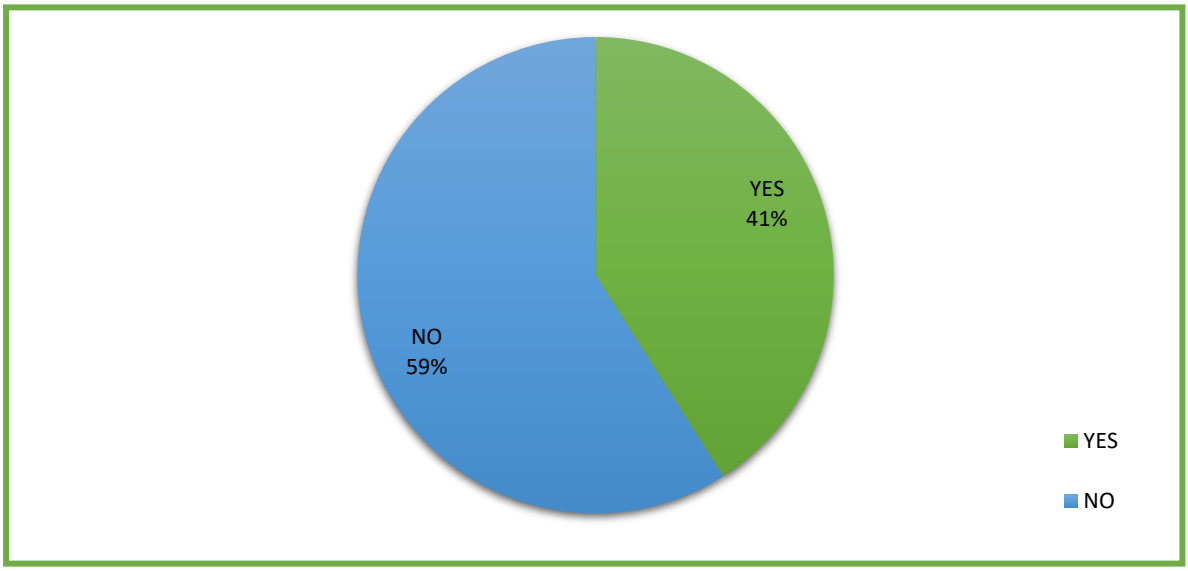

Figure 4.8: Experience in food shortage and money to meet basic needs

(Source: Research Survey, 2017)

Of the 60 respondents that experience food and money shortages, some had coping strategies they adopted to survive while others had none. About 37% reported that they resort to borrowing either food or money from neighbours or friends. The other 37% did not did not have any coping strategies, refusing even to borrow and just waiting for offers or their social grant money. Only a few (2%) resort to loan sharks'/ money lenders. The results also reveal that 58% were relying on help from relatives and/or children.

Table 4.8 Household coping strategies

Coping strategies	**N**	**%**
Begging	5	8
Borrowing	22	37
Loan sharks	2	3
Advance from work	1	2
Help from relatives/children	5	8
None	22	37
Others	3	5
Total	**60**	**100**

(Source: Research Survey,2017)

4.1.11 Farming systems

A farming system, in the context of this study, relates to whether a household relies on rain-fed agriculture or makes use of irrigation methods, as well as whether the household relies on crops, livestock, or both. Survey results presented below indicate that more than half of the households (60%) were depending on rain-fed crop production while 14 % were irrigating their crops. A total of 26% of the households were adopting both methods.

These results validate findings from across the African continent that the majority of subsistence farmers across the African continent rely on rain fed agriculture. In Ethiopia, for example, Von Braun & Olofinbiyi (2007) revealed that 78% of the small-scale farmers in their study relied on rain-fed agricultural production. Such reliance on rain-fed production means that any changes in climatic and environmental conditions will have a direct impact on small-scale farmers, those in Ward 24 inclusive.

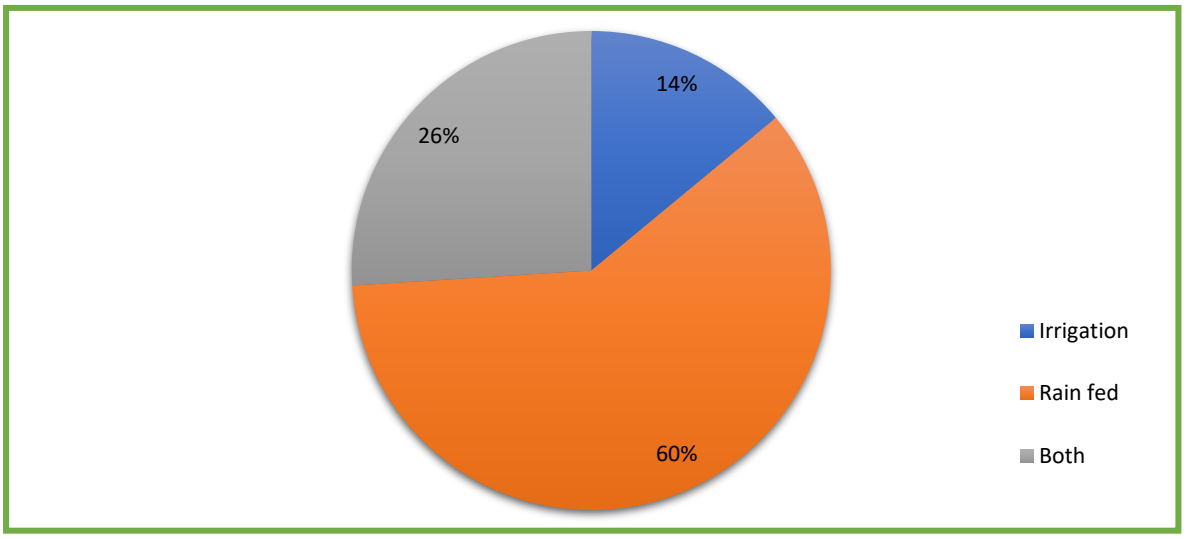

Figure 4.9 Household farming systems in Ward 24

(Source: Research Survey, 2017)

4.1.12 Farming activities

The study sought to know the farming activities that households were engaging in. This was important in order to understand their knowledge about the activities, the history and how the activities were being affected by climate change as well as the adaptation process. The farming activities in the ward included crop farming: growing of grains, fruits, roots and tubers as well

as leaf vegetables and livestock farming which included the rearing of animals. There were other farmers that were practising mixed farming, which is essentially a combination of crop and livestock farming.

Table 4.9 Farming type employed by households

Farming type	**N**	**%**
Crop farming only	85	58
Livestock farming only	5	3
Mixed farming (crop & livestock)	58	39
Total	**148**	**100**

(Source: Research Survey, 2017)

In total, 58% of the households were engaging in crop farming and only 3% were engaging in livestock farming. However, 39% of the households reported practising mixed farming. Most people who focused mainly on livestock also managed to grow crops, however, very few of those who were mainly growing crops raised livestock.

4.1.13 Land ownership status

In most communal areas, subsistence farmers do not own the land they use, but they however have the right to use the land. The survey results (Table 4.10) shows that 66% of the households used communal land to engage in their farming activities. Only 1% percent of the households was renting the land or cultivating by the roadside.

Table 4.10 Land tenure status

Land tenure status	**N**	**%**
Backyard	116	78
Communal field	98	66
Renting	2	1
Roadside	2	1

(Source: Research Survey,2017) *Multiple responses

The study also found that 78% of the households used their backyards for cultivation. This practice is very common in the country. As Ngqangweni & Delgado (2003, p.94) point out

“smallholder farmers in South Africa share their land between residential and farming purposes.” Although some of the households had communal fields, most of them still cultivated in their backyards. According to the respondents, it has always been a tradition to grow crops in the backyard even though you have a communal field. However, the issue of inconsistent rainfall made most of the residents to focus on backyard cultivation since it is easier to manage a small piece of land.

Figure 4.10 Communal field at top and back yard garden at the bottom

4.1.14 Crops cultivated and animals reared

The most cultivated crop in the ward was maize which was being cultivated by 93% of the surveyed households. Most households cultivated maize because they exchanged it with maize meal at the local millers and this was very helpful since they did not have to use money to buy maize meal in supermarkets. Maize meal is very important as it is used to prepare pap which is the staple food of most South African households. Spinach, a vegetable which is used as a relish, was the second popular crop grown. The predominance of farmers growing spinach derives from the fact that the vegetable is easy to maintain and can be grown throughout the year. Farmers also cultivated roots and tubers such as pumpkins (34%), potatoes (30%), sweet potatoes (30%), groundnuts (16%) and beetroot (16%). The least grown crops in the area were

millet and sorghum and they each constituted 1%. Other crops grown included watermelons, sugarcane, peas, butternuts and tomatoes and carrots.

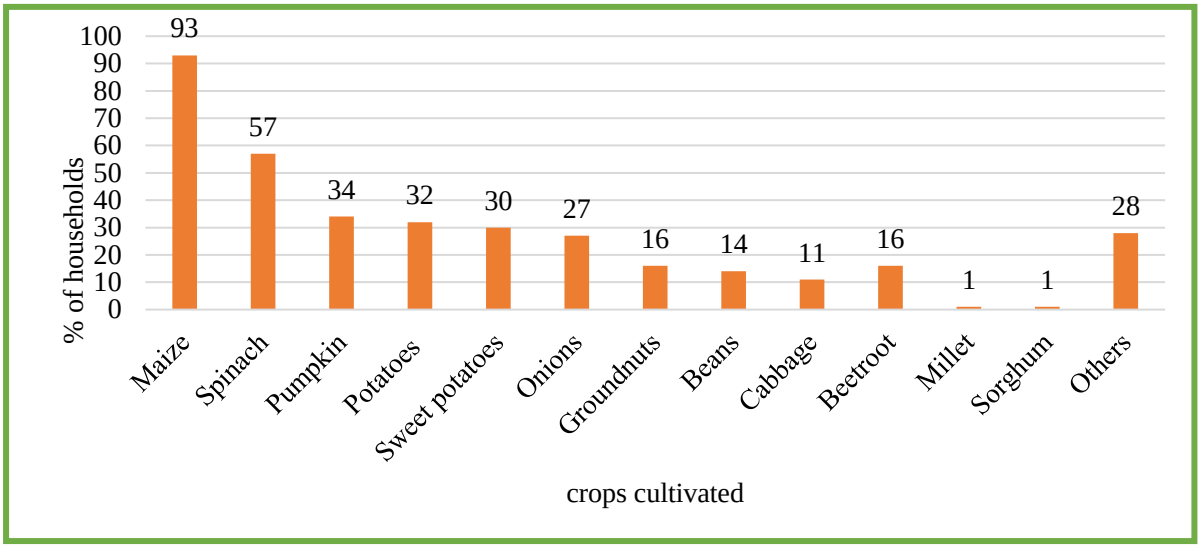

Figure 4.11 Type of crops cultivated by households

(Source: Research Survey,2017) **Multiple responses*

Figure 4.12 Some of the crops that were cultivated in backyard gardens

One of the most important livelihood activity practised by subsistence farmers is livestock rearing. The reasons for keeping livestock ranged from the fact that households would get

income through selling, getting meat as a source of protein, a symbol of wealth and as a source of manure for crops. The most kept animals were cattle, which were being kept by 67% of the households, followed by chickens (62%) and goats (48%) (Table). Only a few households and kept sheep (18%) and pigs (3%) respectively. Other animals which were kept included guinea fouls, doves and rabbits (2%).

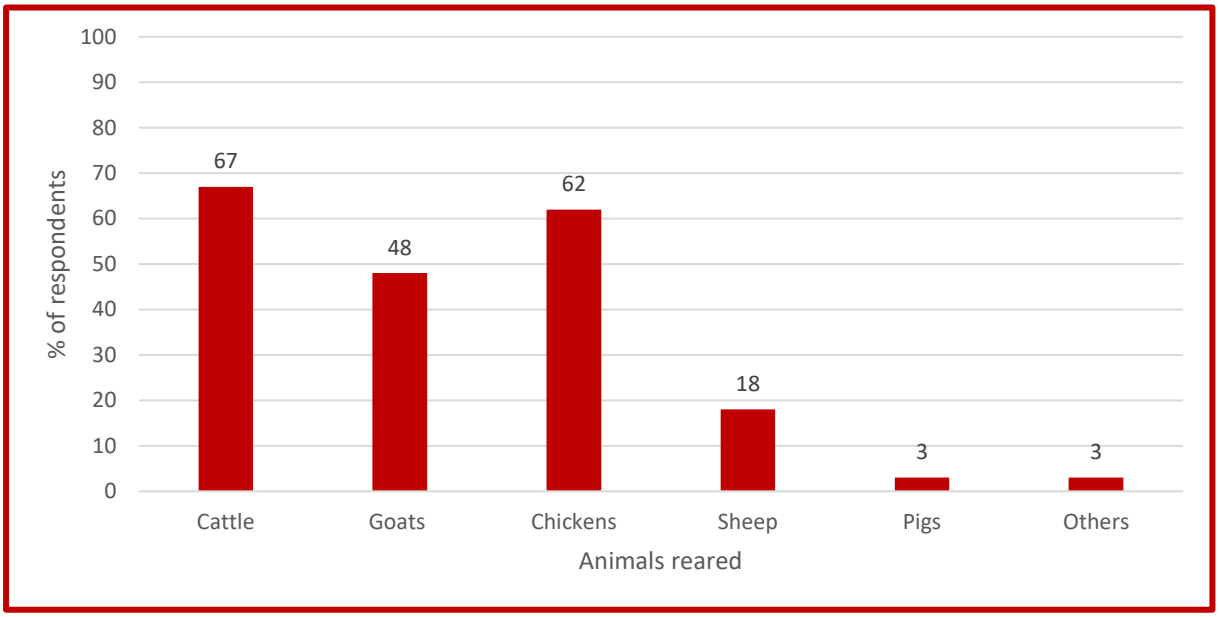

Figure 4.13 Animals reared by households

(Source: Research Survey,2017) **Multiple responses*

4.2 Knowledge and perception of climate change and variability in Ward 24

Climate change and variability are a cause for concern because they affect many aspects of life: availability of water, food production and the general livelihoods. The knowledge and perceptions regarding climate change and variability is therefore important as it may impact on how households embrace or reject adaptation strategies.

4.2.1 Knowledge on climate change

The study found out that majority of the respondents (76%), had some form of knowledge about climate change. Only 24% indicated to not having any form of knowledge regarding climate change and variability. Respondents who had knowledge about climate change described it through changes in different climatic aspects such as temperature, atmospheric pollutants, rainfall, cyclones and seasonal variations.

Table 4.11 Knowledge of respondents on climate change

Question	Theme	Quotes from respondents
What do you know about climate change?	Rainfall	*"that rainfall has decreased and the temperature continues to increase. I believe that climate change is causing changes in the natural systems that is why we are experiencing low rainfall these days"* (Respondent no 5, 10th of July 2017, Ward 24)
	Temperature	*"climate change is the heat we are experiencing. The intensity of the sun is too much; it is no longer the same compared to the olden days. Even at night there is no longer that cool breeze after a long day"* (Respondent no 4, 10th of July 2017, Ward 24)
	Seasonal changes	*"we hear on radio that climate change is making the earth hot, I must believe that this is true because even the seasons are shifting and changing. Summer is very hot and long, even when winter comes you can still feel the heat the same way we do in summer" (* Respondent no 27, 19th of July 2017, Ward 24)
	Pollutants	*"there is too much smoke and dust in the atmosphere and it makes the sky to be unstable*

		causing climate change. This smoke is coming from industries and mines in Gauteng" (Respondent no 85, 5th of August 2017, Ward 24)
	Cyclones	*"climate change is the one which caused catastrophes such as the recent cyclone Dineo" (*Respondent no 5, 10th of July 2017, Ward 24*)*

(Source: Research Survey,2017)

From the above quotes, it can be argued that most of subsistence farmers in Ward 24 had some knowledge on climate change. Although the respondents may not have been endowed with the technical terms regarding climate change and variability, they were nevertheless versed with its causes and impacts, which they described using lay man's terms. About 60% of the respondents indicated that they had heard of climate change on media platforms such as radio, while 13% pointed to television as their source of information. Most respondents indicated that they would hear the information from various sources and be able to relate it to the current environmental changes such as high temperatures, low rainfall, heat waves and cyclones. Other respondents heard about climate change from social media platforms such as facebook, twitter or instagram (9%), and from school (23%). The sources of information varied between ages, with those accessing the information from the internet falling mostly in the 15-24 and the 25-34 age groups. On the other hand, the 35-44, 55-64 and 65 and above age groups seemed to have accessed their information from the radio and television. This finding is important for programming purposes as messages about climate change impacts and adaptation can be tailored and delivered to appropriate age groups through the age-appropriate channels.

4.2.2 Perceptions on climate variability and change

While the majority of respondents attested to having some knowledge about climate change and variability, what were their perceptions on these changes? Their perceptions and knowledge are important because, as Ubisi (2016) argues, smallholder farmers need to be able to identify changes already taking place in their areas for them to be able to institute appropriate coping and adaptation strategies. Furthermore, a farmer's perceptions on climate is a pre-requisite for their chance to cope and adapt (Ubisi,2016). The responses of subsistence farmers' perceptions in Ward 24 are illustrated in figure 4.13.

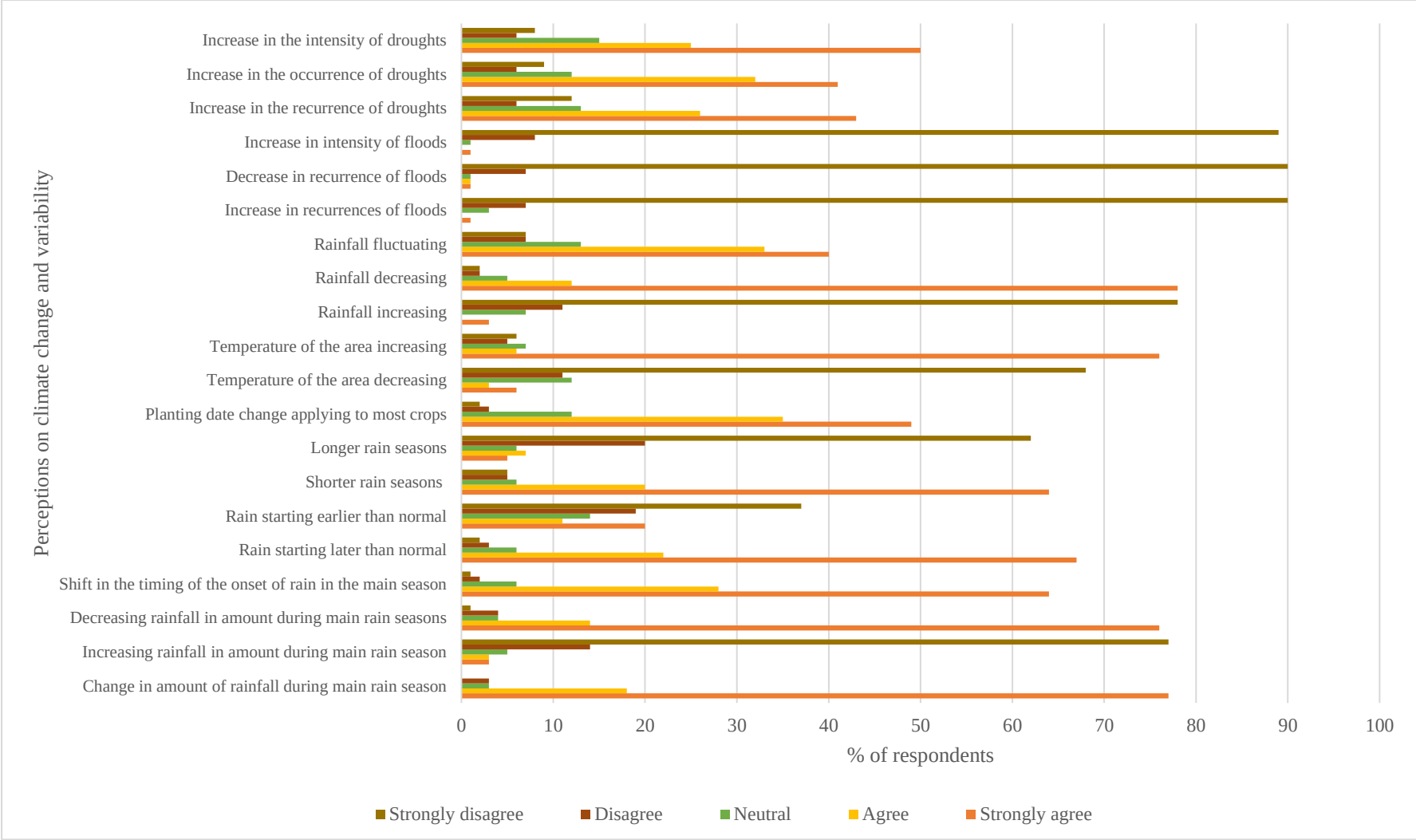

Figure 4.14 Perceptions on climate change and variability

**Multiple responses*

4.2.2.1 Perceptions on rainfall amounts

Most of the respondents (77%) strongly agreed that there have been changes in the amount of rainfall during the previous rain seasons. A total of 76% of the respondents agreed that rainfall had been decreasing in the past years while only 3% were of the perception that rainfall had been increasing. The decrease of rainfall was said to have been influenced by shift in the timing of rain during the main season. One of the respondents had this to say:

> *"The amount of rainfall has reduced and this is being caused by rain not starting during the normal time. Sometimes the rain is early and when it goes away it goes away for good. When the rain is late, we only experience few downpours" (*Respondent 18, 13th of July 2017, Ward 24)

The perceived decrease in rainfall has become a cause for concern in the area because some seasons receive heavy and light rainfall but in a very short space of time and the rainfall is not adequate to support the growth of crops.

4.2.2.2 Perceptions on shifting rain seasons

The decline in rainfall amount was also said to have resulted in the shift of seasons. A total of 67% of the respondents strongly agreed while 24% agreed that the rain season was now starting later than normal, leading to a shorter growing season. Conversely, only 5% of the respondents strongly agreed that the rain season was becoming longer. These findings are in line with Mngumi (2016), who argues that growing seasons have become shorter and the rain season has shifted. Changes in rain season have an influence on the crop planting dates and thus farmers act according to their perceptions. Close to half of the respondents (49%) strongly agreed that planting dates for some of the crops had changed while only 2% strongly disagreed. Most of the crops are only planted when it was raining except for garden crops such as leafy vegetables, tomatoes and onions.

4.2.2.3 Perceptions on temperature changes

The majority of the respondents perceived that temperatures had been increasing in the past few years and that the heat from the sun was becoming very intense. Hence, 76% of the respondents strongly agreed that temperature was increasing while 68% strongly disagreed that

temperatures had been decreasing. The respondents' perceptions tally with conventional knowledge on climate change, which indicates that temperatures are indeed increasing. According to Ziervogel *et al*., (2014), the mean annual temperatures in South Africa have increased by at least 1.5 times the observed global average over the last 50 years. Respondents argued that the temperatures that they were experiencing at night were higher than in earlier years, and that they no longer needed to have blankets at night. In addition, some respondents argued that most of their crops were wilting, showing that indeed higher temperatures were being experienced.

4.2.2.4 Perceptions on floods and droughts

No floods had been experienced in the ward in the past 5 years. Despite this, most respondents indicated that flooding which was constantly occurring in other municipalities and provinces could be linked to climate change and variability. Some respondents even pointed out the existence and destruction caused by Cyclone Dineo in mid-February 2017 as evidence of climate change. Even though their ward was not affected by this particular cyclone, the widespread reports of the destructive nature of the cyclone convinced most of the respondents that indeed, climate change was occurring and influencing the frequent incidence of cyclones.

In terms of drought, 41% of the respondents strongly agreed that they were experiencing drought conditions, while 13% were neutral and only 9% strongly disagreed. The majority of the participants perceived that in recent years, drought occurrences had become more frequent. This has led to decreased production and the abandonment of some crops by subsistence farmers in the area. The respondents argued that there is very little they can do when the soil is dry and temperatures are rising for any crops they cultivate will eventually wilt. This argument is supported by Collier *et al*., (2008) and Rosenzweig *et al*., (2001), who predicted that drought conditions caused by climate change would result in farmers being forced to stop the production of some food crops and even rearing livestock as pastures are degraded.

4.3 Adaptation to climate change in the ward

Climate change is no longer a distant problem. Chapter Two has provided evidence that many countries globally, are experiencing changes in climatic variables such as droughts, high temperatures, variability in rainfall, tsunamis and hurricanes. These effects are a result of the greenhouse effect; whose mitigation is still problematic. Most of the developing countries especially in Africa do not have the capacity to mitigate climate change effects. Adapting to climate change impacts is the only feasible way to reduce the impacts of climate change. In this study, it was important to review the adaption strategies being used by subsistence farmers in Ward 24 at the household level. According to the UNFCCC (2009), adaptation at local level is the most critical issue as local actors are the ones that realise the severity of climate change.

4.3.1 Adaptation strategies used by households

Results from the study revealed that 57% of the households took measures to adapt to climate change while 43% did not. Most of the households were adapting to climate change to sustain their livelihoods as some of them solely depended on farming for food. Subsistence farmers in Ward 24, just like any other farmers across the world, have been trying to adapt to the changes in environment and climate. The adaptation strategies used by the surveyed households ranged from changes in planting dates, soil and water conservation techniques, changes in crop varieties and the use of chemical fertilisers as illustrated in Figure 4.11

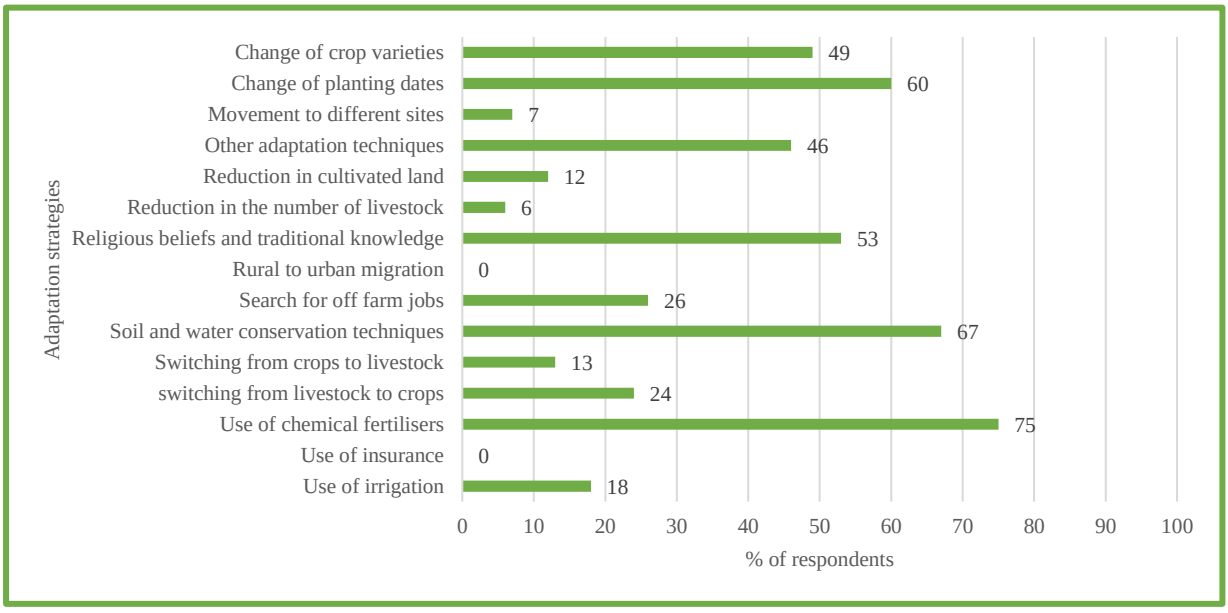

Figure 4.15 Adaptation strategies used in the Ward 24.
(Source: Research Survey,2017) **Multiple responses*

4.3.1.1 Change in planting dates

More than half of the households (60%) that were adapting to climate change reported that they changed their planting dates. This was influenced by how early or late the rains came. Traditionally, farmers would prepare their fields before the rain starts. All they needed to do after land preparation activities was to wait for the rain and begin the sowing process. However, due to the unpredictability of the rain, this system is no longer effective. Most households now start sowing when it starts raining regardless of whether the rain is early or late that season. Preparing the land prior to the start of the rain season is no longer feasible as they may have to prepare the land again when the rains come late, an exercise which is very costly for the farmers.

4.3.1.2 Change in crop varieties

This study revealed that 49% of the households were changing crop varieties. This is meant to ensure that farmers do not depend on one type of crop to sustain their livelihoods. Farmers that plants only one type of crop is exposed to high risks in the event of unforeseen climate changes that could negatively impact on production (Clements *et al*., 2011). One of the respondents said:

> *"I used to plant maize only for subsistence and sell. When these seasons started being unpredictable, I realised I had to do something because my produce reduced drastically and I had to survive. That is when I started planting a wide range of crops from maize, pod crops, leaf vegetables, roots, tubers and even fruits. In this way I could sustain the livelihood of my family." (*Respondent no 123, 24th of August 2017*)*

Changing crop varieties or introducing a wide range of crops increases the chances of farmers dealing with uncertainties brought by climate changes. Different crops respond differently when exposed to harsh climatic conditions. For instance, heat stress may affect one crop negatively but have a positive effect on another. Most of the households confirmed that the reason they plant a variety of crops is to increase their chances of getting more produce.

4.3.1.3 Soil and water conservation techniques

Sixty-seven percent of the households reported adapting to climatic variability and/or changes using soil water conservation techniques. Soil water conservation (SWC) is very efficient to subsistence farmers as it is environmentally, economically and socially beneficial. Households in the ward reported to using a wide range of SWC techniques such as the use of animal waste as manure, rainwater harvesting, crop rotation, intercropping and the use of crop residues. Households that were mostly using cow dung as manure and rain water harvesting were those that were cultivating in their backyard. This is because animal waste and rain harvested water can be used efficiently in a small area. These techniques could not be used in their communal fields which are far larger and would require more labour and resources, which the farmers did not have. The adoption of certain techniques depended on what people had in their households. For instance, rainwater harvesting only benefited those farmers who had water storage facilities: big drums or water tanks. In addition, those that used animal waste as manure were mostly households that owned cows. It would have been expensive for households that were not keeping livestock to use animal waste as they would have had to purchase them.

The study found also out that in the communal fields, farmers made use of remaining crop residues to increase the nutrient and moisture content of the soil. After harvesting, they did not throw away crops residues. Instead, they spread them all over the field and ploughed them into the ground. Other households reported that they were using intercropping. They mostly intercropped legume crops such as beans with maize, where one row would be maize and the other row would the beans throughout the field.

4.3.1.4 Use of chemical fertilisers

The use of chemical fertilisers was also looked at in this study. A total of 75% of the surveyed households reported that they made use of chemical fertilisers. This use was, however, mostly confined to the backyard cultivated areas rather than in the communal fields due to the high cost which made it expensive and unaffordable for most of the poor farmers. Some of the farmers also pointed out that unpredictable rains made it difficult for one to apply fertilisers where one would not be assured that the rains would come. Without the guarantee of rain to provide moisture after the application of fertilisers, most crops are bound to wilt. Mngumi (2016) points out that the use of chemical fertilisers depends on the availability of moisture and cannot be done haphazardly in an environment of unpredictable, rains. Thus, most of the

farmers used fertilisers in their home fields where they could water the plants in case the rains failed.

4.3.1.5 Religious beliefs and traditional knowledge

Some rural areas in Africa are still under the influence of their traditional, cultural and religious beliefs in everything that they do (Malicdem, 2015). These traditional beliefs are likely to impact on how farmers operate and their likelihood to adopt modern farming and adaptation methods. More than half of the respondents (53%) in the study reported using traditional knowledge to adapt to climate change. The old generation in the ward believed in appeasing the ancestors and performing rain making ceremonies in order to improve the chances of receiving better rains. Others however mentioned that such practices were, of late, no longer being adhered to as was the case in the past. One respondent said:

> *"Appeasing our ancestors has always worked, unfortunately our chiefs are becoming too modernised and these practises are fading away. The year 2000 was very dry and a rain making ceremony was performed successfully yielding fruitful harvests and that was the last time it rained." (* Respondent no 38, 17th of July 2017, Ward 24*)*

Other respondents indicated that they relied on indigenous knowledge systems to predict when it would rain and when they should start planting. The colour and nature of clouds would tell them if it was going to rain or not. If the clouds were dark grey and were covering the whole sky, it was a sign that it would rain the following day. If, however, the clouds were dark grey and big, accompanied by strong winds, it would not rain. The explanations by respondents in Ward 24 were similar to the observation by Jiri *et al.* (2015) in Zimbabwe who observed that subsistence farmers sometimes used their indigenous knowledge systems for rainfall predictions.

4.3.1.6 Other adaptation strategies

Figure 4.8 showed that 24% of the households had switched from livestock to crop farming because of the dry spells that households have been experiencing for the past 10 years or so which led to loss of livestock. Besides, loss of livestock due to heat, other households mentioned that livestock theft was very common in the area so they started focussing of crop farming instead. Another adaptation strategy used was searching for off farm jobs (35%)

included child minding, selling of traditional beer, washing laundry and cleaning houses. The study also found that only 12% of the households had reduced the land area cultivated. The argument was that it was much wiser to cultivate a smaller piece of land to reduce the loss of inputs and money spent on ploughing in case they do not harvest anything significant that season. Very few households irrigated their crops mainly because of water shortages in the area. When rainfall is low it also affects water supply from the municipality and this leaves households with prioritising water from taps for domestic use only. Only a few households (18%) that had boreholes could irrigate their crops.

4.3.2 Challenges encountered in adapting to climate change

The discussion in the section above has shown that subsistence farmers in Ward 24 were embracing different adaptation strategies to counter the problems brought about by climate change. However, the farmers were also encountering several challenges in implementing the adaptation strategies. The challenges they were facing are shown in Figure4.17 and are discussed thereafter.

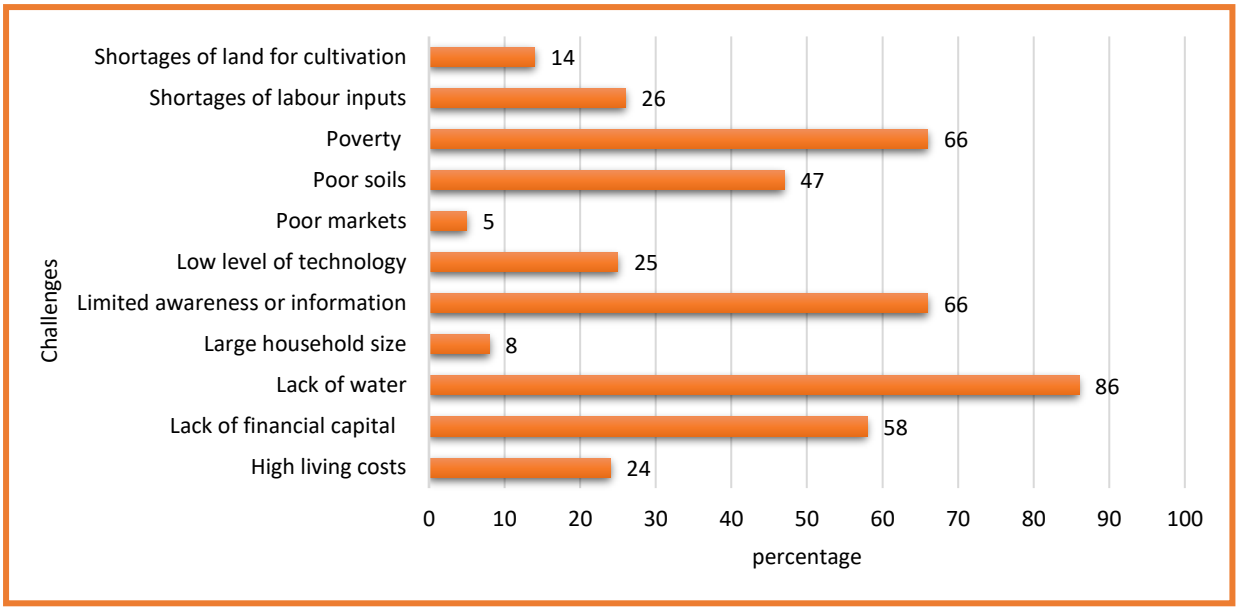

Figure 4.16 Challenges encountered by households in adapting to climate change.

(Source: Research Survey,2017) Multiple responses

Lack of water (86%), limited awareness and information on climate change (66%) and poverty (66%) were the challenges experienced by most subsistence households in trying to adapt to climate change. Lack of water is resulted from the fact that the ward is situated in a semi-arid region which also happens to be a climate change hotspot. Households reported to experiencing low rainfall over the past decade or so and that exacerbated their experiences of water shortages.

Other households mentioned limited awareness and information on climate change as a challenge. There could be several reasons why this is a major challenge. Even though some of the households in Ward 24 had heard about climate change from radios or televisions, not all

of them understood this concept and how it is linked to farming or even how they were expected to adapt and survive. Their lack of understanding even though they had exposure to information was a result of not having anyone to explain the scientific and technical language of climate change and variability. Respondents argued that they were not getting the services from extension officers like they used to back in the days. The inefficiency of agricultural extension services in the distribution of information to subsistence farmers was a challenge to farmers in the ward.

This study also found that poverty was a major challenge and it had influence on other challenges too. The fact that they are poor means that they do not have the financial capital (58%) to afford inputs, machinery and the farming technologies (25%), which were also found out to be constraints hindering them from adapting to climate change. The least experienced challenges which were faced by these farmers included poor markets and large household sizes. Poor markets came across to be the least probably because most if these households produce for subsistence and not for sell (Figure 4.7). On the other hand, large household size was not a popular challenge because few people had large households and most of the households had between 4 – 6 people (Section 4.1.2).

4.4 The effects of knowledge and perception on the adaptation strategies

Knowledge related to climate change and variability, adaptation options and other agricultural production is very essential when it comes to the type of adaptation strategies used by farmers. Lack of knowledge or limitation in information increase the risk of failure that when it comes to adapting strategies used whereas availability of information and knowledge on climate change and variability will help farmers to choose strategies that will make them cope well with these changes. Perception is also critical when it comes to adaptation because one has to perceive climate change associated risks then take steps to minimize the impacts of climate change. This section therefore assesses the effects of knowledge and perceptions of Ward 24 farmers on adaptation strategies they used.

4.4.1 Knowledge and adaptation

A cross tabulation between adapting to climate change and knowing about climate change was performed and the general trend showed that there was a significant difference between the two ($X^2 = 3.98$, df = 1, P = 0.046). Close to half of the respondents (47%) that confirmed to having knowledge on climate change were also employing one adaptation strategy or another. On the other hand, the few (20%) households that did not know anything about climate change did not practice any adaptation strategies. These results revealed that knowledge on climate change played an important role in whether one was adapting to climate change or not. However, the results also revealed that 29% of the respondents in the ward knew about climate change but they did not practice any adaptation strategies. Despite having the knowledge on climate change, some people do not respond to the effect of climate change due to constraints such as poverty, lack of financial capital, limited awareness and information as specified in Section 4.3.2 of this study. Moreover, people can also fail to respond to the effects of climate change due to their orientation or beliefs (Tripath & Mishra, 2016).

To support the findings that the knowledge that farmers in ward 24 possessed influenced their decision to adapt or not to, respondents who knew about climate change where asked their perceptions on whether climate change was important to them or not. When cross tabulated with adapting to climate change, results showed that 40% and 17% respondents who perceived climate change to be very important and quite important respectively were adapting to climate change. On the other hand, those who did not see climate change to be important were few (3% and 2% respondents) as shown in table below. It is clear that respondents who had knowledge on climate changed took measures to adapt while those who did not have knowledge did not

adapt. This implies that knowledge on climate change and variability influence the farmers' ability to adapt.

Table 4.12 Adaptation to climate change by perception on importance of climate change (%)

	Perception on the importance of climate change				
Are you adapting to climate change	Very important	Quite important	Not very important	Not important at all	Total
YES	40	17	3	2	62
NO	26	7	3	2	3
Total	66	25	6	4	100

(Source: Research Survey,2017)

4.4.2 Perceptions and adaptation strategies

Perceptions of ward 24 farmers on climate change and variability were in line with the observed climatic trends in the country as well as changes in their environments. However, there was a need to check whether perceptions of respondents influenced the kind of adaptation strategies they used and to achieve that, cross tabulations between perceptions and different adaptation strategies was performed.

Most respondents perceived that planting dates for most of their crops had changed (Table 4.13) When cross tabulated with change in planting dates as an adaption strategy used, the results showed that of most of the respondents (43%and 39%) that agreed that planting dates had changed, us made use of change in planting dates as an adaptation strategy. Only 4% of the respondents used the same adaptation strategy even though they did not strongly perceive that planting dates had changed.

Table 4.13 Adaptation to climate change by perception on planting dates (%)

	Perception: Planting date change applying to most crops					
Adaptation strategy: Change of planting dates	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Total
	43	39	14	0	4	100
Total	43	39	14	0	4	100

(Source: Research Survey,2017)

Secondly, the use of irrigation and decreasing in rainfall were cross tabulated and all the respondents that made use of irrigation as an adaptation strategy strongly perceived that rainfall had been decreasing.

Table 4.14 Adaptation through irrigation by perception on decreasing rainfall (%)

	Perception: Rainfall of area decreasing					
Adaptation strategy:	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Total
Use of irrigation	87	13	0	0	0	100
Total	87	13	0	0	0	100

(Source: Research Survey,2017)

Thirdly, the perception on temperature increase was cross tabulated with the use of shades and shelters. Most of the respondents (80%) who adapted to temperature increase using shades and shelters, strongly perceived that temperatures have been increasing of late. Only a few 10%) strongly disagreed.

Table 4.15 Adaptation through use of shades by perception on temperature increase (%)

	Perception: Temperature of area increasing					
Adaptation strategy:	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Total
Use of shades and shelters	80	10	0	0	10	100
Total	80	10	0	0	10	100

(Source: Research Survey,2017)

Fourthly, other respondents used SWC techniques to adapt (section 4.3.1.3). This adaptation strategy was cross tabulated with temperature increase and results showed that 73% respondents who used this strategy also strongly perceived that temperatures in the area had increased. Again, when SWC was cross tabulate with rainfall decreasing, results still showed that there were more people (80%) who strongly perceived that rainfall had decreased. It was clear that their decision to use SWC techniques was influenced by their perceptions that temperature was increasing and rainfall was decreasing leaving the soil dry.

Table 4.16 Adaptation through use of soil water conservation by perception on decreasing rainfall (%)

	Perception: Rainfall trends decreasing					
Adaptation strategy:	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Total
Use of soil water conservation techniques	71	23	3	0	3	100
Total	71	23	3	0	3	100

(Source: Research Survey,2017)

Table 4.17Adapatation through use of soil water conservation techniques and temperature increasing (%)

	Perception: Temperature of the area increasing					
Adaptation strategy:	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Total
Use if soil water conservation techniques	80	8	3	3	6	100
Total	80	8	3	3	6	100

(Source: Research Survey,2017)

Overall, the results from the above cross tabulations have shown that the perceptions of farmers in Ward 24 had a positive effect on the adaptation strategies that they used. According to Tripathi & Mishra (2016), perceptions influence adaptation in a two-step process. Firstly, one should perceive climate change and associated risk, then take steps to minimize the adverse effects of climate change. Ward 24 farmers have shown their capability in perceiving climatic and environmental changes correctly and using adaptation strategies which correspond with the perceived changes. To a lesser extent, some of the farmers have shown their inability to perceive climatic and environmental changes correctly because they still used adaptation strategies to deal with the adverse impacts of climate change even though their perceptions were out of line. These findings correspond with a Tripathi & Mishra's (2016) study that perception should be correct otherwise steps taken based on the wrong perception could have adverse effects.

4.5 The role of assets in adapting to climatic variability and change

There is no clear path in successful adaptation. Section 4.3.2 has shown that households engaged in different adaptation strategies were encountering challenges in trying to adapt. The data below is presented according to the Moser (1998) and Frayne *et al*., (2012) categorisation of assets into physical capital, financial capital, human capital, social capital and natural assets. Hossain & Rahman (2006) argue that assets that are available to households, especially those households that are poor, are likely to help them buy their way out of risk. The purpose of this section is to therefore to discuss the kind of assets that households in Ward 24 possessed and the role that such assets played in enhancing their adaptive capacity. The study found out that 83% of the households owned assets while 17% did not own any assets at all.

4.5.1 Physical assets

More than half (59%) of the farming households had water storage facilities as an asset. Most of them possessed the water tanks which ranged in capacity from 500 litres to 5000 litres and others had water barrels of 200 litres in capacity as well. Only 7% of the households had irrigation facilities which was basically a borehole with a pump. The reason why households had these facilities was mainly because water access is a major issue in the study area.

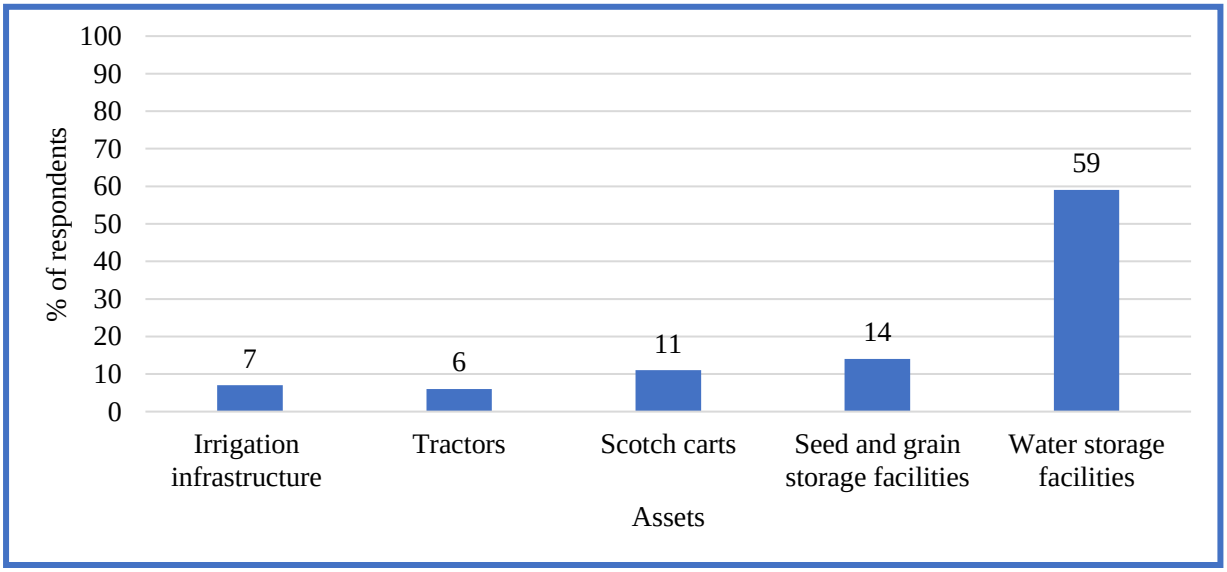

Figure 4.17 Physical assets possessed by households
(Source: Research Survey,2017) **Multiple responses*

Irrigation and water storage facilities were cross tabulated with the general household income and results showed that households which had water storage facilities cut across all the income categories whereas households with irrigation facilities fell under high income categories from R8100 and above. Despite these differences in the socio-economic status, households which had either water storage facilities or irrigation facilities adapted better to climate change. Since access to water in the area was a problem, these households used their storage facilities to keep water for domestic use and those who had bigger tanks and irrigation infrastructure even used the water to irrigate their crops especially when it did not rain much that season.

Figure 4.18 A water tank at one of the surveyed households

The study results show that 6% of the households owned tractors in the area. Households with tractors responded better to climate change impacts because they had to capability to plough and cultivate crops at any given time without any pressure regardless of whether the planting season would have started earlier or later that year. Tractors also enabled them to cultivate larger pieces of land unlike those who had to cultivate manually. At the end of the season, those households with tractors generally had more harvest.

Figure 4.19: One of the few households that owned a tractor

Few households (14%) had seed and grain storage facilities. After harvesting, maize, beans, pumpkin seeds were dried and stored in these facilities. Households with these facilities had the capacity to store a lot of grain for future use either as food or as seeds to plant. Whereas, households without these facilities were forced to consume crops while they were still fresh and sell the remaining crops immediately to avoid loss and that meant that they did not store anything for the future. These findings showed that storage facilities help farmers to adapt to climate change as they can store a lot of food and use it in times of famine.

About 11% of the households owned scotch-carts. They reported that these scotch-carts were very useful especially with daily household activities such as fetching firewood and water. They also used them during the harvesting period to carry their harvest from the fields to their homes and when they take their grains to the millers. Other respondents also mentioned that they carry other people's goods and charge them a small fee and in that way, did not run out of money for bread and airtime. One respondent had this to say:

> *"These days one cannot afford to depend on farming alone since the rain is unpredictable. One season you have a good harvest and the next season you do not have any harvest at all. For me and my family to survive, I have two scotch carts*

which I use to carry people's water and other goods and get paid through money or a bucket of maize, sweet potatoes, chickens or anything that the person is having if we agree. You will find out that even if I fail to have a good harvest that season, I will never run out of food." (Respondent No. 88, 3rd of August 2017.)

As the above quote illustrates, having an asset such as a scotch-cart which generates income enhances a farmer's capacity to cope with economic challenges brought about by the adverse impacts of climate change.

4.5.2 Natural Assets

Vegetation and trees were ranked the highest (49%) type of assets that households had. Most of the households had a lot of fruit trees in their backyards. Households which had big trees resorted to cultivating under the tree shades to reduce the wilting of crops. These tree shades played an important role in the adaptation to high temperatures that were experienced in the area. Beside adapting to high temperatures, fruit trees which included mango, peaches, litchis, avocados and bananas also helped them in sustaining their livelihoods through selling fruits.

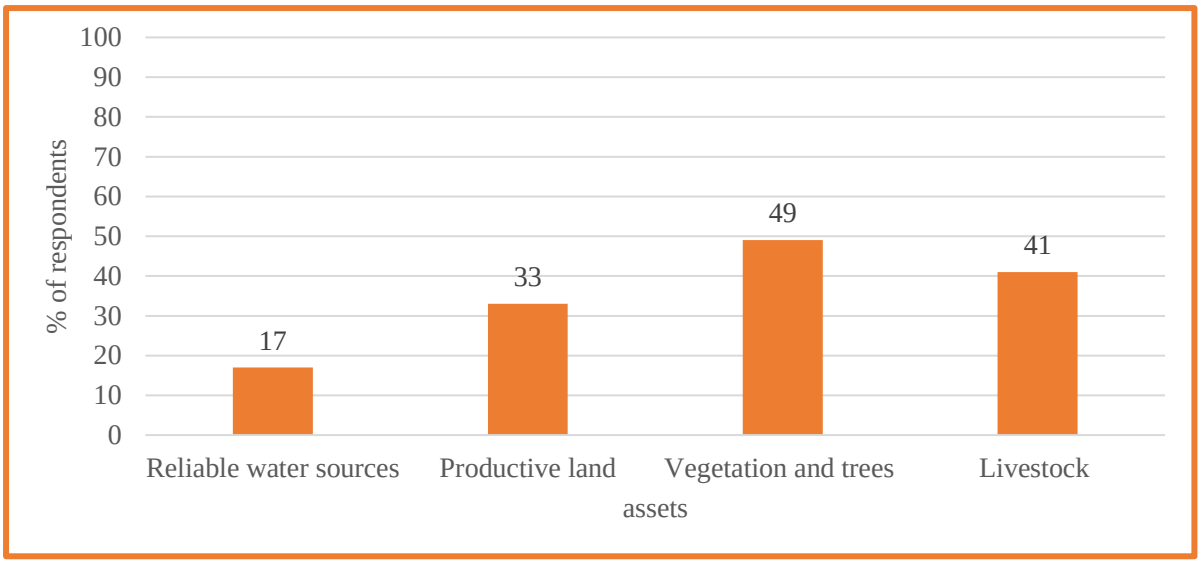

Figure 4.22 Natural assets possessed by households

(Source: Research Survey,2017) **Multiple responses*

The money from selling fruits would be used for different needs for the family. Moreover, those households that owned fields could get firewood from their fields, saving them money that could have been used to purchase the firewood.

Figure 4.20 A respondent explaining how he benefits from his fruit trees

Forty-one percent of the households had livestock as an asset. Households with livestock adapted better to climate change impacts in the area especially during seasons were rainfall was less and the produce was little. This was because they would sell their livestock to buy food, meet other household needs and also get money to purchase farm inputs. A certain respondent considered livestock to be a symbol of wealth which was useful in so many ways and this is what he had to say:

> *"When you have livestock especially cattle you are very rich. I sell livestock in hard times when I do not get any produce and I will be able to pay for my children's school fees, feed my family and buy some farm inputs such as seeds and fertilisers for my crops. I also use livestock to help my family members to pay for lobola or pay for fines from a cultural perspective." (* Respondent no 30, 15th of July 2017*)*

The study also revealed that other natural assets that were available to households were productive land (33%) and reliable water sources (17%). Having productive land helped

farmers to adapt because during seasons when rain was abundant, they were able to produce more and have surplus which they could either sell or store for use in times when they did not harvest well. During dry periods when there was no rain, households with reliable water sources adapted better to this calamity as they would use water sources for irrigation instead of solely waiting for the rain to start cultivation.

4.5.3 Human assets

About 51% of the respondents who had reported to have assets considered having good health as an asset. This was unexpected since the study area was comprised mostly of an ageing population. When good health was cross tabulated with age, the results showed that 57% of the respondents who reported good health to be an asset were between the ages of 55 – 64 and 65 and above age groups. One would have expected fewer respondents in this age group to report good health as one of their major asset given that health generally deteriorates with increasing age. These results however, show that even though most of the respondents were ageing, they regarded themselves as still being fit to conduct farming activities. An elderly respondent mentioned that:

> *"I have noticed that for the past few years, this area is becoming more and more hot and for some people it is difficult to continue with farming activities because they have this high blood pressure. But, I am very fit and in good health, even on the hottest day, I go to the fields and do my work without getting sick." (*Respondent no 108, 17th of August 2017*)*

Having good health helped respondents adapt better because they had the ability to work under harsh climatic conditions such as very high temperatures without getting easily affected.

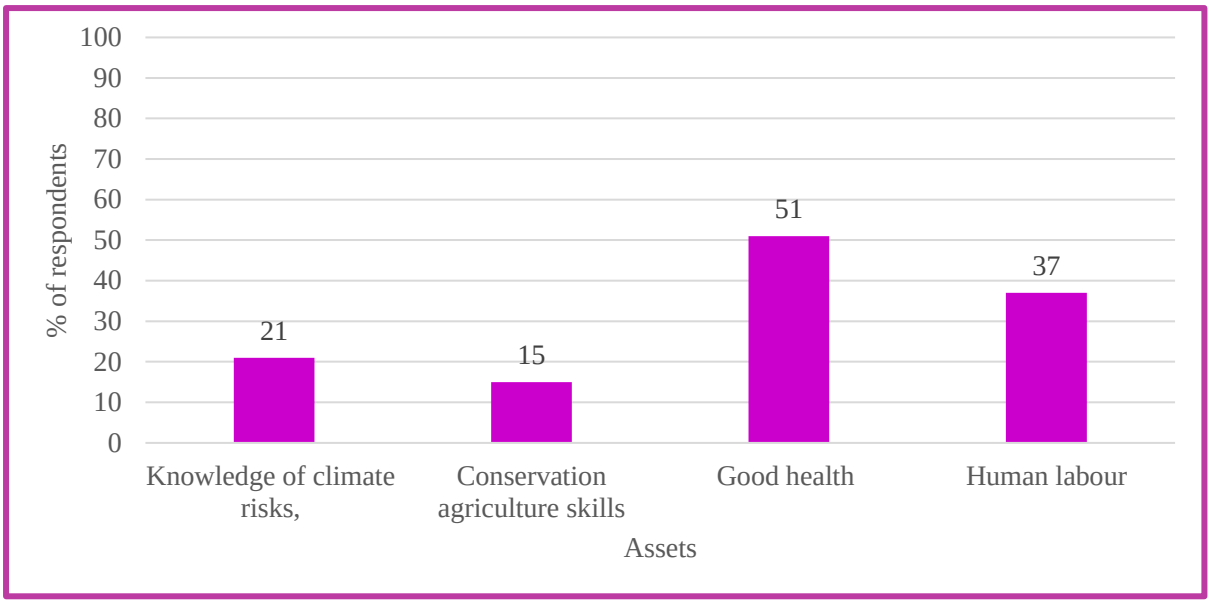

Figure 4.21 Human assets possessed by households

(Source: Research Survey,2017) **Multiple responses*

Thirty-seven percent had human labour and they got assisted in ploughing the fields and herding cattle. Most of this human labour came from other household members except for those who wanted cattle herders, because it is an everyday job they had to get people they would pay.

The study results also showed that 21% and 15% of the people had knowledge on climate risks and conservation agricultural skills respectively. When cross tabulated with educational level, the results showed that most of the respondents who had these skills had gone through primary school, they had secondary education and other qualifications above. Only a few 5% had no formal schooling.

> *"I did not go to any tertiary institution, I only ended in secondary school but that helped me a lot because I did agriculture as a subject. I learnt useful things such irrigating at night and using shades to reduce wilting of crops, zero tillage, intercropping and crop rotation at school. Now, I am able to apply the knowledge I gained from school and try to reduce the impacts of climate change." (* Respondent no 21, 15th of July 2017, Ward 24*)*

Their education and skills helped them adapt better to climate change as they were able to apply the correct adaptation strategies. These results are supported by Lutz & Skirbekk's (2013), argument that formal education is one of the direct key ways through which individuals and

families acquire knowledge, competencies and skills that boost their adaptive capacity in the context of climate change.

4.5.4 Social assets

Social assets were not that common in the study area. Ten percent of the respondents were members in women's savings group which is commonly known as a Stokvel. This was not a farming Stokvel, but rather one that usually helps with groceries during the festive seasons and money to use at the beginning of the following year. Only 4% of the households were involved in farmer based organisations. This organisation was a home-based care facility where members of the group grow and sell vegetables. Some of their products are used to support orphans and other disadvantaged people in the community. One respondent commented that

> *"I am very grateful for the people who volunteer in the home-based care. There are a lot of children in this community who are disadvantaged but because of this initiative they can never go hungry even if it doesn't rain. Dedicated people will always find means and ways to keep the community home based care garden alive."*
> (Respondent no 48, 22nd of July 2017, Ward 24)

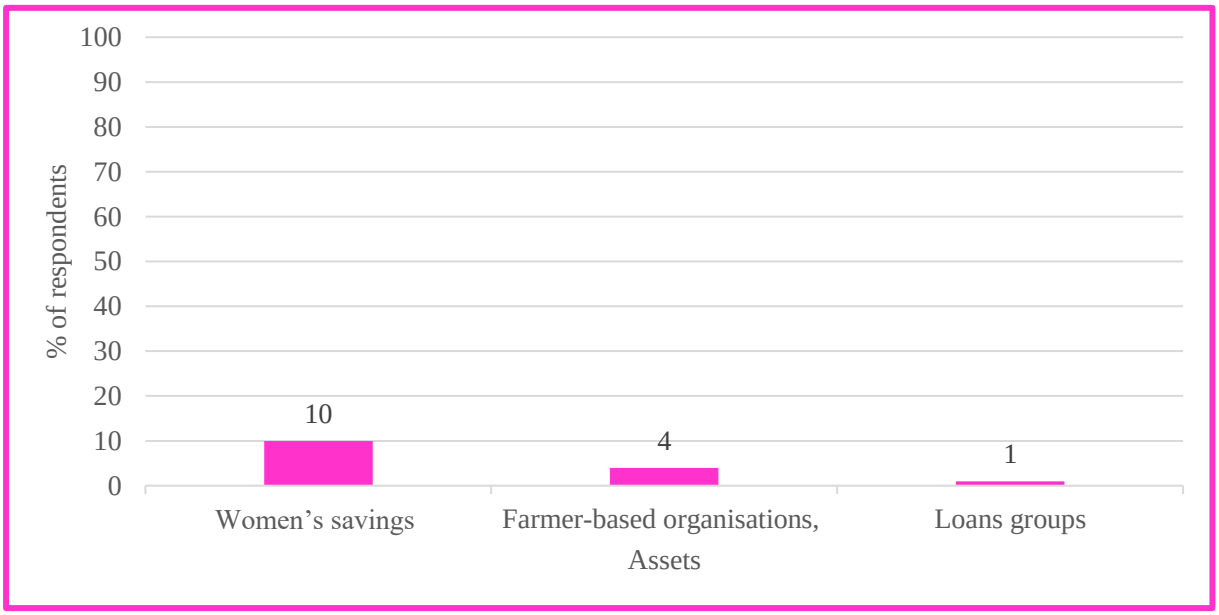

Figure 4.22 Social assets possessed by households

(Source: Research Survey,2017) **Multiple responses*

The other form of social asset that was found in the area was a water drinking facility for livestock especially cattle. This is what the nduna from Ga-Mothiba had to say about the initiative:

> *"Farmers from this area had had enough of losing their livestock through death by heat or sickness because of lack of water. This led to the village men sitting down together to try and find a solution. They finally agreed that all those who had livestock especially cattle had to contribute some money to buy a water tank and create some pond like structures where cattle would come and drink water during the dry season. The ponds would receive water from the rain and the tank was a backup water storage facility so that even when it did not rain, they still had water for their cattle. Mind you, this initiative was not sponsored any officials not even the government, it was just a local community initiative. Every time the cattle are grazing, herdsmen will pass through the water drinking facility for the cattle to drink water."* (Key informant interview, 26th of August 2017, Ward 24)

Figure 4.23 Water drinking facility for livestock in Ga-Mothiba village

Although these assets were possessed by few households, they still played an important role by cushioning farmers from climate change vulnerabilities such as food insecurity.

4.5.5 Financial assets

Only a few households possessed financial assets. None of them reported to have micro insurance and only 8% of had diversified income sources. These farming households have diversified incomes sources to include: selling beauty products, fruits, vegetables, airtime, hairdressing, ploughing for people and carrying goods and water using scotch carts. Diversified income sources helped households to adapt to climate change because the households did not have to rely on agricultural income alone. In agriculturally challenging times, the households were able to use money from other sources to meet their daily needs and to purchase food.

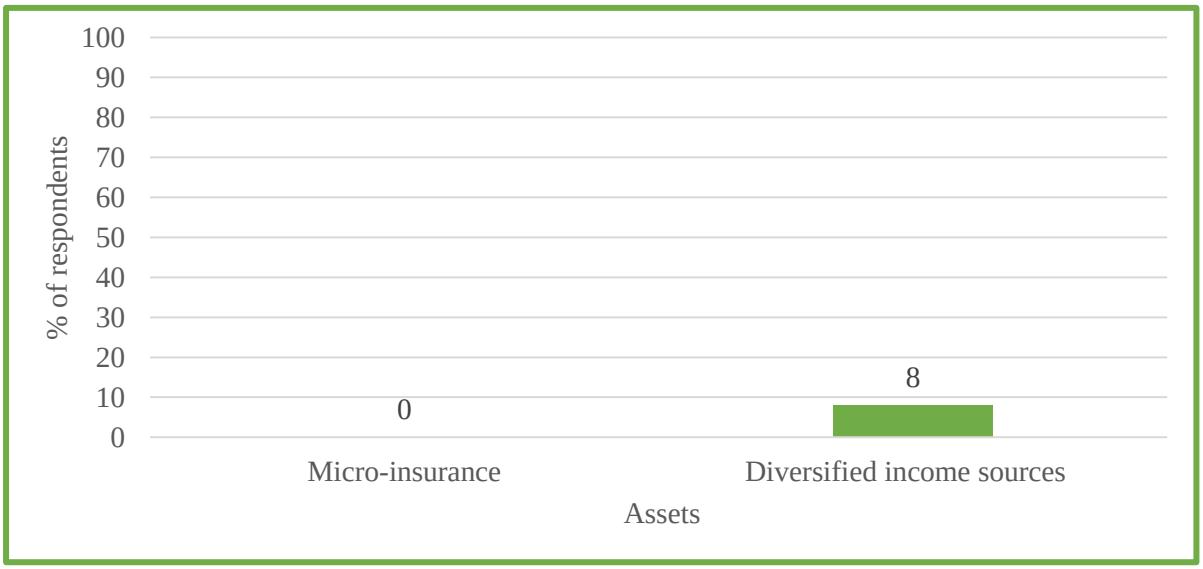

Figure 4.24 Financial assets possessed by households

(Source: Research Survey,2017) **Multiple responses*

A chi square test for independence was performed (X^2 = 4,729, df = 1, P = 0.089) and the result showed that there was a significant difference between adaptation to climate change and the possession of assets. This finding corresponds with the explanations given on how households

with assets adapted better to climate change. In conclusion, the five livelihood assets play an important role in enhancing farmers adaptive capacity in Ward 24.

4.6 Conclusion

The aim of the study was to assess the effects of subsistence farmers' knowledge and perceptions on climate change adaptation as well as ascertain the role played by assets in enhancing the capacity of farmers to adapt to climate change. Firstly, the study findings have demonstrated that subsistence households in Ward 24 had knowledge on climate change and most of the respondents' perceptions regarding climate change were in line with current scientific understanding of climate change and variability. Secondly, the results showed that more than half of the subsistence farmers in Ward 24 were adapting to climate change through different adaptation strategies. While the strategies were useful, farmers were encountering challenges which hindered the adaptation process. These challenges included lack of awareness on climate change, poverty, water shortages and lack of financial capital. Thirdly, several households in the study area possessed different kinds of assets and households with assets were likely to be more adaptive and more resilient to climate change than those without. Households lacking assets found it difficult to adapt to the current climatic and environmental changes. The next chapter summarises the research findings and gives recommendations to enhance the adaptive capacity of subsistence farmers.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The previous chapter presented and discussed the study's research findings in order to meet the study aim, which was to assess the effects of subsistence farmers' knowledge and perceptions on climate change adaptation and to ascertain the role played by assets in enhancing the capacity of farmers to adapt to climate change in Ward 24 of Polokwane Local Municipality. This chapter presents a summary of the key study findings, gives a conclusion and makes recommendations based on the study findings.

5.2 Summary of findings

5.2.1 Socio economic background

The study established that most of the respondents were above the age of 65 years. Thus, the study area comprised mainly of an ageing population. Most of these old aged people were pensioners who relied on the old-age grant from the government. Although the area had many old people, the majority of the respondents were literate, having gone through one level of education or another. The exception was only 10% of the respondents who did not have any formal schooling. In terms of farming, most of the farmers depended on rained agriculture with an exception of the affluent residents who had irrigation facilities. Crop farming was the most dominant farming type practiced in the area, followed by mixed farming and then livestock farming. Crops were mostly cultivated in communal fields and in backyards whereas livestock was reared in the communal lands. The majority of the respondents cultivated maize as it is their staple food and also leaf vegetables. Cattle, goats, sheep and chickens were the common animals they kept.

5.2.2 Knowledge and perception on climate change

The study showed that majority of the respondents had knowledge about climate change. Most of them explained climate change impacts through a series of themes which ranged from decrease in rainfall, temperature increase, pollution of the atmosphere, seasonal changes and extreme weather events. The respondents believed that all these climatic changes were the reason behind their poor agricultural yields. Different people accessed information about climate change differently according to their age groups or generational differences. Elderly people attested to knowing about climate change via radio, while the middle-aged people and the youth knew about it through social media, televisions, from school and from the radio as

well. Lastly, more than half of the respondents regarded climate change to be a very important issue that needed to be addressed as it affected their livelihoods.

On the extent to which climate change and variability was perceived in the area, majority of the respondents were able to correctly perceive changes in climate that were occurring in their area. The perceived changes include a decrease in rainfall that was believed to have been attributed by the shift in the time of rain during the main rain season. Rains were said to start late in the season and it wouldn't even rain for long thereby receiving low amounts of rainfall. Temperature was also perceived to have been increasing over the past few years and according to some respondents (76%), lack of rain caused rise in temperature as there was no a significant period which brought a cooling effect in the atmosphere. Temperature increase was also seen through wilting of crops and not feeling the urge to have blankets at night most of the time. Floods and drought were also perceived to have occurred due to climate change and variability.

5.2.3 Adaptation to climate change

Of the households (53%) that adapted to climate change, results revealed that a wide range of adaptation strategies were employed to fight the impacts of climate change. The most common strategies that they used include changing planting dates, use of soil water conservation techniques, religious beliefs and traditional knowledge, use of chemical fertilisers and change of crop varieties. Households had changed the way they conducted their farming activities to get enough food since most of them relied on farm produce. Even though these farmers were bold enough to implement these adaptation strategies, they faced many challenges. Adaptation was hindered mainly by lack of water in the area. The decrease in rainfall over the past few years exacerbated water shortages in the area to an extend that they no longer irrigated plants using tap water. Another hindrance was limited awareness and education on climate change. This was linked to the absence of agricultural extension services in the ward. Respondents believed that exposure to extension services would have helped them adapt better to climate change. Poverty, low levels of technology and lack of financial capital were also challenges that stood in their way of adaptation.

The study focussed on the effects of knowledge and perception of farmers on climate change adaptation. The results showed that the perceptions and knowledge of ward 24 farmers had a positive effect on adaptation. Respondents showed that the knowledge they had on climate change made them to adapt to climate change and their perceptions on climate change and

variability influenced their choice of adaptation strategies. For instance, respondents who strongly perceived that temperatures in the area had been increasing lately made use of shades and shelters to try and reduce the impact of heat on their crops. More importantly, these farmers who adapted to climate change showed their ability to perceive climatic change and variability correctly and taking steps to minimize the impacts.

5.2.4 Role of assets in in adaptation to climate change and variability

Most of the respondents in the area had different kinds of assets and the study results showed that there was indeed an association between possession of assets and adapting to climate change. Households used their various assets (physical, human, natural, social and financial) assets to adapt to climate change. For instance, there was poor provision of water in the area and households used their water storage facilities to store water for domestic use. Those who owned bigger storage tanks and irrigation facilities went further to irrigate crops during times of no rain. A few households could afford assets such as tractors and they helped them with cultivation even when the soils were too dry and hard.

Another category of assets which proved to be very helpful in the process of adaptation was human assets. Most of the educated respondents had either agricultural conservation skills and/or knowledge on climate change. The knowledge and skills helped them in the implementation of various kinds of adaptation strategies. Another human asset which played a vital role was good health. Although most of these farmers were ageing, they were still fit to continue with production even under harsh weather conditions such as extreme temperatures. Natural assets such as vegetation, trees and livestock were sold by households so that they could send their children to school, buy farm inputs, food and other basic needs in the house. Other respondents resorted to cultivating under trees to adapt to the temperature changes in the area. Very few people had financial and social assets but they helped the farmers to divert from climate related stresses such as food insecurity. For this study, people who possessed assets were in a better position to adapt to climate change than those who did not have assets. Thus, assets are integral to the adaptation process, enabling households to choose how to adapt and how the adaptation process will be carried out. Without assets, the majority of poor households face a bleak future, as they are negatively impacted on by climate change without the ability to react in any way that lessens the impact.

5.3 Conclusion

Climate change is a reality globally and in South Africa. Study findings indicate that subsistence farmers are aware of climate change and its impact. Hence some of the farmers were making efforts to adapt and cushion themselves against the negative impacts of climate change. Farmers were, for example, changing planting dates, changing crop varieties and using soil water conservation techniques. Despite the constraints that subsistence farmers were experiencing in adapting to climate change, some were making efforts to access information on climate change from friends, radio and television. The farmers also noted that information on causes, effects and adaptation to climate change is necessary to aid them in adapting to the negative consequences of climate change. Subsistence farmers also went on to use the assets they had at their disposal to adapt to climate change and these assets enhanced their adaptive capacity. The use of these assets was also influenced by the socio-economic status of the farmers. This study concludes that perceptions and knowledge exhibited by most of ward 24 farmers had a positive effect on how they adapted to climate change. This was evident through the fact that some of the adaptation strategies they were using were directly influenced by their perceptions on climate change. However, for some respondents, their knowledge did not translate into adaptation because they lacked resources and the financial capital to adapt to climate change.

5.4 Recommendations

Based on the findings in this study, a number of recommendations are made. These recommendations are aimed at reducing the vulnerability of subsistence farmers to climate change as well as enhance their livelihoods.

5.4.1 Extension services

The study findings have shown that information is key to climate change adaptation. There is therefore a critical need to have active agricultural extension services in the area so that the extension officers can provide relevant and reliable information to subsistence farmers. In addition, these extension officers should assist farmers with decision-making regarding climate change adaptation. The information should be made available frequently, and in a language and form that the farmers understand so that it is easily accessible to them.

5.4.2 Education and awareness

The knowledge that farmers in Ward 24 possessed regarding climate change played a critical role in determining whether they were able to adapt to climate change or not. There is therefore an urgent need to devise and carry on awareness campaigns on climate change, especially through the Department of Agriculture which is the department responsible for issues related to farming. In addition, educational campaigns can also be carried out in schools so that students are aware of the vulnerability of their communities as well as how to deal with the challenges. It is through awareness and education that people will know and accept the vulnerabilities brought by climate change and act accordingly in their households to adapt to climate change.

5.4.3 Poverty alleviation

Poverty is debilitating and therefore limits the ability and scope of adaptation. Consequently, poverty alleviation becomes key to successful adaptation. The findings of this study have revealed that people in possession of assets adapt better to climate change than those who did not. To increase the level of assets acquisition by households, there is need for more income opportunities for rural households to improve and diversify their livelihood options. Income diversification will also enable farmers to supplement their agricultural incomes and therefore increase their resilience to climate change challenges.

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Appendix A: Household questionnaire survey

EFFECTS OF SUBSISTENCE FARMERS' KNOWEDGE AND PERCEPTIONS ON CLIMATE CHANGE ADAPTATION USING ASSETS: A CASE STUDY OF WARD 24, POLOKWANE LOCAL MUNICIPALITY.

Village name:

I am a student at the University of Limpopo. I am speaking to subsistence farmers in Ward 24 villages about climate change adaptation through assets. Your household has been randomly selected and we would like to discuss these issues with you, or an adult member of your household.

Your opinions will help me to get a better idea about climate change adaptation in Ward 24. There are no right or wrong answers. The interview will take about 45 minutes. Your answers will be confidential. I will not be recording your name, and it will be impossible to pick you out from what you say, so please feel free to tell me what you think.

Are you willing to participate? (CIRCLE THE ANSWER GIVEN)

Yes…1 No…2

IF NO: READ OUT: Thank you for your time. Goodbye.

IF YES: IF WILLING TO PARTICIPATE, READ OUT THE FOLLOWING:

Thank you for agreeing to participate in this study. Just to emphasize, any answers you provide will be kept absolutely confidential, and there is no way anyone will be able to identify you by what you have said in this interview. We are not recording either your address or your name, so you will remain anonymous. The data we collect from these interviews will always be kept in a secure location. You have the right to terminate this interview at any time, and you have the right to refuse to answer any questions you might not want to respond to.

Are there any questions you wish to ask before we begin?

SECTION A: DEMOGRAPHIC AND SOCIO-ECONOMIC INFORMATION

1. Sex of respondent				
Male	1		Female	2

2. What is your relationship to head of the house				
Head	1		Relative	4
Spouse	2		Non- Relative	5
Child	3		Other	6

3. How old are you in years?	years.

4. Which age category do you fall under?				
15-24	1		25-34	5
35-44	2		45-54	6
55-64	3		65+	7
Don't know	4			

5. Marital Status				
Single	1		Married	4
Divorced	2		Separated	5
Widowed	3		Cohabiting	6

6. Work Status				
Self employed	1		Part time	5
Full time employment	2		unemployed	6
Other	3			

7. Occupation	

8. Place of birth	

9. How long have you lived in this ward? …….years.				
Less than a year	1		1-2 years	4
3-6 years	2		7 – 10 years	5
11 – 15 years	3		15+	6

10. What is the highest level of education you have completed?				
No formal schooling	1		Some primary	6
Primary only	2		Some secondary	7
Secondary only	3		College diploma	8
Some university	4		University degree	9
Postgraduate	5		Other	10

11. What is your household size?				
1	1		2-3	4
4-6	2		7-10	5
11-15	3		15+	6

12. What is the total household income per year from agricultural activities?	**R**

13. Which category does it fall under?				
R100-R2500	1		R2600-R5000	4
R5100-R8000	2		R8000-R15000	5
R15000+	3		No income	6

14. What is the total household income per year from other sources (excluding agriculture)?	**R**

15. Which category does it fall under?				
R100-R2500	1		R2600-R5000	4
R5100-R8000	2		R8000-R15000	5
R15000+	3		No income	6

16. Do you sometimes run out of food or money because your income is not adequate?							
Yes, go to Q 16	1		No, go to Q17	2		Don't know, go to Q17	3

17. If yes, which coping strategy do you adopt when you don't have food or money?				
Urban farming	1		Loan shark	5
Begging	2		Stokvel	6
Borrowing	3		Advance from work	7
Other	4			

SECTION B: GENERAL KNOWLEDGE AND PERCEPTION ON CLIMATE CHANGE ADAPTATION.

18. Have you heard of Climate Change?							
Yes, go to Q	1		No, go to Q	2		Don't know, go to Q	3

19. What do you know about it?

20. What is your source of information on Climate Change?				
Television	1		School/college/university	7
Radio	2		Public libraries	8
Newspaper	3		Friends/family	9
Internet	4		Local council	10
Journals or articles	5		Energy supplies	11
Government information/agencies	6		Other	12

21. By ticking one box on each row please indicate how much you would trust information about climate change if you heard it from.				
	1.A lot	2.A little	3.Not very much	4. Not at all
1.Family/friend				
2.Scientist				
3.Government				
4.Energy Supplier				
5.Media				

22. How important is the issue of Climate Change to you personally?							
Very important, go to Q	1	Quite important, go to Q	2	Not very important, go to Q	3	Not at all, go to Q	4

23. Why is it important to you?

24. Do you think climate change can affect you as an individual?					
Yes	1	No	2	Don't know	3

25. If yes, in what way does it affect you?

26. Do you think anything can be done to manage climate change?					
Yes	1	No	2	Don't know	3

27. If yes, what do you think can be done to manage climate change?

SECTION C: AGRICULTURAL ACTIVITY DETAILS

28. What agricultural method do you use?				
Irrigation	1		Rain fed	2

29. What farming types do you engage in?				
Crop farming	1		Nomadic pastoralism	4
Livestock farming	2		Other (please specify)	5
Mixed farming (crop & livestock)	3			6

30. What type of crops do you cultivate?				
Millet	1		Groundnuts	4
Sorghum	2		Sweet potatoes	5
Maize	3		Others (please specify)	6

31. What type of livestock do you rear?				
Chickens	1		Pigs	4
Goats	2		Sheep	5

Cattle	3		Others (please specify)	6

32. What is the tenure status of the land you cultivate?				
Land area owned/communal land	1		Roadside	4
Use public land	2		Backyard	5
Renting land	3		Others (please specify)	6

33. Land use intensity details (please fill in the boxes the amount of land in hectares)					
Area cultivated once a year.	1	Area cultivated twice a year.	2	Area cultivated thrice a year.	3

34. Crops intensity details (Please list the types of crops in the boxes)					
Crops cultivated once a year	1	Crops cultivated twice a year	2	Crops cultivated thrice a year	3

35. Do you mainly produce crops for cash or subsistence?					
Cash	1	Subsistence	2	Both	3

36. If you produce various crops for both cash and for food, please list down the crops you produce for cash and those ones you produce for food.					
Crop name	1	Subsistence/food	2	Cash	3

37. Do you mainly produce crops for cash or subsistence?					
Cash	1	Subsistence	2	Both	3

38. If you produce various livestock for both cash and for food, please list down the livestock types you produce for cash and those ones you produce for food.					
Livestock types	1	Subsistence/food	2	Cash	3

39. Have there been changes in crop production over the past 10 years?					
Increase	1	Decrease	2	No change	3

40. Please provide reasons for the above response

41. Have there been changes in livestock production over the past 10 years?					
Increase	1	Decrease	2	No change	3

42. Please provide reasons for the above response

SECTION D: STATE OF KNOWLEDGE OF FARMERS ON CLIMATE VARIABILITY AND CHANGE.

43. Have you noticed any long-term changes in the mean temperature over the past 10 years?				
Yes	1		No	2

44. Has the number of hot days changed?					
Increase	1	Decrease	2	No change	3

45. Please provide reasons for the above response

46. Have you noticed any long-term changes in the mean rainfall over the past 10 years?				
Yes	1		No	2

47. Has the number of rainfall days changed?					
Increase	1	Decrease	2	No change	3

48. Please provide reasons for the above response

49. What could account for the changes in crop production over the past years?					
Climatic changes	1	Other factors (specify)	2	Do not know	3

50. What could account for the changes in livestock production over the past years?					
Climatic changes	1	Other factors (specify)	2	Do not know	3

51. What is the climatic variable that strongly affects your agricultural production?				
Extreme temperatures	1		Change in the start of rain season	4
Weak rainfall	2		Others (Please specify)	5
Variation in rainfall	3			

SECTION E: FARMERS PERCEPTIONS ON CLIMATIC VARIABILITY AND CHANGE

52. How do you perceive climate change and variability through? (Tick as appropriate)					
	1.Strongly agree	2.Agree	3.Neutral	4.Disagree	5.Strongly disagree
Change in amount of rainfall during main rain season					
Increasing rainfall in amount during main rain season					
Decreasing rainfall in amount during main rain seasons					
Shift in the timing of the onset of rain in the main season					
Rain starting later than normal					
Rain starting earlier than normal					
Shorter rain seasons					
Longer rain seasons					
Planting date change applying to most crops					
Temperature of the area decreasing					
Temperature of the area increasing					
Rainfall increasing					
Rainfall decreasing					
Rainfall fluctuating					
Increase in recurrences of floods					
Decrease in recurrence of floods					
Increase in intensity of floods					

Increase in the recurrence of droughts					
Increase in the occurrence of droughts					
Increase in the intensity of droughts					

53. What has been the trend of rainfall for the past 20 years to date according to your memory? (Please tick as appropriate)					
	1.Strongly agree	2.Agree	3.Neutral	4.Disagree	5.Strongly disagree
1.Increasing					
2.Decreasing					
3.Fluctuating					
4.Constant					
5.Unpredictable					
6.Don't know					

54. What has been the trend of temperature for the past 20 years to date according to your memory? (Please tick as appropriate)					
	1.Strongly agree	2.Agree	3.Neutral	4.Disagree	5.Strongly disagree
1.Increasing					
2.Decreasing					
3.Fluctuating					
4.Constant					
5.Unpredictable					
6.Don't know					

SECTION F: FARMER'S ADAPTATION STRATEGIES TO CLIMATE CHANGE.

55. Have you tried to adapt to current climatic changes/variation?				
Yes	1		No	2

56. If yes what are some of the adaptation strategies you have so far adapted to?				
Change of planting dates	1		Change of crop varieties	10
Movement to different sites	2		Use of irrigation	11
Switching from crops to livestock	3		Use of shades and shelters	12
Switching from Livestock to crops	4		Rural urban migration	13
Reduction in number of livestock	5		Use of insurance	14
Reduction in cultivated land	6		Search for off farming jobs	15
Increase in land area cultivated	7		Religious beliefs or prayers	16
Use of water conservation techniques	8		Change use of chemical fertilizers, pesticides and insecticides	17
Implementation of Soil conservation techniques	9		Other adaptations techniques	18

57. What are some of the challenges you face in adapting to climate change?				
Limited awareness or information	1		Shortages of land for cultivation	7
Poverty	2		Lack of financial capital	8
Low level of technology	3		Poor markets	9
Shortages of labour inputs	4		High living costs	10
Poor soils	5		Large household size	11
Lack of water	6		Others	12

SECTION G: TYPES OF ASSETS THAT FARMERS HAVE ANDHOW THEY HELP IN THE ADAPTATION PROCESS.

58. Do you have any assets?				
Yes	1		No	2

59. What type of assets do you have?				
Human			**Natural**	
Knowledge of climate risks,	1		Reliable water sources	11
Conservation agriculture skills	2		Productive land	12
Good health	3		Vegetation and trees	13
Human labour	4		Livestock	
Social			**Physical**	
Women's savings	5		Irrigation infrastructure	14
Farmer-based organisations,	6		tractors	15
Loans groups	7		Scotch carts	16
Traditional welfare Social support institutions	8		Seed and grain storage facilities	17
Financial			Water storage facilities	18
Micro-insurance,	9			
Diversified income sources	10			

60. Do these assets help you adapt to climate change?				
Yes	1		No	2

61. How are they helping you to adapt?

62. Is there any other information on farming and climate change that you would like to add?

THANK YOU FOR YOUR TIME AND INFORMATION!!

Appendix B: Key informant interview schedule

EFFECTS OF SUBSISTENCE FARMERS' KNOWLEDGE AND PERCEPTIONS ON CLIMATE CHANGE ADAPTATION USING ASSETS: A CASE STUDY OF WARD 24, POLOKWANE LOCAL MUNICIPALITY.

I am a student at the University of Limpopo undertaking a research on climate change adaptation through assets in Ward 24 villages of Polokwane Local Municipality. As the Chief/Nduna of this village, you have been selected to provide your knowledge and understanding of agricultural practises in the ward as well as the adaptation strategies being put in place to curb climate change. Your opinions will help me to get a better idea about climate change adaptation through assets in Ward 24. The interview will take about 45 minutes.

The interview will be guided by the following questions; however, you are most welcome to provide any other relevant information which may not be covered by the questions. For the sake of time and a continuous flow, this interview will be recorded with your permission of course. This interview is strictly for academic purposes alone and the answers you provide will not be taken anywhere else. You have the right to terminate this interview at any time, and you have the right to refuse to answer any questions you might not want to respond to.

Are you willing to participate? (CIRCLE THE ANSWER GIVEN)
Yes…1 No…2
IF NO: READ OUT: Thank you for your time. Goodbye.
IF YES: Thank you we may proceed

QUESTIONS

1. In which village is subsistence farming most common in Ward 24?
2. Do farmers in ward 24 mainly practise crop or livestock farming?
3. Which crops are mainly grown and livestock commonly reared in this Ward?
4. What are the main uses of crops and livestock?
5. Do you know about climate change and what are the indictors of the occurrence of climate change in this area?
6. What challenges do framers face to effectively implement coping and adaptation mechanisms?
7. Which segment of the local community more affected by climate change?
8. Is there any local level farmer based organizational schemes made that helps farmers to overcome the damages caused by climate change/climate variability?
9. What are the challenges faced by the agricultural research and extension services to address climate change issues?
10. What kind of assets (social, financial, physical, natural and human) do households have and how do they assist farmers in adapting to climate change?
11. What are the success stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?

Appendix C: Ethical clearance certificate

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 3935, Fax: (015) 268 2306, Email: Anastasia.Ngobe@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING:	**15 May 2018**
PROJECT NUMBER:	**TREC/101/2018: PG**
PROJECT:	
Title:	Effects of Subsistence Farmers' Knowledge and Perceptions on Climate Change Adaptation Using Assets: A Case Study of Ward 24, Polokwane Local Municipality.
Researcher:	WA Mhlanga
Supervisor:	Dr G Tawodzera
Co-Supervisors:	N/A
School:	Agricultural and Environmental Sciences
Degree:	Master of Science and Agriculture

PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:
i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**
ii) **The budget for the research will be considered separately from the protocol.**
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

Finding solutions for Africa

Appendix D: Approval letter from Makotopong village

[MAKOTOPONG TRIBAL COUNCIL]

June 5, 2017

MAKOTOPONG TRIBAL COUNCIL

ENQ: CHIEF L.W. PHAMBANE
SEC, P.B. CHIPENDO
SEC, R.H. RAMOBA

P.O BOX 600
ROZANO
0723

TEL 071 657 3329

TO WHOM IT MAY CONCERN

CONFIRMATION LETTER

This is to endorse that on the 5TH JUNE 2017 the students from the University of Limpopo reported to the Tribal Office and requesting permission to collect information from the residents of Makotopong as part of their study.

We like to inform members of the community that they have been granted the permission and kindly assist them in any-way possible.

We hope the above is in order.

Yours faithfully
P.B. Chipendo
(secretary)

MAKOTOPONG
TRADITIONAL AUTHORITY
BATHOKWA
05 -06- 2017
SIGNATURE
P.O. BOX 600, ROZANO, 0723
LIMPOPO PROVINCE

Appendix E: Faculty approval letter

25/10/2017

NAME OF STUDENT: Mhlanga WA
STUDENT NUMBER: 201217565
DEPARTMENT: Geography and Environmental Studies
SCHOOL: Agricultural and Environmental Science
QUALIFICATION: MSCA01

Dear Ms Mhlanga

FACULTY APPROVAL OF PROPOSAL (PROPOSAL NO.96 OF 2017)

I have pleasure in informing you that your masters proposal served at the Faculty Higher Degrees Committee meeting on **16 November 2016** and your title was approved as follows:

"Effects of Subsistence Farmers' Knowledge and Perceptions on Climate Change Adaptation Using Assets: A Case Study of Ward 24, Polokwane Local Municipality."

Note the following: The study

Ethical Clearance	Tick One
Requires no ethical clearance Proceed with the study	
Requires ethical clearance (Human) (TREC) (apply online) Proceed with the study only after receipt of ethical clearance certificate	√
Requires ethical clearance (Animal) (AREC) Proceed with the study only after receipt of ethical clearance certificate	

Yours faithfully

Prof P Masoko
Secretariat: Faculty Higher Degrees Committee

CC: Dr G Tawodzera
Dr MR Ramudzuli
Prof TP Mafeo