

Rural households' adaptation to drought and welfare impacts in John Taolo Gaetsewe district, Northern Cape Province

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Dissertation accepted in fulfilment of the requirements for the degree Master of Science in Agricultural Economics at the
North West University

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Graduation ceremony: 18 May 2023

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DECLARATION

I declare that this dissertation is my own original work undertaken in fulfilment of my Masters of Science degree in Agricultural Economics titled: "Rural households' adaptation to drought and welfare impacts in John Taolo Gaetsewe district, Northern Cape Province". This dissertation has never been submitted to any institution or journal, and all sources utilized or quoted in it have been appropriately recognized with complete references.

P.A Applegreen

ACKNOWLEDGEMENTS

I would like to thank God for ordering my steps, guiding me every day, and giving me the strength to persevere with my studies even during times when I felt like giving up.

I would further like to thank the following people who played a significant role in my academic journey:

- Prof. Abayomi Samuel Oyekale for his supervision and dedication in ensuring that I complete my study.
- Dr Khulekani Nxumalo for his guidance and constructive criticism as well as direction on writing this thesis.
- Amogelang Setlhatlhoso for assisting me with data collection with the aim of ensuring the success of this study.
- My cousin Naome Phetoe, thank you for being my biggest cheerleader. You of all people know this journey was not an easy one yet you always found a way to put a smile on my face through it all. I am truly grateful.
- My mother Mothogobeng Applegreen, my brother Kagiso Applegreen and my nephew Leano Applegreen. I would like to show my heartfelt gratitude for your love and support through this entire journey.
- Lastly, National Research Foundation (NRF) for funding my degree for the accomplishment of this study. I am truly grateful.

DEDICATION

I would like to dedicate this dissertation to my father Mr Mpho Abraham Applegreen. Thank you for being my mentor, my life coach and most importantly the best father a daughter could ask for. You are truly an inspiration.

ABSTRACT

Drought is a global problem that has a negative impact on the welfare of millions of people in both industrialized and developing nations. In South Africa, poor rural households, who depend on rain-fed subsistence agriculture for their livelihoods are most susceptible to drought and have the least ability to buffer and absorb its impacts. The primary goal of this study was to identify the different adaptation methods being used against the occurrences of drought, to analyse the effects of drought adaptation strategies on rural households' welfare and to compute the welfare enhancement impacts that are associated with each adaptation method. The study was conducted in John Taolo Gaetsewe district, Northern Cape province. A mixture of multistage and simple random sampling techniques were used in the study to select rural households, who were affected by drought. The results showed that the average age of households' heads was 52 years. Only 41% of the households' heads had an education level between Grades 8 and 12, and about 63% were male. Average farming experience was 7.67 years and pensioners made up about 47%. Also, 65% of households' heads depended on government assistance, while 85% lacked access to formal credit. Additionally, 63% of household heads lacked access to extension services and information about drought. To determine the various adaptation strategies used against drought occurrences and their determinants, the study used multinomial logistic regression. Crop diversification and livestock diversification, drought tolerant crops, zero tillage, crop rotation, mulching, delayed planting, dry planting, and rainwater harvesting were found to be among the nine adaptation techniques used by the sampled rural households. According to the results of the multinomial logistic regression, marriage status, education, farming experience, access to knowledge about the drought, and access to extension services were all positive and statistically significant at ($p = 0.05$). These findings suggested that access to extension services, education, farming experience, and marriage were significant determinants of the adoption of various drought adaptation measures that would help to improve the welfare of rural households. The 2SLS results showed that farming experience, access to drought knowledge, and access to extension services, significantly influenced the per capita consumption expenditure of rural households. The study also used propensity score matching to calculate the welfare enhancement impacts related to each adaptation strategy. These results revealed that adopting at least one of these adaptation strategies could significantly enhance the welfare of rural households. Considering the findings of the study, several recommendations were made. These included rural households having access to drought adaptation strategies, access to drought information and regular visits by extension officers.

Keywords: Rural, Households, Adaptation, Drought, Welfare

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ACRONYMS

2SLS – Two Stage Least Squares

3SLS – Three Stage Least Squares

ABET – Adult Basic Education and Training

APDUSA – African Peoples’ Democratic Union of Southern Africa

ATT – Average Treatment Effects on the Treated

DMA – Disaster Management Act

FAO – Food and Agricultural Organization of the United Nations

GAR - Global Assessment Report on Disaster Risk Reduction

GMM – Generalized Methods of Moments

HLPE – High Level Panel of Experts of Food Security and Nutrition

IFAD – International Fund for Agricultural Development

IFRC – International Federation of Red Cross and Red Crescent Societies

IPCC – Intergovernmental Panel on Climate Change

IV – Instrumental Variables

JTGD – John Taolo Gaetsewe district

KBM – Kernel Based Matching

MNL – Multinomial Logistic Regression Model

MNP – Multinomial Probit Model

NDMF – National Disaster Management Framework

NNM – Nearest Neighbour Matching

OECD – The Organisation for Economic Competition and Development

OLS – Ordinary Least Squares

READ – Rural Environment, and Agricultural Development

RM – Radius Matching

STATA – Statistics and Data software package

PCA – Principal Component Analysis

PSM – Propensity Score Matching

RUM – Random Utility Maximization

VIF – Variance Inflation Factor

CHAPTER ONE

INTRODUCTION

1.0 Background

The globe is experiencing drought, which is a result of climate change and has a negative impact on the welfare of millions of people in both developed and developing countries (Global Assessment Report on Disaster Risk Reduction (GAR), 2011). For instance, in China, environmental change such as droughts have been the source of economic underperformance thus affecting the welfare of the people (Zhao, Huang, Huang, Wang, Leng, and Xie, 2019; Wang, Jin, Fan, Obembe, and Li, 2021). Similarly, in Latin America, Brazil, majority of the farmers have been prone to vulnerable welfare conditions because of the dire consequences attributed to drought (Marengo, Torres, and Alves, 2017; Nelson, Rosegrant, Koo, *et al.*, 2009). However, across the globe, the need to further the research on the factors that could affect the welfare of the farmers following the experiences of climate change such as drought cannot be over emphasized.

In Sub Saharan Africa, drought has been a perennial experience, which has seen to have a diverse effect on the welfare of the small, medium, and large-scale farmers, is thus, affecting their economic livelihoods. Drought remains to be a fundamental factor affecting the smallholder farmers with farmers failing to have more disposable income as result of reduced harvest (Shiferaw, Tesfaye, Kassie, Abate, Prasanna, and Menkir, 2014; Lottering, Mafongoya, and Lottering, 2020). Contrary to such Sub-Saharan Africa research, little is still known about how the drought affects welfare positions, particularly in the context of South Africa. This is because the hydro-meteorological variables, socioeconomic factors, and the stochastic nature of water demand in different parts of the world make it difficult to understand and define the phenomenon (Umdale, Ichikawa, Manandhar, *et al.*, 2014). Although definitions of drought may differ by industry and region, it is generally defined as a prolonged period, lasting months, or years, during which precipitation is below the annual average, leading to a water shortage (Nairizi, 2017).

A drought is one of the most expensive natural catastrophes, according to Huang, S., Leng, G., Huang, *et al.*, 2017, due to the negative effects it has on commerce, tourism, agriculture, and infrastructure. For the past 50 years, drought have been a serious issue in Africa, contributing to asset depletion, environmental damage, poverty, unemployment, and forced migrations (Shiferaw *et al.*, 2014).

In recent years, there has been severe droughts in several parts of the world, particularly in Africa. These regions include Angola, Namibia, and Kenya to mention a few. Angola is amongst one of the African countries that are currently experiencing drought (Phiri, 2021). This extreme drought has resulted in dwindling water supplies, which has had a significant impact on crops, with losses of up to 40 %, and has increased the risk of animal survival (Prates, 2021).

Namibia is no foreigner to the adverse effects of drought itself. In fact, approximately 430 000 people in Namibia were faced by hunger in 2020 due to the most severe drought that the country has ever experienced (Integrated Food Security Phase Classification, 2020). Like most of the other African countries, when it comes to drought and the severe welfare effects of drought, Kenya is also not exempted. Kenya has been declared a drought national disaster in September 2021 after experiencing three consecutive poor rainy seasons (International Federation of Red Cross and Red Crescent Societies (IFRC), 2019).

All these regions were declared national disasters by their respective governments. The effects of the drought in these areas were noticeable in 2015, and the global patterns of regional drought were in part caused by the powerful El Nino events that emerged in the spring in the Northern Hemisphere (Mahlalela, Blamey, Hart, N.C.G., *et al.*, 2020).

Within South Africa, the World-Wide Fund for Nature (2018), ranked the nation as the 30th driest in the world and noted that there has been a water deficit there. With annual rainfall ranging from more than 1500 mm in the east to less than 100 mm in the west, it is a semi-arid nation. South Africa experiences 450 millimetres of annual rainfall on average, which is much less than the global average of 860 millimetres (Botai, C.M., Botai, J.O., and Adeola, 2018).

The South African government has made several attempts in recent years to lessen the effects of drought, leading to the creation of a comprehensive set of disaster management policies and laws that are essential for managing the risk of drought in agriculture, particularly in shifting the emphasis from a reactive to a proactive response. Implementation of the National Disaster Risk Management Framework of 2005 and the Disaster Management Act of 2002 are two examples (Vogel, Koch, and Van Zyl, 2010). The cornerstone of the disaster management legislation in South Africa is the Disaster Management Act 57 of 2002 (DMA). It contains a thorough institutional framework for disaster management, including the categorization and declaration of disasters, money for recovery and rehabilitation following a disaster, and volunteers for disaster management (Sithole, 2014).

The Disaster Management Act of 2002 led to significant advances in drought management strategy of South Africa, but there were still a lot of holes that needed to be filled (van Niekerk, 2014). The reason for a thorough overhaul of the drought policy in South Africa, was the National Disaster Risk Management Framework of 2005 (Kunguma, 2020).

The failure to adequately analyse and assess institutional, governance, and drought response, including serious reflection and learning, is one of the major oversights in effectively reducing drought risks in the country, even though South Africa has many good policies, frameworks, and laws in place (Austin, 2008).

According to case studies conducted in South Africa, poor rural communities, whose livelihood depend on rain-fed agriculture are more susceptible to drought and have the least ability to withstand and mitigate its consequences (Schreiner, Mungatana, and Baleta, 2018). For poor rural

communities, even minor drought events can lead to yield losses, wreaking havoc on already precarious and non-diversified livelihoods. Many people are unable to organize the resources needed to cushion losses, even in prosperous years, and their well-being keeps declining as a result (Cervigni and Morris, 2016). These kinds of self-reinforcing effects really exist. Each drought gradually erodes livelihoods, increasing the vulnerability of people and communities to subsequent droughts and welfare losses. They are especially visible in disadvantaged areas (Mutekwa, 2016).

Income and consumption are frequent, direct, and observable indices of welfare level following exposure to exogenous environmental shocks like drought (Skoufias and Vinha, 2013). Therefore, if households are unable to maintain their current level of consumption perfectly when their income is impacted by droughts, they must fund a portion of it with the income they do have. Households may also change investment priorities because of limited economic resources (Shah and Steinberg, 2015).

The ability to adapt is influenced by a variety of economic, social, institutional, political, and biophysical factors, including dynamic climatic and non-climatic processes that both support and limit adaptive behaviour (Adger, Barntte, Brown, et al., 2012). Effective adaptation is dependent on the individual or capacity of groups for adaptation, access to human, economic, social, and institutional resources, as well as natural resources, and their potential to mobilize those resources in response to drought (Yung and Phear *et al.*, 2015). Successful adaptation strategies will enhance people's adaptive capacity through education, employment and with support of social capital (Sozibilir, 2018). It is through these strategies that people will attempt to alleviate or avoid the negative impacts of environmental changes such as drought.

Within the foregoing context, the main goal of this study was to examine how drought affects rural households' welfare and adaptive implications. The study aimed to identify the various adaptation mechanisms being adopted by rural households and their determinants, to analyse the effects of drought on rural households' production and other income-generating activities, and to highlight important policy alternatives that result from the analysis.

John Taolo Gaetsewe district (JTGD) in the Northern Cape Province would be used as a case study to examine the issue of drought and its consequences on the welfare of rural households. The conclusions derived from the research could be utilized to offer suggestions for how households can effectively use adaptation strategies during drought in such a way that the adopted adaptation strategies have a meaningful impact on their welfare.

1.1 Problem statement

Drought has wreaked havoc on the agricultural industry in South Africa, which is especially susceptible to heat and consumes more than 60% of the total water supplies in the country

(Maluleke, 2020). This had an impact on the overall socioeconomic structure of the agriculture-based economy, as well as the health of the ecosystems of the nation, the threat that lower farm harvests provide to food security in the nation, and an increase in poverty, especially among rural households (El Chami and El Moujabber, 2016).

According to research conducted in several developing nations, including South Africa, poor rural households whose livelihoods depend on rain-fed agriculture are more susceptible to drought and less equipped to absorb and buffer the losses (Abdu-Raheem and Worth, 2011). Consequences include a lack of water availability, which affects opportunities for consumption, manufacturing, and environmental water needs and ultimately results in poverty (Schreiner *et al.*, 2018).

The Northern Cape Province was one of the three Provinces that Tandwa (2018) asserted had been designated as national disaster zones in 2018. The Northern Cape Province experiences annual rainfall ranging from 50 to 400 mm, which is less than the average annual rainfall of the nation which was 450 mm (Botai, C.M., Botai, J.O., de Wit, *et al.*, 2021). There has been no improvement in rainfall in the Northern Cape and the Province has been without good rainfall since 2015 (Ramafoko, Lekunze and Luvhengo, 2021).

According to Jordaan (2012), drought in the Northern Cape Province was caused by below-average rainfall, however, it was exacerbated by above average temperature and human activities. Drought can have detrimental effects on the health of individuals as well as their social, economic, and political prospects (West, 2018). Due to the consequences of droughts, low-income households are forced to sell up their land or other productive assets to buy food. To survive, some rural households' default on loans, pull their kids out of school, or engage in exploitative environmental management techniques (Barbier and Hochard, 2018). When there is prolonged drought in an area, it affects crop production, animal production, developments, employment, water supplies and most importantly loss of welfare.

Many authors have come to an agreement that for rural households to build resistance against drought, they need to adopt various coping and adaptation strategies (Abid, Scheffran, Schneider, *et al.*, 2015; Berhanu, and Beyene. 2015; Bryan, Ringler, Okoba, Roncoli, *et al.*, 2013; Jha, Gupta, Chattopadhyay, *et al.*, 2018; Yila, and Resurreccion, 2013). Rural households have adopted different livelihood strategies such as migration of individuals with the aim of improving their standards of living (Christian, 2017). Rural households have also adopted various climate change adaptation strategies such as planting drought tolerant crops such as sorghum, diversify crop varieties planted, livestock diversification, dry planting, and early planting (Mushore, Mhizha, Manjowe, 2021). Despite the adoption of these various adaptation strategies, rural households in the Northern Cape Province still find themselves seeking assistance from government when faced with severe drought (Matlou, 2021).

South Africans are at risk of drought because of inadequate policy implementation, and some of the most severely affected Provinces, like the Eastern Cape, Western Cape, and Northern Cape, are dependent on drought relief in the form of trucks delivering water, food parcels from organizations like the International Fund for Relief and Development, and some farmers receiving funds for drought relief to help save their livestock (van Der Rheede, 2016). As a result of the adverse effects of drought, government is losing a lot of money as it spends more money on trying to cushion the impact of drought in the country (Mmatlou, 2019). For instance, during the drought in the Western Cape Province, about R5 billion was lost to the economy due to drought. Consequently, the tourism sector suffered, the agricultural sector suffered, jobs were lost, and food prices increased (Palm, 2018). This meant that the National Treasury would need to spend more money on disaster relief and neglect funding for other economic activities. Furthermore, government would need to import more agricultural products and a shortage in local produce could result in high consumer prices and interest rates (Mmatlou, 2019).

In 2020, the South African government had placed R300 million aside from the emergency fund of the Department of water and sanitation emergency towards drought relief (Davis, 2020). The aim was to use these funds for drilling boreholes and ensuring that there is water for consumption in households. However, residents of the Northern Cape expressed their concerns as they were of the view that this money would not be sufficient (Davis, 2020) simply because the province had been experiencing drought for some time (Jordaan and Sakulski, 2013).

Muthelo (2018) asserted that farmers' options for managing and adapting in delicate situations like drought are constrained by a lack of knowledge, resources, and assets that support their livelihoods. Additionally, increasing drought adaptation capacity and resilience is a crucial component of reduced vulnerability, which would considerably improve the welfare of rural households. However, it is unknown to what extent rural households' vulnerability affects their decision-making about coping or adaptation measures.

According to the researcher's knowledge, very few studies focused on the effect of drought adaptation strategies and the effects that they have on the welfare of rural households in terms of consumption expenditure. Therefore, the aim of the study was to identify the types of impact that drought had on the welfare of rural households, to determine which adaptation strategies were effectively adopted by rural households and to also determine what impact these adopted adaptation strategies made on improving the welfare of rural households. The decision to conduct the current study was driven by the knowledge that there were a few studies that explored how drought adaptation strategies affected the welfare of rural households in terms of consumption expenditure. As a result, this work tried to fill this knowledge gap.

1.2 Research questions

- i) Do rural households adopt any drought adaptation methods to improve their welfare?

- ii) What impact do drought adaption measures have on the welfare of rural households?
- iii) What is the welfare enhancement impacts associated with each adaptation method?

1.3 Research objectives

- i) To identify the different adaptation methods being used against occurrences of drought.
- ii) To analyse the effects of drought adaptation strategies on rural households' welfare.
- iii) To compute the welfare enhancement impacts that are associated with each adaptation method.

1.4 Hypotheses

- i) Drought has a negative impact on rural households' welfare.
- ii) Adaptation strategies have a positive impact on rural households' welfare.
- iii) There is a relationship between welfare and each adaptation method.

1.5 Significance of the study

To better the welfare of rural households in the JTGD, this study evaluated the various drought adaption strategies available, investigated the variables that affected adaptation strategy choice, and decided which adaptation strategy would be most effective. The results of this study may assist the government and other decision-makers as well as the community members in their efforts to minimize the negative effects of drought as soon as possible by educating them about the effects of drought, drought adaptation strategies, and methods to sustain incomes and consumption expenditures.

The conclusions and suggestions made in this study could assist decision-makers revise current regulations, including the Disaster and Management Act 57 of 2002 and the National Disaster Management Framework of 2005. The research findings would also aid in developing strategies that will ensure the best possible implementation of the policies to lessen the effects of drought on rural households' welfare. The results of this study may inspire additional research on drought adaptation and rural households' welfare in the JTGD. They may also advance knowledge by improving understanding and appreciation of how drought affects rural households' welfare.

When evaluating the implementation of the Disaster and Management Act 57 of 2002 and the National Disaster Management Framework of 2005, the Department of Agriculture and Rural Development as well as other disaster management organizations may be able to use the results on the adaptation strategies used by various households as information. This study could make another contribution to the 2030 South African National Development Plan goal of national food security.

1.5 Organization of chapters

Five chapters make to the structure of the research. The introduction is in Chapter 1, and the literature review is in Chapter 2. The research methodology is covered in Chapter 3 and includes descriptions of the study region, study population, sample size, sampling technique, and methods of data collection and analyses. The results and discussion thereof are presented in Chapter 4 and the conclusion and recommendations are presented in Chapter 5.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.0 Introduction

This chapter reviewed the pertinent research on drought adaptation mechanisms employed by rural households. It also discussed the consequences of drought on rural households' welfare. A review of relevant literature is presented in the first section of this chapter in accordance with the goals of the study that were set forth in the chapter before. The second section of the literature outlines the theoretical framework that the study used to analyse the empirical data that were collected from the JTGD in the Northern Cape Province.

2.1 Welfare of smallholder farmers

Smallholder farmers make up a large section of the global population, with an estimated 500 million smallholder farmers globally out of a total of 570 million farmers, comprising 85 % of farms worldwide (Harvey, Rakotobe, Rao, *et al.*, 2014). In 2014, approximately 35% of the food produced in the world was produced by smallholder farmers, who cultivated land on plots smaller than two hectares (Lowder, Skoet, and Raney, 2016). For instance, approximately 98% of smallholder farmers cultivated farms that were less than two hectares in China, which alone accounted for nearly half of all small farms worldwide (Rapsomanikis, 2015). With land holdings of less than one hectare, about 80% of farmers in India are smallholder farmers (Qazi, 2017). Smallholder contributions to food production vary greatly by nation, reaching as high as 86.6% in India, 80% in China, and low single digits in Brazil and Nigeria (Rapsomanikis, 2015).

Smallholder farmers are a vulnerable population that is frequently disregarded by development policy, despite the critical role they play in ensuring global food security and nutrition. They also make up most of the impoverished and hungry people in the world. Numerous of these smallholder farmers are underprivileged, food insecure, and have limited access to markets and services because they are thought to make up half of the world's hungry people (Fan and Rue, 2020). They are limited in their options but manage to harvest their land and provide food for a substantial fraction of the population of the world (Rapsomanikis, 2015).

According to a study by Norman (2017), a large portion of smallholder farmers in India subsist on less than 1.90 dollars per day and frequently raise staple crops to sustain their families. In 2015, Sustainable Food Lab, Agribusiness Systems International, and Wrigley Jr. Company, worked together to carry out a study in the Uttar Pradesh, India, region known for its mint cultivation (Daniels, 2017). According to the report, mint is typically the only cash crop grown by smallholder farmers, who plant it in between crops of basic staples.

On average, a household grows 60% of the food they consume. Additional food items, farm inputs, housing, healthcare, education, marriage, and unanticipated costs are all purchased with cash earned through mint and other sources of revenue. The distribution of land among farmers in Brazil is also unequal. Guedes, Brondízio, Barbieri *et al.*, (2011) suggested that this is a direct outcome of the high concentration of land ownership in the country. The Brazilian government established a poverty line of 140 Brazilian reais per month, which is very low to ensure that social measures are directed on the poorest people. The level of income produced by smallholdings is below this limit.

One of the key features of smallholder farmers' production systems is their reliance on women, their use of rudimentary, antiquated technologies, low returns, and large seasonal labour swings (Odiwuor, 2022). Smallholder farmers can be crucial in helping the rural poor create livelihoods. Even though smallholder farming is crucial for ensuring households' food security, its productivity is rather low. One of the possible causes of urban and rural households' lack of interest in or abandonment of agricultural production is low yields (Fan and Rue, 2020).

With 54% of the population working in agriculture, Africa is primarily a rural continent. Majority of farmers maintain small, dispersed plots of land, but they provide most of the food produced in the continent, making the smallholder agriculture sector a crucial component of the rural economy of the world (Rapsokins, 2015). Smallholder farming accounts for more than 60% of the population in sub-Saharan Africa, and the sector generates around 23% of the GDP in the region. More than 60% of the labour force works in agriculture, which is the primary economic activity in many sub-Saharan nations. More than 75% of the impoverished in these areas rely on agriculture for their daily survival (Goedde, Ooko-Ombaka and Pais, 2019).

A study was carried out in South Africa by Malomane (2019) with the goal of analysing the role of smallholder farmers' cooperatives in rural development, which further explored the creation of a framework for the growth of smallholder farmers through cooperative development. According to the study, smallholder farmers frequently engage in mixed crop-livestock production. Since the major goals of farming are to satisfy domestic family needs, operations in such farms are typically run by family members. Smallholder agriculture provides most households in sub-Saharan Africa with their primary source of income, and smallholder households also handle much of the agricultural production in the continent (Giller, Delaune and Silva, 2019). Although sub-Saharan Africa is incredibly diverse, many smallholder farmers generate a significant portion of the food for their households. In turn, a big portion of their agricultural production is also consumed by the households (Food and Agricultural Organization of the United Nations (FAO), 2012).

Pienaar and Traub (2015) estimated that 13% of agricultural land in the country was farmed by 4 million smallholder farmers in the former homeland regions of South Africa. Small-scale farmers frequently lack institutional capacity and assistance, have labour-intensive farms, and use conventional production methods (Pienaar, 2013). According to a study by Mathebula, Molokomme, Jonas, *et al.*, (2017), households can diversify their income by working on other farms or in non-

agricultural jobs. As a result, agricultural households in rural areas of South Africa often employ a variety of livelihood strategies depending on their access to natural resources, physical assets, human capital, and financial resources, all of which are largely influenced by socioeconomic and biophysical factors.

Social welfare subsidies from the government, notably old age grant which is R1980 (for adults below 75 years) and R2000 (for adults above 75 years of age); and child support grants, which is R720. These grants are provided monthly and are the main sources of income for most rural households (Bhorat, Cassim and Hirsch, 2014). Average monthly remittances from family members who do not reside permanently with their families total R123 (Pienaar and Traub, 2015).

Smallholder farmers already confront several agricultural production risks throughout the tropics that limit their development and ability to successfully contribute to their welfare (Harvey *et al.*, 2014). Most smallholder farmers are found in rural locations, where a lack of institutional and physical infrastructure restricts their ability to expand and access resources like information on production techniques and market prospects (Khapayi and Celliers, 2016), this is true in especially for new crops and varieties, as it prevents people from developing agriculture and creating high-value goods, whose market demand is expanding quickly. High transaction costs are one of the main obstacles limiting smallholder farmers' expansion, and they are primarily caused by inadequate infrastructure (Olutwayo, 2019). Smallholder farmers have also been shown to be severely constrained by a lack of human capital. They frequently lack basic literacy skills and are technologically illiterate, which can be major barriers to entering formal institutions where technological information is shared (Matlou *et al.*, 2021).

Most smallholder farmers lack the marketing and financial capacity necessary to compete on the level of quality demanded by markets. Lower production quality is a result of production knowledge gaps. Most smallholder farmers produce tiny amounts of low-quality goods due to low endowment in production elements including land, water, and capital assets, which results in their products being ignored by output markets. Any decreases in agricultural output can have a severe impact on the food security, nutrition, income, and well-being of smallholder farmers because they often directly depend on agriculture for their livelihoods and have limited resources and capacity to withstand shocks (Harvey *et al.*, 2014).

2.2 Drought and welfare conditions of smallholder farmers

One of the natural disasters that South Africa is vulnerable to is drought. South Africa regularly suffers rainy and dry spells because of its high level of spatiotemporal rainfall variability (Crétat, Vizy,

and Cook *et al.*, 2012). The dual agricultural economy that supports the population of the nation depends on rainfall for both rural subsistence farmers and commercial growers. Therefore, destructive droughts that have regional and national socio-economic repercussions are caused by negative departures from the seasonal rainfall anomaly (Meque, Pinto, Maure *et al.*, 2022).

The economy, food security, and livelihoods of the region depend on agricultural productivity in South Africa. In South Africa, agricultural operations range from intense crop production to mixed farming in areas with abundant summer and winter rainfall, cattle ranching in the bushveld, and sheep and goat farming in desert regions. Wheat, sugar cane, and sunflowers are the next most widely produced crops after maize (Masipa, 2017).

The most noticeable effect of a drought is a decrease in crop production because of insufficient and uneven rainfall (Seleiman, Al-Suhaibani, Ali *et al.*, 2021). Farmers often struggle with harvests that are insufficient to meet their needs as well as those of their families and other obligations. When compared to 2014, when the nation produced 12.345 million tons of maize, the average annual national production of maize in South Africa, for instance, showed a dropping performance in 2016 (Masereka, Ochieng, and Snyman, 2019). The intensity of the damage brought on by a drought is typically unpredictable since it depends on several variables, such as the pattern of rainfall, the soil's ability to retain moisture, and moisture loss through evapotranspiration (Seleiman *et al.*, 2021). Growth relationships between nutrients and water, photosynthesis, and agricultural yields are all hampered by drought.

Although output from natural pastures tends to be less responsive to drought than crop production, pasture production is nonetheless likely to be reduced in areas where crops have been severely impacted by drought (Fahad, Bajwa, Nazir, 2017). Poor pasture growth is a result of low rainfall, which can also affect the availability of crop leftovers as fodder (Abazinab, Duguma, and Muleta, 2022). Lack of forage in the area around the village causes livestock to lose weight and die more often.

Both industrialized and developing regions depend heavily on livestock for both sociocultural and food security reasons (Nyamushamba, Mapiye, Tada, *et al.*, 2017). In low-income countries, livestock is significantly more important to rural households than it is in high-income nations. They have a significant role in household finances, produce a significant amount of household cash income, support agriculture, and offer transportation (Herrero, Grace, Njuki, *et al.*, 2012). Most of this livestock is produced under adverse conditions, which reduces their yield. Due to their extensive maintenance needs, livestock are susceptible to water and feed shortages during dry spells (Sejian, Gaughan, Bhatta *et al.*, 2016). Livestock are vulnerable to hydric stress, immunosuppression, nutritional stress, and even death because of frequent and severe droughts (Dzavo, Zindove, Dhliwayo *et al.*, 2018).

Loss of animals close to the farming community limits residents' access to manure, a product that is crucial for maintaining soil fertility on routinely farmed soils and serving as a fuel source if firewood is scarce. Moreover, as farmers struggle to make ends meet, they end up encouraging their labourers to look for work elsewhere since they cannot afford to keep them on the farm, which leads to a loss of employment because of decreased agricultural production (Visserand Ferrer, 2015).

In addition to a reduction in food production directly, droughts can significantly lower the purchasing power of groups due to changes in the relative price of grain compared to other commodities (GAR, 2011). According to National Agricultural Marketing Council (NAMC) (2015), the overall price of food climbed by 4.4% in 2015, while the price of grains, bread, and maize increased by 6.4% in September 2015 compared to the consumer price index, which was 4.6%. Nkosi and Faku (2015) claimed that meat costs increased by 5% during this time. Poor consumers frequently bear the brunt of the effects of decreased supply and raised costs since they spend a bigger percentage of their household budget on basic goods, which could cause them to cut back on consumption or fall farther into poverty (Schanzenbach, Nunn, Bauer *et al.*, 2015).

2.3 Socio-economic factors and welfare conditions of the farmers

2.3.1 Age

Studies done in South Africa show that farming households usually constitute of the elderly, with the average age ranging from 52 in the United States and 62 in South Africa (Sihlobo, 2015). Studies done by Litchfield and McGregor (2008) and Cheema and Sial (2012) proved in their studies that age brings with it gains in welfare. Age-related changes in rural households may therefore reflect increased work experience, which is linked to higher income and asset ownership, both of which raise household consumption and lower the likelihood of being poor (Lekobane and Seleka, 2016).

2.3.2 Gender

Gender was found to influence household welfare significantly (Boudet, Buitrago, De La Briere, et al., 2018). Female-headed households are more likely to be impoverished than male-headed households (Nwosu, 2018). Boudet *et al.*, (2018) identified that female heads in rural households have a higher dependency ratio than male. In addition, women typically earn considerably less than men and have less access to economic possibilities (Oritz-Ospina and Roser, 2018). In rural households, women frequently manage complicated households and pursue numerous means of subsistence (FAO, 2011). They often engage in activities including growing crops, taking care of animals, processing and cooking food, working in agricultural or other rural businesses for pay, gathering fuel and water, trading, and marketing, taking care of family members, and maintaining their dwellings (Singh, 2014). This leads to their choosing lower paying employment that provide them more time to do household duties even though they pay less. Jobs that pay less indicate a lower income per person, which has an impact on household welfare.

2.3.3 Household size

According to a study by Fusco and Islam (2017), parents' take-home pay decreases when there are more children living with them. The study also discovered that it lowers the number of students enrolled in school, particularly at the secondary and tertiary levels, and lowers the cost per student who stays in school. It also causes households to save less money. Additionally, a bigger household size results in higher expenses for necessities like food, clothes, health care, and education. An increase in household size further burdens the home financially and frequently lowers the welfare of the household (Nishimwe-Niyimbanira and Meyer, 2016).

2.3.4 Education

Education is crucial to the ability of an individual to generate money in both agriculture and other professions. A study by Oduro-Ofori, Aboagye, and Acquaye (2014) sought to determine the impact of education on farmers' agricultural productivity. Data was gathered from 100 farmers, and it was discovered that productivity grew as farmers' educational levels rose, with the maximum agricultural production return occurring at the secondary school level. In a study on agricultural education and rural development that was conducted in Nepal, it was shown that education boosts agricultural productivity first through enhancing farmers' capacity for decision-making and secondarily by reducing their technical efficiency (Chaudhary and Pasa, 2015). Therefore, it is believed that having more education will increase one's chances of landing a better job and, consequently, earning more money, boosting the welfare of rural households (Wanka, 2014).

2.3.5 Income

According to Sumaryanto, Susilowati, Saptana, et al., (2021), most rural households rely on on-farm employment as a source of income, however, Davis, Di Giuseppe, and Zezza (2017) revealed that there is a relative increase in off-farm farm income as more and more people shift away from agricultural-based employment. Thus, income earned by households that is available for spending grows. Consumer spending naturally rises when disposable income rises because people have more money to spend or save. Increased control over goods and services results from higher household income, which also enhances the welfare of the household (Epaphra, 2014).

2.3.6 Employment

Employment boosts the economy by giving low-income households access to income, reviving domestic demand for products and services, and promoting overall growth (International Labour

Organization (ILO), 2017). In the long run, work can boost social welfare, facilitate the return of displaced people, and aid in social healing (Karnani, 2011). According to a study by Hussam, Kelley, Lane *et al.*, (2021), employment offers not only financial benefits for daily living but also a variety of psychosocial benefits through significant latent functions such as imposing a schedule on the working day, implying frequent interactions with people outside the nuclear family, connecting people to larger-than-life goals and purposes, defining aspects of personal status and identity, and enforcing activity (Hussam, Kelley, Lane, 2021). A person can better understand the real world and how it will change in the future through education and information. Education encourages the development of people who can play a part in raising productivity and, consequently, the amount of output in the economy (Neamtu and Laurentia, 2013). Therefore, being a household head without a job lowers welfare.

2.4 Adaptation methods that are used against the occurrences of drought and their determinants.

Many people believe that the most effective strategy to lessen the harmful effects of climate change is through adaptation. Farmers can retain their food, financial, and way of life security through adaptation even in the face of climatic and socioeconomic change Kom *et al.*, (2020). The local agriculture cycle, which considers seasonal climate variation as well as other socioeconomic factors, typically dictates how each farmer chooses to adapt.

2.4.1 Age of the household head

The general adoption of adaptation techniques in response to climate change and unpredictability is influenced by the age of the household head (Amare and Simane, 2017). Beyene, Gowda, and Suresh (2017) claimed that a key determinant of whether farming households utilize adaptation strategies is the age of the household head. These results imply that household heads are less likely to implement adaptation measures as they age. This assertion is supported by Ogunpaimo, Oyetunde-Usman, and Surajudeen (2021), who argued that younger farmers are more likely than their older counterparts to adopt adaptation strategies, possibly because they are more innovative and eager to try new technology and methods to improve agriculture, whereas older farmers may be aware of the negative economic implications of such strategies due to years of experience. However, older farmers adopt adaptation tactics more quickly than younger farmers, according to a study by Waaswa, Nkurumwa, Kibe *et al.*, (2021), since young farmers are unable to access land and other production resources possessed by adults and older farmers.

2.4.2 Gender of the household head

Gendered vulnerabilities result from the way that gender constructions in most cultures affect how men and women can access crucial resources that are required for growth. Atube, Malinga, Nyeko

et al., (2021) found that gender had a favourable effect on the adoption of adaptation tactics in a study on the factors influencing smallholder farmers' adaptation strategies to the effects of climate change. A study by Derressa *et al.*, (2009) found that male-headed households were more likely than female-headed households to learn about new technology and utilize different adaptation strategies. In contrast to their male counterparts, the female heads of agricultural households participated in adaptation measures at a far lower rate in the study by Assan, Suvedi, Olabisi *et al.*, (2018). Women may have limited access to education, land, and other resources because of pre-existing social barriers.

2.4.3 Household size

According to Mtintsilana and Akinyemi (2020), the size of a farming household operation decreased the likelihood that it would apply climate-adaptive practices. The likelihood of adapting to climate change is higher for large households than for small households (Ndamani, and Watanabe, 2016). This is because households with large families may be compelled to divert a portion of their labour force to off-farm activities to earn money to reduce the pressure on consumption brought on by a large family (Deressa *et al.*, 2009). Large families may also contribute to the harmonization, perception, discussion, and exchange of observations connected to the climate (Ojo and Baiyegunhi, 2019). The second supposition holds that households with large families typically have access to more labour, enabling them to handle a range of agricultural tasks (Mtintsilana and Akinyemi, 2020).

2.4.4 Education level of the household head

A key strategy for promoting successful climate change adaptation could be education (Intergovernmental Panel on Climate Change (IPCC), 2014). According to a study by Feinstein and Mach (2019), education can enhance disaster awareness and response by facilitating economic diversification away from climate-sensitive sectors, accelerating the dissemination of information throughout society, and lowering inequality, which increases societal vulnerability. Education may also affect adoption rates because it improves welfare. A farmer is more likely to obtain knowledge, recognize climate change, and adapt to it if they have a higher level of education (Kidanu, Kibret, Hajji *et al.*, 2016). Furthermore, a fundamental awareness of climate change science, the ability to comprehend the complexity and uncertainties of climate change, and an appreciation for systems thinking are all necessary for farmers to embrace adaptation approaches (Davidson and Lyth, 2015).

Destaw and Fenta (2017) asserted that literate farmers are more knowledgeable about new technologies than their illiterate counterparts. The results are in line with those of Belay *et al.* (2017), who discovered that educated farmers are more inclined to accept new technologies since they are conscious of the possible benefits of the suggested countermeasures to climate change. This judgment was supported by a study on the value of education by Kom *et al.*, (2020). According to the study, educated farmers are also more conscious of climate change and more inclined to use cutting-edge adaptation strategies to enhance their agricultural output. Literate household heads are

more receptive to their farming methods and have better access to scientific information than uneducated farmers (Hirpha *et al.*, 2020).

2.4.5 Farm income

Asrat and Simane (2018) found that income from farm and non-farm sources is positively and significantly associated with climate change adaptation in their study "*Farmers' Perceptions of Climate Change and Adaptation Techniques in the Dabus Watershed, North-West Ethiopia.*" This might be because the money received from these sources might make it simpler for farmers to pay for adaptation measures. The possibility of households responding to climate change is increased by higher agricultural and non-farm income (Adzawla, Azumah, Anani, 2020). Farmers with greater yearly incomes are more likely to employ climate change adaptation strategies than farmers with lower incomes, according to Marie, Yirga, Haile *et al.*, (2020). This can be the case because farmers that earn more money have more money to spend on different adaptation strategies. The results of this study are supported by studies by Iheke and Agodike (2016), who discovered a positive and significant link between income level and application of climate change adaptation methods. Intriguingly, a study by Muzamhindo, Mtabheni, Jiri *et al.*, (2015), discovered a negative correlation between farm income and the choice to adapt to climate change. There may be little incentive for farmers who are still working in the conventional agricultural system and making substantial farm incomes to get involved in new endeavours because they are happy with their current circumstances.

2.4.6 Access to extension services

The primary function of agricultural extension in the agricultural sector is education. Extension officers are expected to deliver information to farmers and encourage them to share it. Extension officers are expected to do additional services as part of their duties and include them in their job description in addition to offering institutional assistance and meeting farmers' requirements to support agricultural productivity (Maponya and Mpandeli, 2013). Programmes for public awareness and education that can assist farmers in reducing the effects of climate change have been identified to involve agricultural extension (Akamigbo, and Nnaji, 2011). Di Falco *et al.*, (2011) claim that extension services aid adaptation by raising farmers' awareness of climate change and their familiarity with adaptation tactics. According to a study by Mandleni and Anim (2011), formal extension positively and significantly raised people's understanding of climate change and adaptation.

The results are in line with those of Ojo and Baiyegunhi (2018), who discovered that access to extension services is positively correlated with farmers' adoption of improved crop varieties, crop diversification, and adjusted sowing times. According to Abid *et al.*, (2015), farmers who have access to extension services are more likely to employ mixed cropping and improved varieties as climate change adaptation strategies. Enhancing timely information and regular support from extension

services is essential for assisting farmers in their efforts to adjust to the consequences of climate change.

2.4.7 Access to climatic information

The availability of climatic data has a significant impact on the available adaptation strategies (Destaw and Fenta., 2020). Belay *et al.* (2017) assert that access to climate knowledge affects the ability to adapt to climate change. In that case, a farmer made better adaptation choices because they had better weather information (seasonal or mid-term forecasts). Smallholder farmers with access to meteorological data were more likely to apply climate change adaptation techniques like late and early planting, using early maturing crops, growing food and fodder trees, and conserving soil and water. According to a study by Muthelo., Owusu-Sekyere, and Ogunedeji, (2019), access to climate-related information had a favourable and significant impact on how people coped with drought.

In general, households that received weather forecast information are more likely than those that did not have access to weather forecast information to adapt to climate change by adopting multiple cropping, rearranging planting dates, and keeping animals (Mugari, Masundire, and Bolaane, 2020). As a result, this finding highlights the value of understanding climatic forecasts for enhancing climate change adaptation. Farmers that have access to climate forecast information are more likely to grow a range of crops and alter their planting schedules to consider the current and predicted weather conditions (Merie *et al.*, 2020).

2.5 Theoretical framework

The random utility maximisation (RUM) model is a prominent theoretical model for analysing discrete decisions that assumes of individuals' utility maximising behaviour (Ajak, Kyazze, and Mukwaya, 2018). According to the concept of RUM, farmers choose a variety of adaptation strategies to maximize their gain. The idea holds that a farmer is a sensible economic agent who bases decisions on anticipated rewards or satisfaction (Abid *et al.*, 2016). A farmer makes a logical selection based on this concept by choosing the adaptation approach that will benefit him or her the most. The choice of a farmer to adapt to a drought, on the other hand, is one that was made voluntarily. This implies that a farmer may be systematically different from those who use a different approach or do nothing at all from those who utilize a certain technique to adapt to drought.

A decision made by a farm household to adopt a range of adaptation tactics in response to climate change is often based on observable and unobservable features of the household, farm, and community (Berhe, Hoag, Tesfay *et al.*, 2017). When farm households make decisions during various risk scenarios, such as a drought, these characteristics are essential. Households' adaptation decisions are made jointly in response to climate change, and as a result, the livelihood activities that support better welfare (Alhassan, 2020).

Farm households' participation in the implementation of various adaptation strategies is associated with future benefit maximization, assuming that they can make rational judgments. These anticipated advantages encourage households to keep using a range of adaptation techniques that give them the most unobserved value (Asmare, 2019). Households may experience varying levels of unobserved utility throughout time because of variations in predicted benefits at various points in time. Since decisions reflect changes in both observable and unobservable features, households' utility may, in fact, fluctuate over time.

Farmers' decisions about which adaptation technique to use to lessen climate change effects are heavily influenced by socio-economic aspects that must be recognized (Marie *et al.*, 2020). Depending on the terrain, farming practices, socio-demographic variables, livelihood strategies, and farm characteristics, farmers' adaptation tactics may change.

The study adopted the random utility framework, which was utilized to capture the various adaptation approaches employed against drought occurrences and their determinants with the goal of improving the welfare of rural households in the conceptual framework of this study. In this theory, a household head is a decision maker who has been harmed by drought and is able to compare two drought adaptation choices in the choice set using a preference indifference operator.

Assume that this household head is rational and wants to maximize utility, or that he or she wants to know that his or her welfare will improve. Given a variety of drought adaptation options, this household head would choose the option that maximizes his or her utility or ensures that he or she achieves greater welfare.

Heads of rural households make decisions based on the perceived value of various adaptation methods in response to negative consequences of drought. These verdicts are obtained from the behaviour of the households' head in terms of utility (or profit) maximization. If u_a and u_b signify the utility of the household head i , who is responsible for choosing between any two options, then the linear random utility model may be presented as:

$$u_{ia} = v_{ia} + \varepsilon_{ia} \tag{1}$$

Where, u_{ia} represents the household head i 's utility of selecting option a , v_{ia} represents the observable or explainable variable of a utility that household head i has for option a and ε_{ia} represents a stochastic element (random or unexplainable) that signifies unobservable influences on individual choices, and error of measurement. This random component, or error term, is thought to be independently and uniformly distributed by the utility function (Alam, 2015).

This theory presupposes those economic actors (in this case, the heads of rural households) only employ coping and adaptation strategies when they think doing so will be more advantageous than farming without them. Although utility is not immediately apparent, farmers' actions can be observed in the decisions they make.

2.6 Conceptual framework

The following framework was drawn from the theoretical framework above.

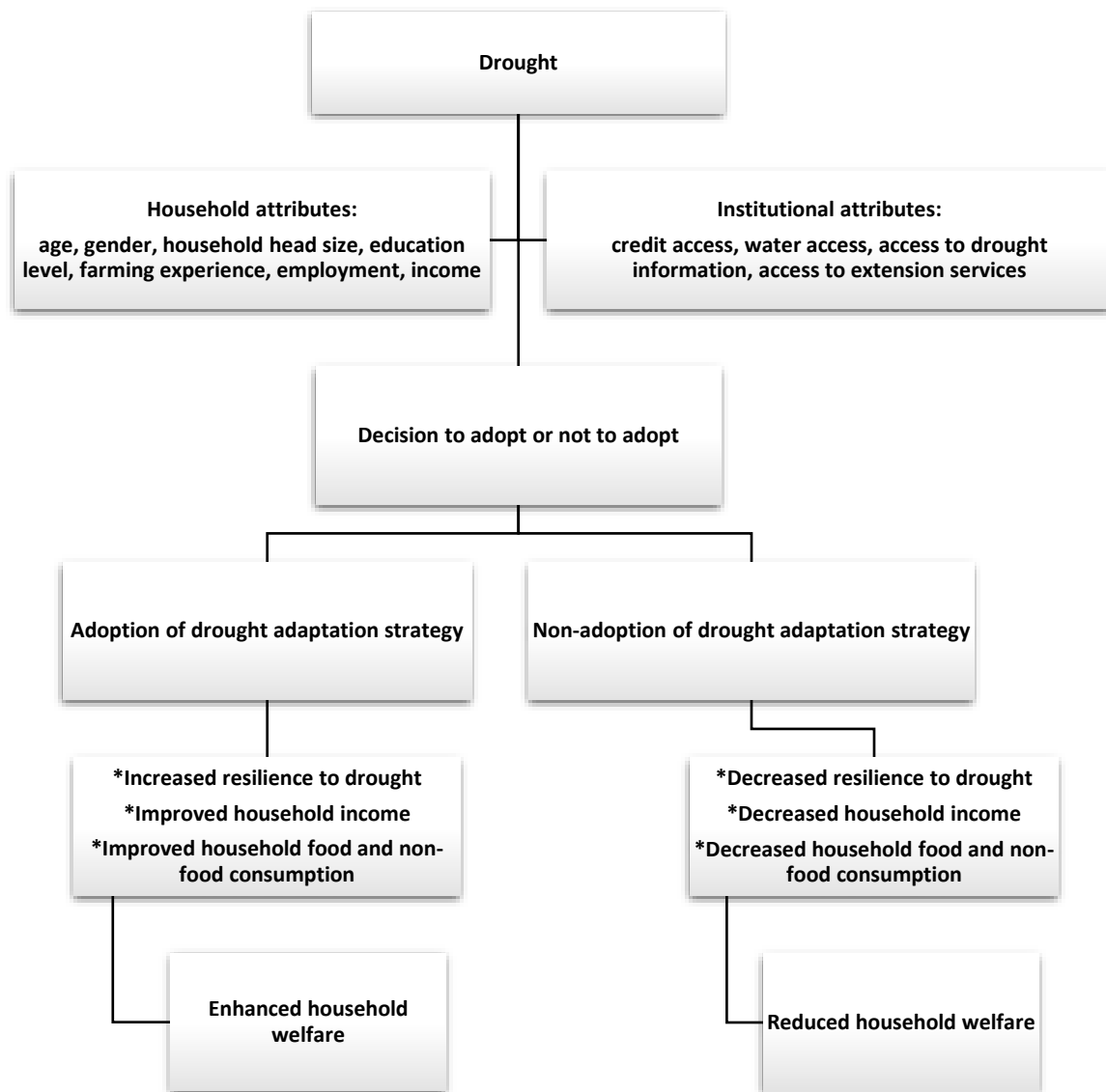


Figure 2. 1: Conceptual framework of drought adaptation strategies and welfare impacts.

Source: Author's conception (2019).

The framework above illustrates the relationship between key variables. Household attributes (age, gender, household size, education, farming experience, employment, and income) and institutional attributes (credit access, water access, access to drought information, and access to extension services) are background factors that are determinants of drought adaptation and have an impact on rural households' welfare.

For rural households to cope with the adverse effects of drought that compromise their welfare, they must decide to adopt or not adopt various drought strategies.

The framework suggests that households that adopt drought adaptation strategies will have inverse resilience to drought, improved household income, and improved food and non-food consumption, which will have a positive impact on their welfare as compared to households that decide not to adopt any drought adaptation strategies.

2.7 The effects of drought adaptation strategies on rural households' welfare

By modifying natural or human systems in response to current or foreseeable climatic conditions or threats, adaptation is a policy option for mitigating the negative effects of climate change (Elum *et al.*, 2017). When responding to agricultural drought impacts, Bahta and Myeki (2021) defined adaptation as enhancing resilience and reducing household vulnerability.

Weather unpredictability and other climate change-related occurrences affect small-scale farmers in Africa (Apraku, Morton, and Apraku Gyampoh, 2021). Crop diversification, livestock diversification, drought tolerant crops, crop rotation, delaying planting date, rainwater harvesting, and coping measures such as spending savings, changing food consumption patterns, and being involved in other off-farm activities to diversify income can significantly reduce the effects of drought risk among farm households (Ali *et al.*, 2017). These measures have the potential to operate as a climate buffer, as well as a critical role in increasing agricultural output and farm household income. Even though a variety of adaptation strategies have been put into place across industries and regions, the solutions are not all-encompassing or equally accessible (Bierbaum, Smith, Lee *et al.*, 2012).

The goal of adaptation is to anticipate the negative impacts of climate variability, take the appropriate steps to prevent or reduce the harm they cause, and take advantage of any opportunities that may present themselves (Magnan, Schipper, Burkett *et al.*, 2016). It comprises utilizing methods that are compatible with the climate to lessen the negative consequences of global warming. For poor countries to accomplish long-term poverty eradication and sustainable development, climate change adaptation is a major priority (Liu, Yu, and Wang, 2015).

Farmers have always adjusted to climate change and will do so indefinitely. Uncertainty exists over their capacity to identify strategies and solutions that are suitable for responding to climate change, as the necessary adaptations may be outside the scope of their experience (Smit and Pilifosova, 2001). Determining the effects of adaptation to climate change on productivity is critical. It aids in understanding how the collection of tactics used by farmers in response to the changing climatic conditions brought on by climate change effect farm income from livestock and crop production (Kom *et al.*, 2020). Assessing whether farm households that implemented adaptation techniques genuinely saw an improvement in the welfare of the household is necessary in more detail (Di Falco *et al.*, 2011).

Since the 20th century, crops that can withstand droughts have been created using traditional plant breeding methods, enabling the plant to continue to grow and bear fruit even in the absence of rain (Ngumbi, 2019). According to Katusiime (2015), adopting drought tolerant crops is beneficial as the

crops can adapt to water-stressed situations, they have low nutrient requirements, and the improved seeds help in improving and increasing crop yields. A study by Mupakati and Tanyanyiwa (2017), investigated how smallholder farmers in Chiredzi district, Zimbabwe, were utilized drought-tolerant crops like cassava. According to the study, farmers' use of drought-tolerant crops was by far the most successful long-term adaptation strategy they had used to help diversify their sources of income.

To adapt to the environmental changes and economic risks brought on by climate change, farmers employ crop diversification as one of their methods (Akinagbe and Irohibe, 2014). To increase productivity and fix nitrogen in the soil, farmers often utilize multiple cropping systems, or they intercrop with cash crops like cowpea and soybean, or they use cover crops to shield plants from heat stress.

Another adaptation method that is the backbone of livelihood in many African countries is livestock production (Eeswaran, Nejadhashemi, Faye, 2022). Livestock helps poor communities with sustainable livelihoods, food security, and climate resistance (Weindl, Lotze-Campen, Popp *et al.*, 2015; Rojas-Downing, Nejadhashemi, Harrigan *et al.*, 2017). To increase resilience, livestock diversification is necessary since small animals, especially poultry, can make up for food lost during crop failure, as was seen in southwest Madagascar (Hänke, Barkmann, Coral *et al.*, 2017). Resource efficiency and weather resilience can be increased by diversifying livestock systems and incorporating livestock into agricultural systems (Rojas-Downing *et al.*, 2017).

Diversification is the norm in real life. Few people have a single source of income, retain all their wealth in one asset, or use all their resources in one activity. To meet their basic needs, enhance their well-being, and manage risk, rural people construct increasingly broad portfolios of livelihoods through the process of diversification, which entails integrating increasingly various resources and assets (Wan *et al.*, 2016).

The concept of income diversification is well-known as a means of self-insurance, and it does not appear to be a passing trend or to be limited to survival (Tadele, 2021). It may also be linked to livelihood insecurity, such as the inability to raise enough money to restart agricultural output when economic conditions are deteriorating, as well as livelihood success in reaching security of income (Majbauddin, Otani, Tsunekawa, 2020). However, the better welfare is linked to employment in non-agricultural sectors. In general, diversification appears to be more advantageous for rural households than for urban ones.

Another essential technique for supplementing farm household income and preserving rural livelihoods is off-farm employment (Giannakis *et al.*, 2018). Off-farm employment includes both paid work outside the farm home (off-farm wage work) and running a non-farm business (Van den Broeck and Kilic, 2019). Off-farm employment has long been thought to be an important method for preserving rural livelihoods by stabilizing farm household income. Several studies have shown that

off-farm work complements farm labour and slows the transition out of agriculture (Giannakis *et al.*, 2018). A rural home with numerous income streams will have less fluctuating overall income than a household with a narrow focus. Comparatively speaking, households with a greater variety of income sources are at an advantage over those with a lesser variety. As income diversification advances, so do the number of earning activities and the distribution of quantities among each component. Rural households use income diversification to reduce risk or prepare for impending or past weather shocks (Wan *et al.*, 2016).

2.8 Chapter summary

The study sought to reveal the kind of impact that drought has on rural households' welfare, to determine how these households can improve their welfare if they decide to adopt various adaptation strategies and deduce how the adaptation strategies impact rural households' welfare. This chapter addresses the knowledge gap by looking at how the drought in South Africa generally affected rural households. The main takeaways from this literature are that smallholder farmers account for most people in the world that are hungry and destitute and that millions of them are a vulnerable demographic that is frequently ignored by development strategy. Smallholder farmers typically have few resources and little ability to withstand shocks because their primary source of income is usually agriculture. Thus, any decreases in agricultural productivity may have a considerable effect on their ability to access food, maintain a healthy diet, earn a living, and overall well-being. The literature also claims that because South Africa is prone to drought, it is inevitable that rural households will suffer greatly from the negative consequences of drought. For rural households to increase their wellbeing, they require assistance in balancing their income and spending during dry spells and improving their consumption. a selective literature review of theoretical and empirical research has been conducted in this chapter since it serves as the foundation for the model creation in chapter three.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter gives a concise overview of the study area, research design, sampling technique, and variables measurement. It also defined the sampling frame and size, data collection and data analysis. Furthermore, econometric models such as multinomial logistic regression (MNL), Two stage least squares (2SLS) and propensity score matching (PSM) were provided.

3.1 Description and selection of the study area

The Northern Cape Province of South Africa served as the location of study. With about a third of the total land area in South Africa under its jurisdiction, the Northern Cape Province is thought to be the biggest province in the country. However, in comparison to other provinces in the nation, it has one of the smaller populations at just over a million (Sifolo, 2015). The province is in a barren region that is bordered by the Atlantic Ocean in the west, Namibia in the north, Botswana in the east, and the Western Cape province in the south of the country (Augustyn, Bauer, Duignan *et al.*, 2019). The five districts that make up the Northern Cape are: Frances Baard district, Pixley Ka Seme district, John Taolo Gaetsewe district, ZF Mgcawu district, and Namakwa district, with Kimberly serving as the capital city of the province. In addition to the five district municipalities, the Province has 26 more smaller local municipalities (Alexander, 2018). One of longest rivers in South Africa, known as the orange river, originates in the Northern Cape and is part of the international borders for Namibia and Lesotho, two neighbouring nations (Misachi, 2017).

This study was conducted in the John Taolo Gaetsewe district, which is in the Northern Cape Province between latitude: 26°07' and 27°58' South and longitude: 21°46' and 24°06' East. Previously known as Kgalagadi, the John Taolo Gaetsewe district municipality is a Category C municipality that is situated in the northern region of the Northern Cape Province and borders Botswana to the west. One of the five districts in the Northern Cape, it is made up of the villages that make up the majority (80%) of its 186 towns and settlements, including the three local municipalities of Gamagara, Ga-Segonyana, and Joe Morolong (Municipalities of South Africa, 2019). There are 242 264 people living there in total, giving the area around 21 322 km² and a population density of 9 persons per km² (Statistics South Africa Community Survey, 2016).

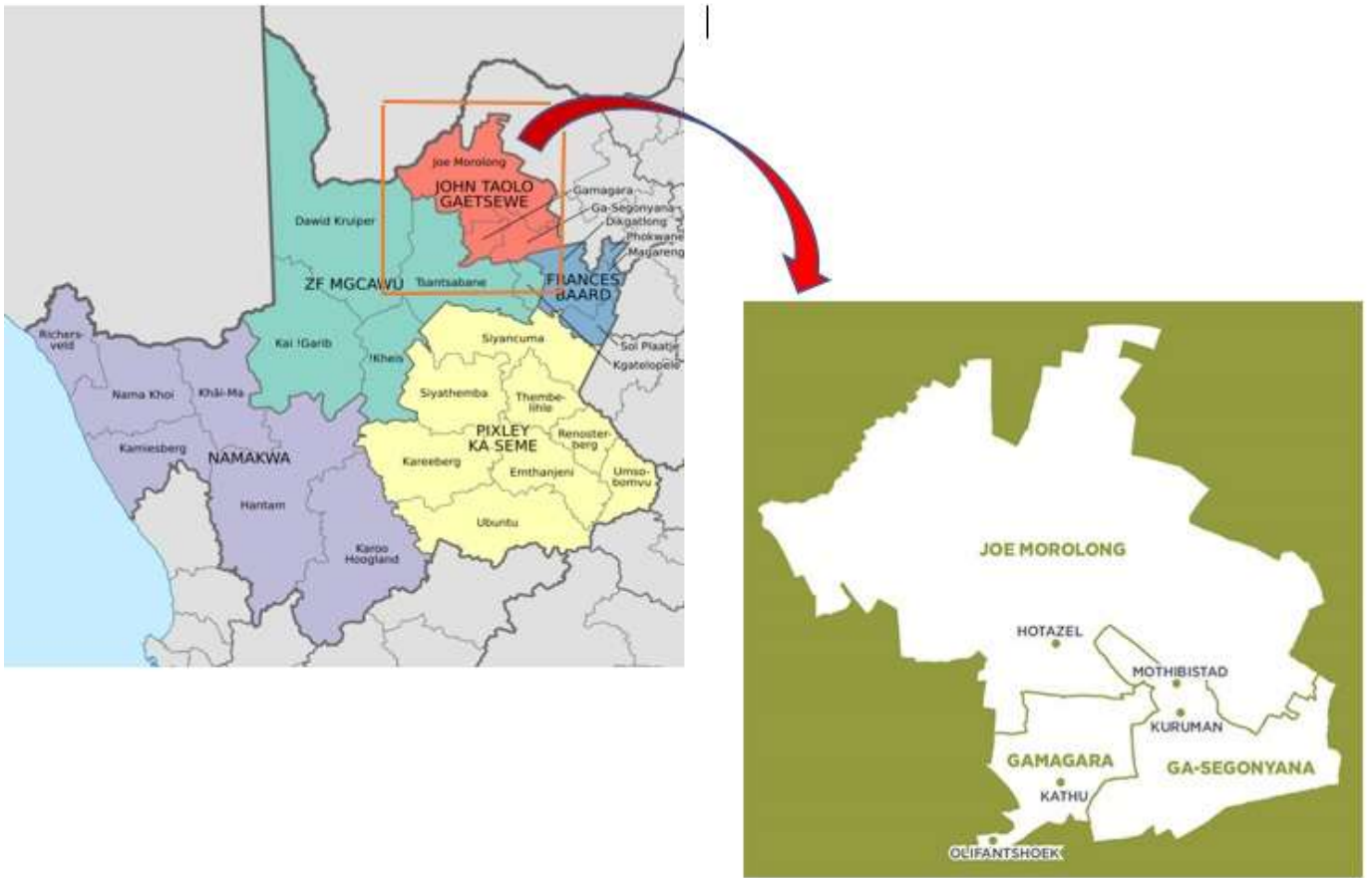


Figure 3. 1: Map of John Taolo Gaetsewe district showing all three local municipalities.

Source: Municipalities of South Africa (2019).

3.2 Research design

This study used a cross-sectional design and, where the investigation determined the relationship between drought and welfare indicator in the JTGD. The most appropriate approach to address the research objectives was the quantitative research method. The collection and analysis of data were done using a quantitative research technique, which emphasized statistics and figure presentations. Implicitly, a quantitative research approach can be thought of as having a scientific bent (Bryman and Cramer, 2011). The time and effort that the researcher would have spent expressing his results were reduced by using statistical data for the research descriptions and analysis (Eyisi, 2016).

3.3 Sampling procedure

A mixture of multistage and simple random sampling techniques were used to select rural households, who were affected by drought in different ways. The first stage of the multistage sampling procedure was selecting the province to sample. The Northern Cape province was purposively selected among all the other eight (8) provinces because its average rainfall was lower than that of all the other provinces and it was declared a national drought disaster area in 2015 (African People's Democratic Union of Southern Africa (APDUSA), 2016). In the second stage, three out of five districts namely, Pixely Ka Seme, John Taolo Gaetsewe and Namakwa, were purposively selected for being completely affected by drought (John Taolo Gaetsewe District Municipality, 2016). In the third stage of the multistage sampling procedure, John Taolo Gaetsewe district was randomly selected among those affected by drought by means of writing down each district on three separate pieces of paper which were folded, placed in a bucket, and randomly drawn from the bucket by the researcher. All three local municipalities (Gamaraga, Ga-Segonyane and Joe Morolong) of the John Taolo Gaetsewe district were included in the study. Furthermore, villages in each local municipality were randomly selected by the researcher, so were the households. The researcher sampled a total of 360 respondents. Though initially the sample size was 374, only 360 respondents were sampled due to COVID-19 and the many restrictions and curfews that were implemented.

3.4 Sampling frame and sample size

The sampling frame was designed to be an enumeration of rural households located in JTGD, Northern Cape Province. The households sampled included both male and female individuals who were above 18 years of age living in rural households. According to Statistics South Africa Community Survey (2016), the John Taolo Gaetsewe district had a total number 72310 households. Of the 72310 households, only 13 910 households are in rural areas (informal and traditional dwellings). Since the study is focused on rural households, a sample size was derived from the 13 910 households who reside in rural areas.

The sample size was calculated using the Raosoft Software calculator, which applies the formula:

$$SS = Z^2 \times p \times (1 - p) / C^2 \quad (3.1)$$

Where, SS = sample size, Z^2 = Z-value (e.g 1.96 for a 95% confidence interval), p = the % age of occurrence of a state of a condition, C^2 = confidence interval was 0.05 (5%).

Therefore, the sample size was 374 households.

3.5 Data collection

Rural communities are defined by Bracken (2008) as communities who have low population densities, limited resource bases, relative isolation, and cultural or ethnic homogeneity. Whereas rural households are defined as farming households whose farms are characterized by the biophysical elements of their surroundings (Harris, 2018).

Primary, cross-sectional data were collected with quantitative data collection instrument from rural households. The target population in this study area were male and female individuals who were above the age of 18 years as they do not require consent to participate in the conduction of the questionnaire and most of the time, they are the household heads. For quantitative data, the methods of data collection were through questionnaire. The questionnaire had six (6) sections, sections A – F, which required information on household characteristics; income, expenditure, and consumption patterns; infrastructure and utilities; access to agricultural services; access to drought information; and adaptation information respectively. A total of 360 questionnaires were conducted for the study.

3.6 Data analysis

The researcher ensured that the data were in a format that was acceptable for analysis after collecting and coding them. STATA (Version 15.1) software programme was used for data analyses. First, the study conducted a descriptive analysis on rural households' welfare and drought adaptation. The factors influencing the adaptation strategies used by farmers were then examined using MNL. Based on the principle of RUM, the MNL model is a discrete choice model used in drought adaptation research. To analyse the data gathered, the study also used two-stage least squares (2SLS) followed by propensity score matching (PSM).

Research objectives	Data collection methods	Data analysis	Hypothesis
To identify the different adaptation methods being used against occurrences of drought and their determinants	Questionnaire	Multinomial logistic regression (MLN)	Drought has a negative impact on rural households' welfare.
To analyse the effects of drought adaptation strategies on rural households' welfare	Questionnaire	Two-stage least squares (2SLS).	Adaptation strategies have a positive impact on rural households' welfare.
To compute the welfare enhancement impacts that are associated with each adaptation method	Questionnaire	Propensity score matching (PSM).	There is a relationship between welfare and each adaptation method.

Source: Author's conception (2019).

Presented in Table 3.1 is the research matrix showing study objectives, data needed, data collection tools, and hypotheses.

3.6.1 Descriptive statistics

Selected variables were described and summarized using some descriptive statistics (Kaur, Stoltzfus, and Yellapu, 2018). Before performing inferential statistical comparisons, descriptive statistics should always be explored as a crucial initial step in research. Measures of frequency, minimum, median, and mode were all included in the descriptive statistics, along with selected measures of central tendency, dispersion/variation, and position.

3.6.2 Multinomial logistic regression

In adoption studies with several options, the MNL and multinomial probit regression (MNP) models are the two analytical tools that are frequently used. Because the MNL and the MNP are frequently used interchangeably, they are both helpful for examining farmers' adaptation choices. Both individual adaptation methods and various combinations of adaptation strategies can be assessed using these methodologies. This study used an MNL model to assess the factors influencing farmers' adaptation decisions because it is widely used in adoption decision studies including a variety of options and is simpler to compute than the MNP.

The question of whether households should take action to adapt to climate change was investigated using the general idea of RUM (Deressa, Hassan, Ringler *et al.*, 2009). Economic agents, such as households, were only expected to employ their adaptation options when doing so would be seen as being significantly more useful or beneficial overall than staying in the basic category. Although the economic agents' utility is not immediately obvious in this setting, their actions can be seen in

the choices they made. Assuming that there is a utility of two options for households, the linear random utility model could then be specified as follows:

$$U_j = \beta_j X_i + \varepsilon_i \text{ and } U_k = \beta'_k X_i + \varepsilon_k \quad 3.2$$

where, U_j and U_k represent the perceived utility of adaption options j and k, respectively; β_j and β'_k are the estimated parameters; and ε_i and ε_k are error terms assumed to have independent and identical distributions (Bramo, 2022).

If a household selects option j for climate change adaptation, it implies that the utility of option j is seen to be higher than the utility of other options (such as option k), as represented as:

$$U_{ij}(\beta_j X_i + \varepsilon_i) > U_{ik}(\beta'_k X_i + \varepsilon_k), \quad j \neq k \quad 3.3$$

We can calculate the likelihood that a household will choose option j from a set of climate change adaptation alternatives using the relationship as follows:

$$P(A_i = 1/X) = (U_{ij} > U_{ik}) \quad 3.4$$

Equation (3.3) can be expressed and simplified in the following way:

$$P(\beta_j X_i + \varepsilon_j - \beta'_k X_i - \varepsilon_k) > 0/X \quad 3.5$$

$$P(\beta_j X_i - \beta'_k X_i + \varepsilon_j - \varepsilon_k) > 0/X \quad 3.6$$

$$P(\beta_j^* X_i + \varepsilon^*) > 0/X = F(\beta_k^* X_i) \quad 3.7$$

Where:

P is a probability function.

U_{ij} , U_{ik} and X_i are as defined above;

$\varepsilon^* = \varepsilon_j - \varepsilon_k$ is random disturbance term.

$\beta_j^* = \beta_j - \beta'_k$ is a vector of parameters that are unknown and may be interpreted as a net influence of the vector of independent variables influencing adaptation.

$F(\beta_k^* X_i)$ is a cumulative distribution function of ε^* evaluated at $\beta_k^* X_i$. The exact distribution of F depends on the distribution of the random disturbance term, ε^* .

Depending on how the random disturbance term is believed to be distributed, Bramo (2022) claims that multiple qualitative choice models for the above function can be calculated. Let there be a random variable representing any farm household's adaption measure to describe the MNL model. We suppose that each farmer is faced with a set of options for adaptation methods that are mutually

exclusive. These metrics are thought to be influenced by a variety of climate conditions, socioeconomic factors, and other variables, X. The MNL adaptation choice model establishes the following association between the propensity to choose Option iA and a group of Explanatory Variables X:

$$Pro(A_i = j) = \frac{e^{\beta_j' X_i}}{1 + \sum_{k=0}^j e^{\beta_k' X_i}} \quad (j = 0, 1, \dots, j) \quad 3.8$$

Where, β_j is a vector of coefficients for the independent variables (X). Equation 3.8 can be normalized to eliminate uncertainty in the model by assuming that 0 is true and estimating the probabilities as follows:

$$Pro(A_i = j) = \frac{e^{\beta_j' X_i}}{1 + \sum_{k=0}^j e^{\beta_k' X_i}} \quad j = 0, 1, \dots, J, \beta_0 = 0 \quad 3.9$$

The estimated J log-odds ratios are obtained from Equation (3.10).

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = X_i'(\beta_j - \beta_k) = X_i' \beta_j, \text{ if } k = 0 \quad 3.10$$

The log of one alternative with relation to the base alternative is thus the dependent variable. Since the MNL coefficients are challenging to interpret, connecting them to the result is both tempting and inaccurate. For the effects of explanatory variables on the probabilities to be interpreted, marginal effects are usually derived as specified in equation 3.11:

$$\frac{\partial p_j}{\partial x_i} = P_j(\beta_j - \sum_{k=0}^i P_k \beta_k) = P_j(\beta_j - \bar{\beta}) \quad 3.11$$

Marginal effects calculate the anticipated change in probability that a certain choice will be made with respect to a unit change in an explanatory variable (Alhassan, Kwakwa, and Adzawla, 2019). Since the former is dependent on the sign and size of the other coefficients, the marginal effects and their respective coefficients may have various signs.

Table 3.2 presents a description of independent variables used to compute the multinomial logistic regression.

Table 3. 2: Variables used to explain participation status in a multinomial logit model.

Independent variables	Description
-----------------------	-------------

Age	Continuous variable (in years)
Gender	Dummy variable 0 = Male; 1= Female
Household size	Continuous variable
Marital status	Single = 1, 0 otherwise
	Married = 1, 0 otherwise
	Divorced = 1, 0 otherwise
	Widow/Widower = 1, 0 otherwise
	Cohabitation= 1, 0 otherwise
Farming experience	Continuous variable (in years)
Education	No education = 1, 0 otherwise
	Adult Basic Education and Training (ABET)= 1, 0 otherwise
	Primary= 1, 0 otherwise
	Secondary = 1, 0 otherwise
	Tertiary = 1, 0 otherwise
Employment	Unemployed = 1, 0 otherwise
	Employed = 1, 0 otherwise
	Self-employed = 1, 0 otherwise
	On pension = 1, 0 otherwise
Income	Continuous variable (Rands)
Total expenditure	Continuous variable (Rands)
Access to drought information	Yes = 1, 0 otherwise
Access to extension services	Yes = 1, 0 otherwise

Source: Author's conception (2019).

Table 3.3 further represents the various adaptation options that are available to rural households.

Table 3. 3: Adaptation options for rural households.

Drought adaptation strategies	Variables
Crop diversification	Yes = 1, 0 otherwise
Livestock diversification	Yes = 1, 0 otherwise
Rainwater harvesting	Yes = 1, 0 otherwise
Drought tolerant crops	Yes = 1, 0 otherwise
Crop rotation	Yes = 1, 0 otherwise
Mulching	Yes = 1, 0 otherwise
Dry planting	Yes = 1, 0 otherwise
Delayed planting	Yes = 1, 0 otherwise
Zero tillage	Yes = 1, 0 otherwise

Source: Author's conception (2019).

3.6.3 Two-stage least squares (2SLS)

A two-stage least square regression was used to analyse the effects of drought adaptation strategies on consumption expenditure (welfare) of rural households in the study area. In this study consumption expenditure was used as an indicator of welfare instead of income. This is because consumption is possibly a better indicator to employ as compared to income, as consumption metrics represent household welfare levels more accurately than income indicators (Agency for Statistics of Bosnia and Herzegovina, 2017). Additionally, since the poor tend to spend somewhat consistently on a small number of well-known things, expenditure may be better measured than income, which might fluctuate and be unpredictable. People also do not easily disclose their income which makes data collected inaccurate (Marotta and Yemtsov, 2010). Therefore, the study made use of per capita consumption expenditure as the dependent variable.

Drought adaptation strategies were indexed using Principal Component Analysis (PCA) and presented as the dependent variable. When using the two-stage least squares (2SLS) method, instrumental variables are to be used to estimate a casual effect. It is a more sophisticated form of least squares regression. To estimate the parameters of a linear regression model, the ordinary least squares (OLS) method is frequently utilized. The sum of squared errors is minimized using OLS estimators. It is a regression that estimates unknown parameters in a model using the mathematical basis for the best-fitting regression line, with the purpose of minimizing discrepancies between observed responses (Cliff and Billy, 2017). OLS is repeated twice while performing the two-stage least squares algorithm. The instruments are used in the first stage to estimate the independent variables, and the estimate of the independent variable is utilized to estimate the dependent variable in the second stage (Zhang, Uddin, Cheng *et al.*, 2018). Application of ordinary least squares to a model has setbacks despite being unbiased, as it may result in estimates that are inaccurate and inference techniques that are flawed (Ayinde, Apata, and Alaba, 2012).

This study assumed that the relationship between drought adaptation strategies by rural households and consumption can be caused by several factors, therefore, the 2SLS was used to cover these factors.

First stage regression

The first stage of the Two-stage least squares identified the endogenous variables that appeared to cause problems. The included explanatory variable X was regressed in the first step of the two-stage least squares method to produce a new variable. According to the general rule, the new variable Z should be linked with variable X rather than the error term.

Using the given linear equation:

$$Y = B_0 + B_1X_1 + U_1 \tag{3.12}$$

We then regressed variable X_1 on Z_i where, Y was the consumption, X was the drought adaptation techniques, and ε is the error term (all variables are exogenous).

$$\text{Therefore, } \hat{X} = B_0 + \pi_1Z_1 + n_1 \tag{3.13}$$

Where, Z_1 which is the instrumental variable.

Second stage regression

The initial equation was regressed in a second step, replacing all the variables with fitted values from the first stage regression.

$$\text{Thus, } Y = B_0 + B_1\hat{X} + \dots \varepsilon_1 \tag{3.14}$$

3.6.4 Propensity score matching (PSM)

The propensity score acts as a balancing factor, ensuring that treated and untreated participants have equal distributions of measured baseline covariates. Therefore, the distribution of observed baseline covariates will be the same between treated and untreated participants in a group of subjects with the same propensity score (Austin, 2018). PSM is used to calculate how many different adaptation techniques will have an influence on welfare. A dummy variable for adoption of adaptation strategy was used which is equal to 1 for adopter and zero if otherwise.

To assess the impact of drought adaptation strategies on rural households' welfare, matching techniques were used. A Propensity Score Matching (PSM) was employed to estimate the impact of the number of adaptation strategies used on rural households' welfare (Zakari, Ibro, Moussa, and Abdoulaye, 2021). PSM was used to estimate the average treatment effect (ATE) of adoption of strategies on the welfare of rural households.

Households who adopted adaptation strategies (treatment group) were matched with those that did not adopt any adaptation strategies (control group). The idea is to match each adapter with an otherwise identical non-adapter on the basis of similarity in the observed data. The average difference in the outcome variable between the treated group and the control group is then measured (Christian, 2017).

Practically, a probit or logit model is estimated where participation is explained by several pre-treatment characteristics and the propensity score that ranges from 0 to 1 are determined by using the predictions estimated. Propensity score is estimated as the probability of adopting at least one drought adaptation strategy, using the vector X as conditioning factors (Verhofstadt and Maertens, 2014).

$$PS = P(D = 1|X)$$

$$ATE = E[Y(1) - Y(0)] = E[Y(1)] - E[Y(0)]$$

The propensity match can use different models to estimate the propensity score. This study uses the logit model of drought adaptation strategies by controlling all the variables X which affect, meanwhile, the adaptation strategies and outcome variables. Although PSM seeks to compare the differences between adapters and non-adapters with identical underlying traits, it cannot correct unobservable bias (Asfaw, S, Shiferaw, Simtowe *et al.*, 2012). PSM can control only observed variables. Therefore, Stata 15.1 was used where the `psmatch` command was employed to estimate ATE and ATET.

3.6.5 Model testing for endogeneity

When an explanatory (independent) variable relates to the residuals (sometimes referred to as the "error term" or "disturbance term") in an econometric model, endogeneity is present. By declaring that u has an anticipated value of 0 given any X , this violates the exogeneity constraint, the most crucial OLS estimation assumption (i.e., $E(u|X_1, X_2, \dots, X_1) = 0$) (Lu, Ding, Peng *et al.*, 2018 and Mothiba, 2019).

This study uses the instrumental variable (IV) technique for addressing problems associated with endogeneity. Finding "useful" and "powerful" instruments might be difficult yet using a "poor instrument" could jeopardise the performance of the selected econometric model (Bettis, Gambardella, Helfat *et al.*, 2014). To address various endogeneity problems, a variety of alternative methodologies (Instrumental variables (IVs), generalized method of moments (GMM), 2SLS, and three stage least squares (3SLS) have been employed extensively within the social science disciplines (Lu *et al.*, 2018). However, the IV-based estimation is still quite common for cross-sectional and panel datasets because of its strong underlying assumptions in dealing with endogeneity and criteria relevant to selecting appropriate IVs. Endogeneity was dealt with in this study using the 2SLS method.

According to a study by Bascle (2008), in the first stage, the F-statistic of the 2SLS regression should be more than 9.08 with three instruments and 10.83 with five instruments when there is a single endogenous regressor.

3.6.6 Model testing for multicollinearity

Multicollinearity is an econometric issue that arises when at least two strongly linked factors are assessed in a regression model at the same time (Daoud, 2017; Wu, 2020). The primary issue with multicollinearity is that it causes unstable and biased standard errors, which in turn cause unstable p-values used to determine the statistical significance of predictors (Vatcheva and Lee, 2016). This problem then makes it difficult to interpret the results of the model as they will then be unrealistic, untenable, and further creates an overfitting problem. It was, therefore, wise to run a multicollinearity test before choosing which variables to include in a model (Lavery *et al.*, 2017).

Studying the variance inflation factor (VIF) for each predictor or carefully examining a correlation matrix of the predictors included in the model can both be used to ascertain the degree of multicollinearity. For this study VIF was used to analyse multicollinearity of each predictor. VIF measures the degree to which the variance in the dependent variable is inflated. Additionally, it shows the degree to which an ordinary least squares regression analysis adjusts for the inflation in the estimated by a predictor variable's strong linear association with the other predictor variable(s) (Vatcheva et al., 2016).

3.6.7 Model testing for heteroscedasticity

Heteroscedasticity is a phenomenon where a statistical assumption of homoscedasticity is violated by data computed. The violation of this statistical assumption of homoscedasticity may lead to an increase in Type I error rates or consequently a reduction in statistical power (Rosopa et al., 2013). In many practical statistical situations, heteroscedasticity in the results of a linear regression model is a common occurrence. Ordinary least squares regression models, which assume homoscedasticity, are fitted without considering the presence of this heteroscedasticity, which may lead to inaccurate estimates of the covariance matrix and ineffective estimates of the regression parameters (Vynck, 2017). The heteroscedasticity test checks if the regression model can predict the dependent variable consistently across all values of the explanatory variables. Failing to detect and control heteroscedasticity could have major consequences on theory, research conducted as well as practice (Khaled et al., 2019). Therefore, if the p value is 0.05 or less, it is impossible to reject the null hypothesis, indicating that there are no heteroscedasticity data (Ali, Ormal, and Ahmad, 2018).

3.7 Limitations of the study

Data was collected shortly after lockdown in South Africa had been lifted due to COVID – 19. This posed a challenge as some households were not willing to participate when conducting the questionnaire in fear of possibly contracting the COVID – 19. Although all COVID - 19 measures were adhered to and social distancing was practiced, the respondents were still sceptical. Some households did not even allow the enumerator to enter their yards.

3.8 Ethical consideration

The researcher requested for permission to conduct the research from the North-West university and vowed to adhere to the ethical responsibilities aligned with the code of conduct for researchers in the North-West University.

Since primary data were collected through administration of questionnaires, all the participants were well informed with regards to the purpose of the study and how the results of the study would be used. The questionnaires clearly stated who the researcher was, where the researcher was from and why the researcher was conducting the questionnaire. The questionnaire further emphasized

that participants are to participate voluntarily in the study, their responses would be kept confidential, and they could withdraw from participating at any time during interviews.

3.9 Chapter summary

In this chapter, the research site was defined, data used were discussed and sampling techniques that were implemented were well elaborated. Furthermore, the analytical procedure used were clearly highlighted.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

In this chapter, the results of data analyses are presented. This chapter aimed to accentuate the factors that affect rural households' adaptation to drought and its welfare impacts. This chapter is divided into four parts. The first part being the socio-economic and demographic characteristics of the respondents. This was followed by adaptation methods being used against the occurrences of drought and the effects of drought adaptation strategies on rural households' welfare. Lastly, the welfare enhancement impacts that are associated with each adaptation method was presented.

4.1 Socio-economic and demographic characteristics

Demographics give an overview of the sample utilized in the study and how it reflects the various features of the population. Age, gender, household size, level of education, and respondents' marital status are among the demographic data that were collected. A total of 374 households were required to be sampled, however, only 360 households were sampled. This was because the data was collected during the period of COVID – 19 and 12 households could not be sampled due to COVID-19 and the many restrictions and curfews that were implemented.

4.1.1 Age of the household heads

The results presented in Table 4.1 show that 19% of the respondents were between 40 and 49 years old. About 24% of the respondents were between 50 and 59 years old. Majority of the household heads (35%) were old being 60 years and above. This suggested that most of the households' heads were adults. The probable reason why there were more individuals who were older than 40 years could be attributed to the fact that younger people usually migrate from rural areas to urban areas in the hope of getting better work or better schools (Mutekwa, 2016). Urban areas had a high employment rate, so young people preferred to relocate to these places with the hope of improving their standard of living (Alarima, 2018). This choice is made at the household level, where the goal was to either maximize expected income or reduce risk by diversifying the portfolio of income-generating activities of the household (Wan, Li, Wang, W., Liu, *et al.*, 2016). On the other hand, when people retire or lose their jobs, most of them go to rural areas where they typically live permanently (Cromartie, von Reichert and Arthun, 2015).

4.1.2 Gender

Results in Table 4.1 also showed that 63% of the rural households' heads were male and only 37% were female. Males are typically recognized as the head of the households in most rural and traditional settings. This implies that the male character made household decisions (Cheteni, Khamfula, and Mah, 2019). According to a study by Ngubane (2010), males are regarded as the heads of their houses in the traditional African family in South Africa. This idea was consistent with a study by Yusuf and Adisa (2012), which found that 52% of households' heads were men.

4.1.3 Marital status

Table 4.1 showed that 37% of the sampled rural households' heads were married, 31% were single, 21% were widowed, 8% were cohabiting and 3% were divorced. According to Moore and Govender (2013), people living in urban regions had a 1.3 times lower likelihood of getting married than people living in rural areas. According to a study by Marginean (2014), marriage inspired people to lead moral and respectable lives. It followed that those who join marriage were more likely to have a steady income, potentially from a job, and a high degree of education. Furthermore, Wilcox (2015) asserted that higher rates of marriage are substantially associated with stronger levels of state GDP per capita, upward economic mobility, lower rates of child poverty, and higher median family incomes.

4.1.4 Household size

The results further showed that 51% of the rural households had households' sizes between 5 – 6. This was quite a large household size, and it can be difficult, especially in years of drought when spending more on family needs were necessary. The size of the household indicated how many people in the household needed to be fed, clothed, and sent to school (Twongyirwe, Mfitumukiza, Barasa, *et al.*, 2019). Having large household sizes became a problem for households who depended solely on remittances, who had only one member of the family with formal employment and who had seasonal employment (Mutekwa, 2016).

4.1.5 Education

A study on "*The Impact of Educational Attainment of Household Poverty in South Africa*" by Wanka and Rena (2014) stated that The Human Capital Theory established by Gary Becker suggested that there was a link between education and poverty in the sense that education had a way of reducing poverty. Education had the potential to put people in a path of acquiring skills which improved productivity and increases the chance of rural households obtaining employment which led to earning higher incomes in future (Sajjad, 2019).

The findings indicated that majority of the households' heads (43%) went to school for 12 years. This means that they went to school all the way up to matric (Grade 12). About 34% had about 15 years of schooling experience. This meant that these individuals got an opportunity to obtain a tertiary

qualification. Roughly 17% only ended their schooling years at primary level with only 7 years of schooling experience. About 5% of the household heads had about 4 years of schooling experience which means that they only got an opportunity to go to school up until primary school, however, got an opportunity to also do ABET. Lastly, 1% of the household heads had no schooling experience altogether. According to these findings, majority of the households' heads were literate, which meant they were most likely to be knowledgeable on drought as it affects livelihoods in the study area. They were also more likely to engage in different drought-relief strategies to improve their welfare.

Table 4. 1: Socio-economic and demographic characteristics of rural households.

Characteristics	Frequency	Percentage
Age		
20 – 29	21	6
30 – 39	59	16
40 – 49	69	19
50 – 59	85	24
60 and above	126	35
Gender		
Male	226	63
Female	134	37
Household Size		
1 – 2	67	19
3 – 4	95	26
5 – 6	182	51
7 – 8	16	4
Farming Experience		
< 5	238	66
6 – 10	55	15
11 – 15	27	8
16 - 20	16	4
> 20	24	7
Farming Activity		
Farming as a primary activity	150	42
Farming not as a primary activity	210	58
Type of Farming		
Farming at home (own yard)	158	44
Farming on communal land	179	50
Had own farm	23	6
Marital Status		
Single	110	31
Married	134	37
Divorced	12	3
Widow/Widower	75	21
Cohabiting	29	8
Education Status		
No Education	5	1
ABET (Level 1 – 4)	17	5
Primary (Grade 0 – Grade 7)	63	18
Secondary (Grade 8 to Grade 12)	151	42
Tertiary (TVET College/University)	124	34
Employment Status		
Unemployed	57	16
Employed	71	20
Self-Employed	63	17
Pensioner	169	47
Employment Type		

No formal wage employment	226	63
Seasonal	15	4
Part-time	16	4
Full time	94	26
Contract	9	3
Income		
< 5 000	269	75
5 001 – 10 000	54	15
10 001 – 15 000	32	9
> 15 000	5	1
Source of Income		
On Farm	22	6
Off Farm	103	29
Grant	235	65
Access to credit		
Yes	270	75
No	90	25
Source of credit		
Loan shark	83	23
Relatives	133	37
Banks	54	15
No access to credit	90	25
Grants		
Yes	234	65
No	126	35
Source of grants		
Disability grant	14	4
Child support grant	90	25
Old age grant	126	35
Foster care dependency	0	0
Care dependency	4	1
No grant	126	35
Access to drought information		
Yes	133	37
No	227	63
Access to extension services		
Yes	133	37
No	227	63

Source: Author's conception (2021).

4.1.6 Farming experience

According to the results of the study, 66% of the sampled households had 5 years or less of farming experience. This showed that households had just started farming especially since food prices were high. Food prices in South Africa were highly influenced by forces of the global market, however, high unemployment rate in the country prevented many local customers from affording even the most basic meals (Marias, 2022). As a result, rural households were more inclined to start farming with the aim of reducing consumption expenditure of food items (Nkwanyana, 2022).

About 34% of the households have farming experience above 5 years. For households to be able to cope with adverse effects of drought, they need to have some sort of farming experience. A study

by Zhou and Li (2022) confirmed this notion as it showed that having farm experience improves personality qualities of individuals, builds a certain amount of potential human capital which in turn results in helping households with self-adaptability, dealing with setbacks, and may have positive effects on the long-term development of households. Furthermore, experienced farmers have a wealth of indigenous knowledge and information about changes in climatic conditions and the best agronomic methods to follow to mitigate the effects of hazards like drought, which can negatively affect the livelihood of rural households. As a result, having farm experience could improve the livelihood of rural households (Atube, Malinga, Nyeko *et al.*, 2021).

4.1.7 Farming Activity

The study found that 58% of the households do not primarily participate in farming. The reason for this finding was that rural households in the Northern Cape province were so severely affected by drought that those whose focus was on crop production found themselves in a situation where they could not prepare land due to lack of water, therefore planting was consequently affected. This meant no crops or vegetables were provided to both the market and the household which resulted in financial losses (APDUSA, 2016). For those households who focused on livestock production had a challenge of grazing land and increased water scarcity which resulted in deaths of the livestock. Consequently, this affected household income, which further affected consumption expenditure (Bahta and Myeki, 2022). Therefore, households had to either stop production, reduce crop yields, or sell their livestock to make ends meet (Matlou, 2019).

4.1.8 Farm type

Agriculture contributed to the welfare of rural households directly as rural households are both producers and consumers of agricultural food products (Alexandri, Luca and Kevorchian, 2015). This contribution is clearly shown as 50% of the households' farm on communal lands. This finding is in line with Mashala (2014) who asserted that in South Africa, most smallholder, and emerging farmers farm on communal land. Communal farming is a traditional agricultural method that is mostly used by rural households in underdeveloped nations. Farming on communal land has proven to be crucial in bringing socio-economic alleviation provided that the economic benefits are appreciated, as communal lands perform several roles and produce large economic returns per hectare (Mmbengwa, Nyhodo, Myeki, *et al.*, 2015). The study further found that 44% of the households' farm in their own yards. According to Nkwanyana (2022), many farming households in South Africa engage in backyard farming either as a business opportunity or for their own household consumption with the aim of reducing consumption expenditure of food items. The study further found that only 6% of the households have their own farms. The reason for this is due to the fact that South Africans have limited access to land as the South African government is still fighting the battle of land expropriation without compensation (Smith, 2019).

4.1.9 Employment status and employment type

The results in Table 4.1 showed that roughly 47% of the household heads were pensioners. About 20% household head were employed, 17% were self-employed and 16% were unemployed. According to (Osarfo, Senadza, Nketiah-Amponsah, *et al.*, 2016) both farming and non-farming employment was very important to rural households as employment serves as a source of livelihood diversification. Literature demonstrated that households with workers had more income mobility, lower rates of poverty, and stabilized consumption in the face of consumption shocks (Dewen, 2010; VanWey and Vithayathi. 2013).

The findings in Table 4.1 indicated that pensioners made up most household heads, indicating that those in charge of households were typically elderly individuals between the ages of 55 and 80. The health and wellness of older people in South Africa are significantly impacted by pensions received (Schatz, Gómez-Olivé, Ralston, *et al.*, 2012). Pensions serve as a reliable and consistent safety net that meets the daily needs of older persons and their households (Ortiz, 2014).

4.1.10 Income and sources of income

Drought and other weather shocks were major contributors to the variability of income in developing nations (Shah and Steinberg, 2015). According to van de Ven (2018), income is an important measure of welfare at household level for understanding the well-being of household individuals during drought as this affects their economic behaviour. As a result of the data in Table 4.1, 75% of the sampled households had an income between R0 to R5000 of which majority (65%) of this household income was from old age grants provided by government as a social safety net.

Results in Table 4.1 further revealed that 65% of income came from social grants, 28% was from off-farm income and 6% of the income was from on-farm formal employment. These social grants differ from old age grant, which was R1990 for adults, who were between 60 and 74 years of age, and R2010 for adults, who were 75 years of age and above (Cloete, 2022). The disability grant, which is R1990, while the child support grant which amounted to R624 monthly (Human, 2022).

4.1.11 Access to credit and source of credit by rural households

Figure 4.1 showed that 75% of the sampled households had accessed to credit and 25% of households had no access to credit. In developing countries, a lot of rural households experience unstable and poor incomes (Castaneda, Doan, Newhouse, *et al.*, 2016). Due to the negative consequences of the drought and the rise in consumption prices, many households experience income shocks (Kurosaki, 2015). Rural households faced with drought impacts try to soothe income by adopting traditional production as well as diversifying employment and economic activities (Shiferaw *et al.*, 2014). In the presence of income shock, these households also tried to soothe consumption. This was achieved by borrowing money from formal and informal money lenders and by saving money (Carter and Lybbert, 2012).

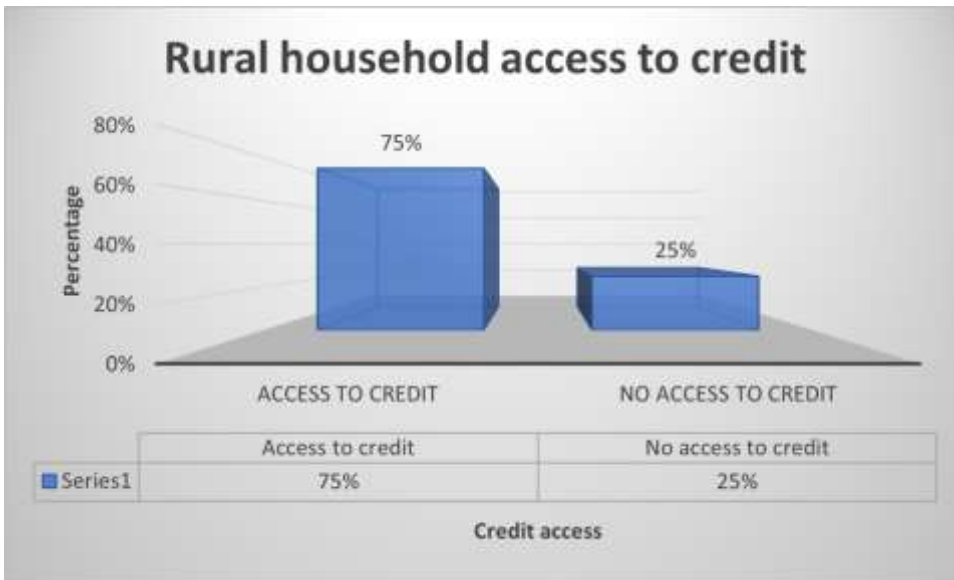


Figure 4. 1: Access to credit of rural households.

Source: Own survey results (2021).

Research has shown that rural lending greatly improves households' capacity to satisfy their financial needs for productive investments and agricultural inputs (Tang, Guan, and Jin, 2010). According to another research, having access to rural loans may boost rural households' readiness to adopt new technologies, which would help the household raise the mean levels and the riskiness of its income (Awotide, Abdoulaye, Ailene *et al.*, 2015). Additionally, having access to rural loans enables the household to balance its spending through droughts and other climatic disasters (Manganhele, 2010).

Figure 4.2 shows the source of credit received by the sampled households. The table shows that credit received by friend/relatives was 36.9% and credit received through loan sharks was 23%.

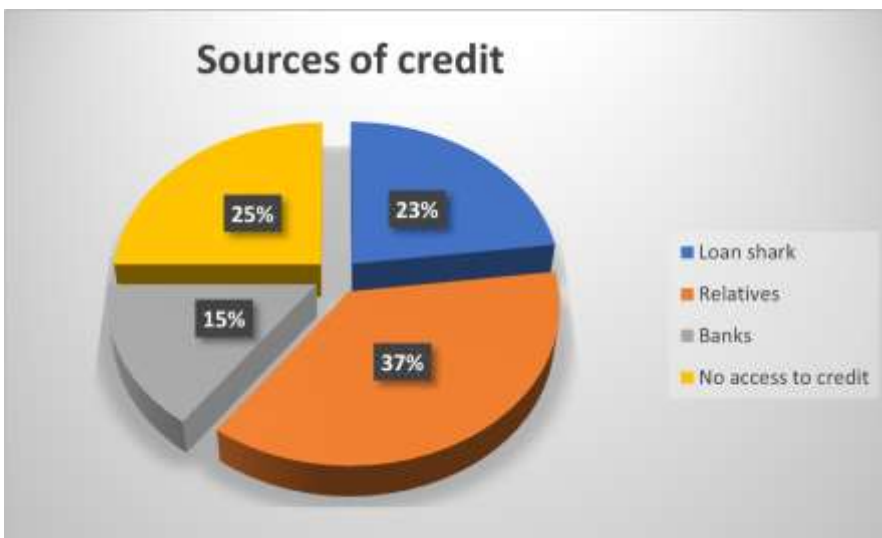


Figure 4. 2: Source of credit of rural households.

Source: Own survey results (2021).

According to Fichera (2010), borrowing money from friends or relatives is a much better option for many households because besides the fact that they know the people they borrow money from personally, the money borrowed also has no interest attached to it and agreements can be made as to when exactly the money can be paid back.

4.1.12 Grants and types of grants

In South Africa, social grants are very important as they directly benefit over 16 million poor people monthly (Sikhakhane, 2017). Social grants smooth income and consumption in many households; this is because they represent a significant source of income in many rural households and for some households, they are sadly the only income (Gutura, 2015). South African households use social grants for various reasons such as paying for school fees, paying household bills, buying food and for health care purposes (Duriex, 2012). Figure 4.3 showed that 35% of the sampled households received old age grants, 25% received childcare grants, 4% received disability grants, 1% received care dependency grants and the rest of the households received no grant.

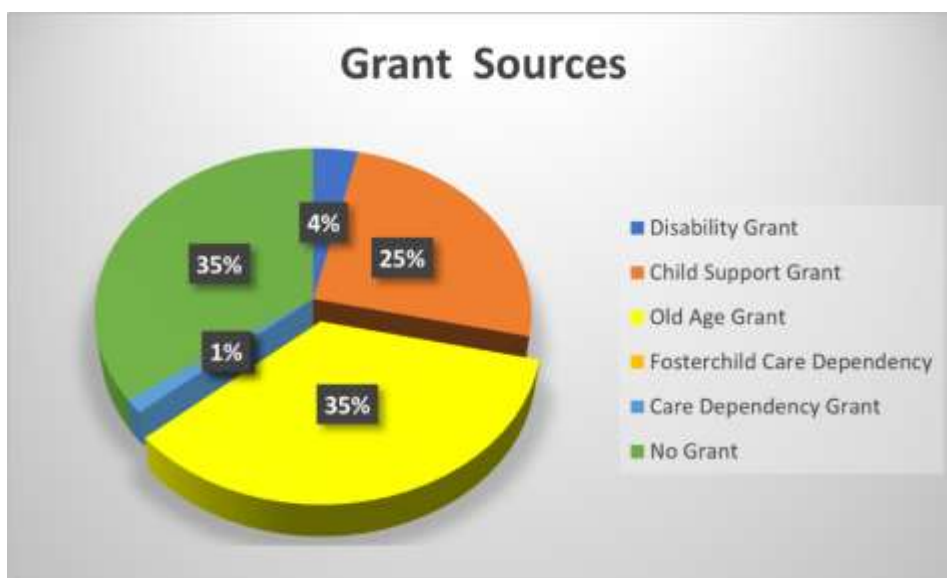


Figure 4. 3: Grant sources of sampled population.

Source Own survey results (2021).

4.1.13 Access to drought information

Looking at Figure 4.4, 37% of the sampled population in JTGD had access to drought information and 63% of the sampled population did not had access to drought information. This demonstrated that most farmers were unaware of the drought both before and during. Planning for future drought responses requires a great deal of knowledge of prior drought effects (Umdale *et al.*, 2014).

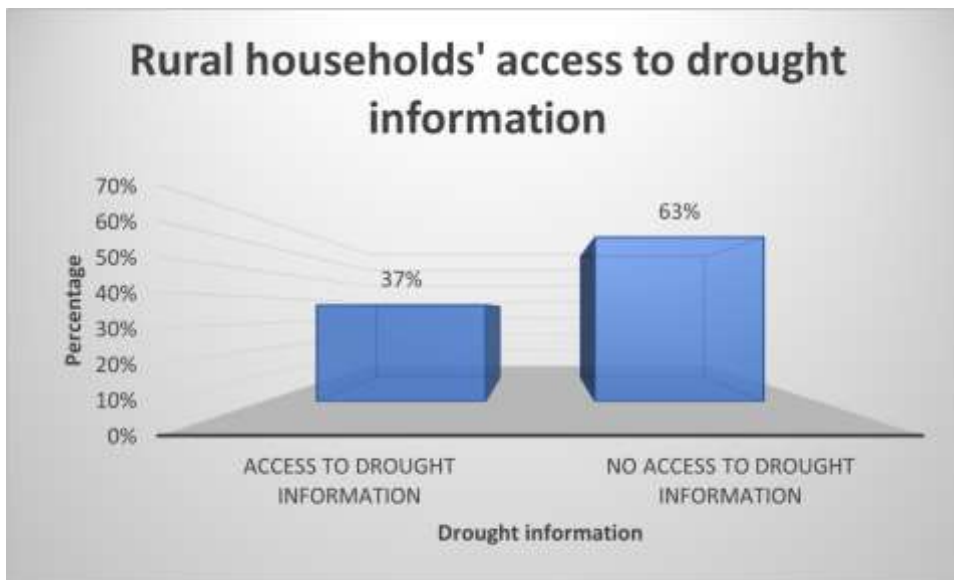


Figure 4. 4: Rural households' access to drought information.

Source: Own survey results (2021).

4.1.14 Access to extension officers

Only 37% of household heads had access to extension services, according to the results of the study, which showed that 63% of the selected household heads did not have such access. These results showed that due to lack of access to extension services, households were not well informed about adaptation strategies, and the households that had access to adaptation strategies lack better knowledge in understanding how these strategies may be used to their maximum potential to improve the welfare of the household. According to studies by Maka, Ighodaro, and Ngcobo-Ngotho, (2019) and Jha *et al.*, (2021), access to extension services improved farmers' awareness of changing climatic circumstances and enhances individual farmers' knowledge of various management strategies they might employ. Additionally, research suggests that agricultural extension services contribute to educational initiatives that improve rural households' capacity to deal with the effects of drought (Antwi-Agyei and Stringer, 2021).

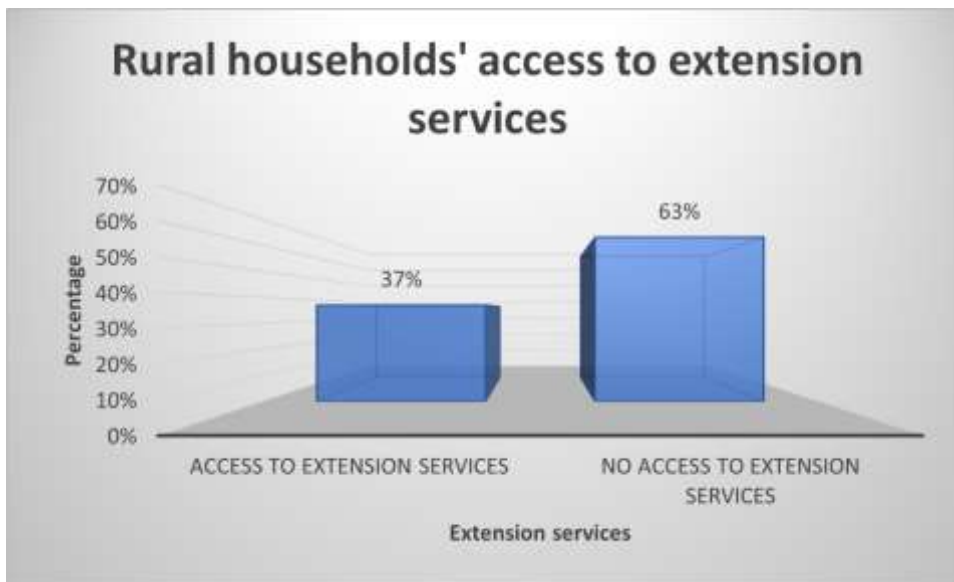


Figure 4. 5: Rural households' access to extension services.

Source: Own survey results (2021).

4.2 Drought adaptation strategies used by rural households.

Rural households in Jaolo Gaetsewe district were asked during conduction of the questionnaire what kind of strategies they used to adapt to drought. The results were analysed and indicated on a bar graph. The bar graph shows that 35% of the respondents did not adopt any strategies of adaptation. This is because not all households were farmers, and some were not well equipped with the appropriate tools that would promote the need to adapt. Diversification of livestock is one of the adaptation strategies that was adopted the most in the study since many households farmed with livestock as compared to crop production. The households preferred livestock production because of the water shortages in the John Taolo Gaetsewe district and the limited access to water. Although not a lot of households preferred crop production, about 10% of the sampled households adopted crop diversification as an adaptation strategy. As shown in the graph below, about 8% of the sampled population used rainwater harvesting as an adaption strategy. Figure 4.6 further showed that drought tolerant crops (3%), crop rotation (3%), mulching (1%), dry planting (6%), delayed planting (6%) and zero tillage (3%) are some of the drought adaptation strategies that were employed in rural households of JTGD. The households that were involved in agricultural activity indicated that they resorted to using these strategies since drought has been a major issue not only in the JTGD but in the entire Northern Cape Province (Ngqakamba, 2019).

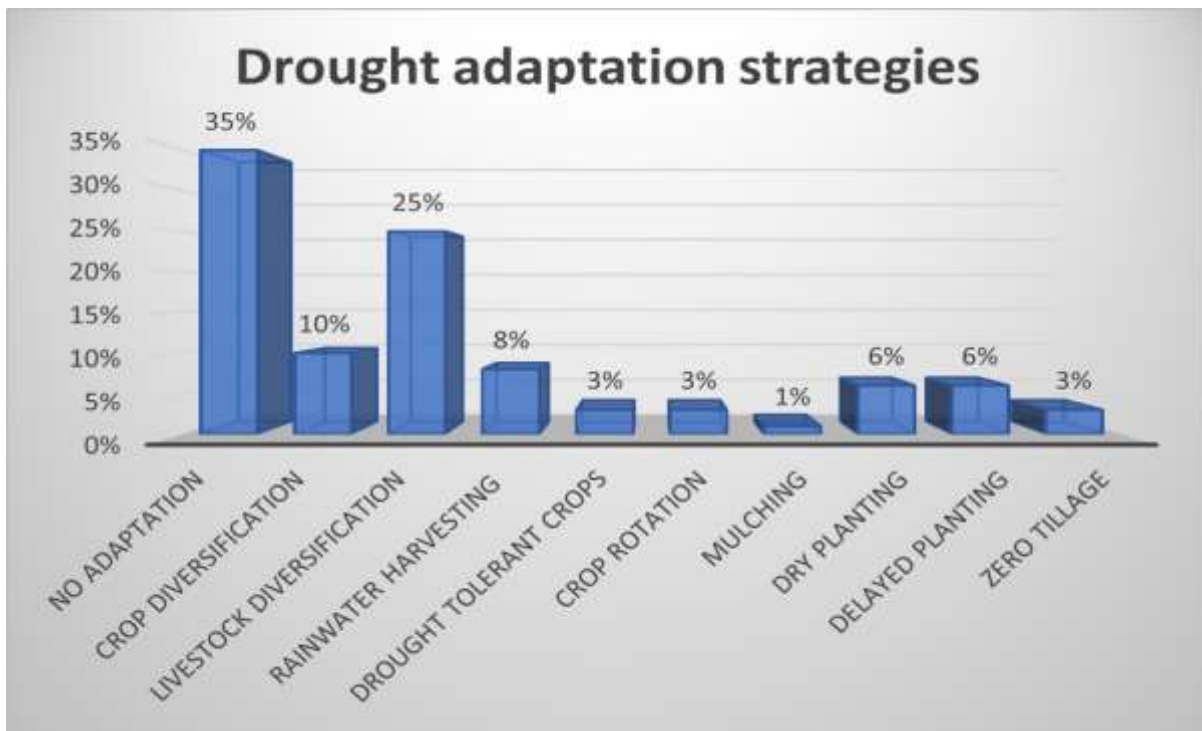


Figure 4. 6: Drought adaptation strategies used by rural households.

Source: Own survey results (2021).

4.3 Empirical results of multinomial logistic regression

4.3.1 Multinomial logistic regression model

The results of the multinomial logit model are presented in this section, along with a discussion of the factors that influenced how drought adaptation measures were chosen in the JTGD study regions. The factors impacting rural households' drought adaptation techniques were investigated using MNL. The relationship between the likelihood of choosing a strategy and a few explanatory variables are presented on the MNL model for adaptation strategy selection (Tazeze *et al.*, 2012). Crop diversification, livestock diversification, drought tolerant crops, zero tillage, crop rotation, mulching, delayed planting, dry planting, and rainwater collection were found to be among the nine adaptation techniques used by the sampled rural households. In this study, "no adaptation" served as the baseline category against, which the anticipated coefficients were measured. The *Chi*-square test indicated that the likelihood ratio statistics were significant, as was shown in Table 4.3. The MNL model definition was found to be appropriate, and the model has already been used in several studies to evaluate the factors influencing climate change adaptation alternatives (Zizinga *et al.*, 2017; Marie *et al.*, 2020 and Destaw *et al.*, 2021). STATA version 15.1 was used to predict the outcomes for the MNL model. As a result of the research done by Ubisi *et al.* (2017), the base category for the MNL was decided upon as being No adaptation.

4.3.2 Estimated results of the multinomial logistic regression

Table 4.2 shows how factors influencing rural households' choice of adaptation measures in the research area were represented by the results derived from the MNL model. The MNL calculated data that identified the various adaptation approaches utilized to combat drought events. The MNL adaption model was ran with these restructure options, and the parameter estimates showed some notable levels. The likelihood ratio statistics (LR chi-square (153)) = 383.03 were highly statistically significant ($p < 0.000$), as revealed by chi square statistics. This suggested that at least one of the independent factors affected the dependent variable in a meaningful way. The goodness of fit of the model was relatively good, with a R squared of 0.2900, which was between 0 and 1. This indicated that the data was well-suited to the model. The F test score of the model was 5.50, which was good because it was higher than 4. These results indicate that the MNL was sufficiently consistent with the MNL assumptions and that the model had a high explanatory power.

Table 4.2 displays the calculated coefficient results along with the degrees of statistical significance. Different drought adaption strategies had different sets of explanatory variables. The results of drought adaptation measures were compared to a no-adaptation baseline. The conclusions of the study showed that rural households employed a wide range of adaptation techniques in response to the negative effects of drought. Table 4.2 summarizes these measures.

Table 4. 2: Parameter estimates of the multinomial logistic regression model of rural households.

Explanatory Variables	Crop diversity	Livestock diversity	Rainwater harvesting	Drought tolerant Crops	Crop rotation	Mulching	Dry planting	Delayed planting	Zero tillage
	Coeff p-value	Coeff p-value	Coeff p-value	Coeff p-value	Coeff p-value	Coeff p-value	Coeff p-value	Coeff p-value	Coeff p-value
AGE	0.025 (0.296)	-0.032 (0.151)	0.018 (0.446)	0.047 (0.282)	0.057 (0.163)	-0.004 (0.979)	-0.040 (0.168)	0.024 (0.355)	-0.076 (0.090)*
GENDER	-0.965 (0.068)*	-0.418 (0.395)	-1.276 (0.025)**	-1.080 (0.222)	-1.089 (0.249)	-24.342 (0.991)	-1.008 (0.138)	-0.556 (0.418)	2.000 (0.076)*
HHS	0.021 (0.887)	-0.024 (0.859)	-0.219 (0.188)	-0.010 (0.698)	0.039 (0.891)	-2.897 (0.062)***	0.090 (0.629)	-0.036 (0.849)	-0.162 (0.543)
MRTSSIN	-0.089 (0.883)	-0.492 (0.418)	0.678 (0.353)	0.466 (0.647)	0.725 (0.520)	-19.925 (0.988)	-0.736 (0.370)	-0.465 (0.551)	-2.213 (0.095)*

MRTSDIV	19.570 (0.993)	18.326 (0.994)	1.637 (1.000)	1.251 (1.000)	19.805 (0.993)	7.752 (0.999)	18.858 (0.993)	0.267 (1.000)	-0.738 (1.000)
MRTSWID	1.681 (0.018)**	1.284 (0.056)*	2.773 (0.000)***	1.788 (0.142)	-0.668 (0.641)	1.975 (0.506)	1.430 (0.088)	0.397 (0.649)	-0.876 (0.526)
MRTSCOHA B	-0.801 (0.366)	-0.223 (0.759)	-16.159 (0.994)	-16.519 (0.996)	-0.690 (0.634)	-22.434 (0.995)	-1.097 (0.351)	-16.839 (0.994)	-0.266 (0.829)
FARMEXP	-0.048 (0.212)	0.073 (0.004)**	0.043 (0.123)	0.068 (0.111)	0.110 (0.013)* *	0.320 (0.070)*	0.032 (0.328)	0.039 (0.176)	0.125 (0.012)**
EDUNO	-17.403 (0.998)	-0.389 (0.844)	-17.223 (0.997)	-17.898 (0.999)	- 13.7687 (0.999)	3.807 (1.000)	-16.437 (0.998)	-16.864 (0.998)	-15.283 (0.999)
EDUABET	-1.071 (0.390)	-0.566 (0.582)	-1.073 (0.198)	-43.640 (1.000)	-42.461 (1.000)	3.332 (0.179)	0.507 (0.052)*	-1.066 (0.423)	-41.442 (1.000)
EDUPRI	-0.976 (0.186)	-0.171 (0.766)	-0.507 (0.474)	-1.521 (0.232)	-0.229 (0.835)	-18.310 (0.991)	0.350 (0.607)	0.583 (0.358)	-0.320 (0.771)
UNEMPLOY ED	-0.619 (0.354)	-0.562 (0.345)	0.406 (0.543)	-0.710 (0.521)	-2.716 (0.160)	-12.741 (0.984)	0.103 (0.888)	-0.072 (0.917)	-0.518 (0.647)
EMPLOYED	0.508 (0.574)	0.899 (0.296)	0.933 (0.378)	2.668 (0.111)	3.562 (0.134)	1.181 (0.999)	-0.574 (0.623)	1.620 (0.166)	-2.251 (0.231)
SELF- EMPLOYED	0.409 (0.606)	0.863 (0.234)	1.646 (0.153)	-14.706 (0.995)	2.707 (0.047)	-8.765 (0.998)	0.687 (0.457)	1.776 (0.159)	-1.392 (0.347)
INC	-2.930 (0.968)	-0.000 (0.482)	-0.000 (0.268)	-0.000 (0.246)	-0.000 (0.136)	-0.004 (0.990)	0.000 (0.678)	-0.000 (0.113)	0.000 (0.611)
DRTINF	1.522 (0.032)**	-0.308 (0.596)	1.561 (0.058)	-0.319 (0.736)	14.392 (0.994)	21.549 (0.993)	1.188 (0.160)	2.031 (0.060)**	15.419 (0.994)
EXTS	2.001 (0.008)*	4.847 (0.000)***	1.906 (0.012)**	2.965 (0.004)**	5.015 (0.000)* **	-0.193 (0.955)	2.230 (0.004)**	2.313 (0.002)**	3.962 (0.000)** *
Constant	-3.741 (0.033)	-0.425 (0.780)	-3.674 (0.051)*	-4.894 (0.093)	-21.671 (0.991)	-4.204 (0.999)	-1.509 (0.470)	-4.721 (0.028)**	-15.110 (0.994)
Goodness of fit									
Base Category	No adaptation								
Number of Observation s	360								
LR chi2 (153)	383.03								
Log likelihood	-468.79546								
Prob>chi2	0.000								
Pseudo R square	0.2900								
*, **, ***, Significant at 10, 5 and 1 % probability level respectively									

Source: Author's computation (2021).

Coefficient estimates from the multinomial logit model can be used to estimate the direction effect, but not the size effect. Therefore, the following STATA command “margins, dy/dx (independent variables)” was used having computed the MNL regression. The results from this command provided us with marginal effects. These results are presented in Table 4.3.

Table 4. 3: Marginal effect due to independent variables.

Explanatory variables	Crop diversity	Livestock diversity	Rainwater harvesting	Drought tolerant crops	Crop rotation	Mulching	Dry planting	Delayed planting	Zero tillage
	p-value	p-value	p-value	p-value	p-value	p-value	p-value	p-value	p-value
AGE	0.920	0.173	0.035**	0.285	0.258	0.058*	0.965	0.159	0.216
GENDER	0.956	0.972	0.990	0.939	0.919	0.947	0.991	0.984	0.996
HHS	0.531	0.634	0.648	0.187	0.734	0.749	0.024**	0.399	0.946
MRTSSIN	0.972	0.984	0.999	0.869	0.858	0.813	0.988	0.973	0.981
MRTSDIV	0.996	0.992	0.994	0.999	0.999	0.993	1.000	0.992	0.999
MRTSWID	0.003	0.117	0.268	0.002**	0.377	0.165	0.727	0.438	0.452

MRTSCOHAB	0.990	0.992	0.990	0.995	0.997	0.992	0.996	0.993	0.995
FARMEXP	0.094*	0.024	0.108	0.510	0.331	0.143	0.071*	0.983	0.833
EDUNO	0.995	0.998	0.996	0.998	0.999	0.999	1.000	0.999	0.999
EDUABET	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
EDUPRI	0.970	0.936	0.990	0.974	0.781	0.994	0.991	0.961	0.933
UNEMPLOYE D	0.935	0.922	0.998	0.794	0.856	0.406	0.984	0.926	0.938
EMPLOYED	0.959	1.000	0.991	0.967	0.692	0.688	1.000	0.942	0.930
SELF- EMPLOYED	0.999	0.996	0.993	0.985	0.995	0.979	0.997	0.994	0.981
INC	0.971	0.972	0.985	0.981	0.901	0.777	0.990	0.968	0.960
DRTINF	0.981	0.996	0.988	0.997	0.986	0.995	0.993	0.998	0.997
EXTS	0.000***	0.720	0.000***	0.495	0.231	0.028**	0.309	0.761	0.899
*, **, ***, Significant at 10, 5 and 1 % probability level respectively									

Source: Author's computation (2021).

4.3.3 Discussion of the results of multinomial logistic regression model (MLN)

i) Age

The results of Table 4.2 indicate that the age of the household head had a negative impact on the adoption of zero tillage as an adaptation strategy. This suggested that, when compared to the base group, being older showed a lower likelihood of rural households adopting zero tillage as an adaptation strategy at a 10% significant level (0.090). Hussain *et al.*, (2010) came to the same conclusion, and found that age had a negative impact on zero tillage crop production. This assertion was supported by Aryal *et al.*, (2021), who claimed that older individuals are less likely to modify their farming methods and adopt sustainable land management. However, the conclusions of this study were disputed by Lawn and Tamini (2019), who in their study, found that older farmers were more likely to have access to useful tools and knowledge as well as to diversify their businesses.

ii) Gender

The study found that crop diversification (0.068) and rainwater harvesting (0.025) were statistically significant at 10% and 5% respectively. However, these adaptation strategies were negatively correlated to gender. This implied that household heads whether male or female, were less likely to adopt crop diversification and rainwater harvesting as adaptation strategies. This finding was in contrast with a study by Thayaparan (2022) that found that female farmers who engage in crop diversification are more likely to adopt crop diversification as an adaptation strategy as they tend to cultivate more than one crop as compared to their male counterparts. Another study by Baiyegunhi (2015) found that male farmers were more likely to adopt rainwater harvesting technology as compared to their female counterparts.

The study also found that zero tillage (0.076) was positively correlated with gender and statistically significant at 10% level. This implied that household heads whether male or female were more likely to adopt zero tillage as an adaptation strategy. This finding was supported by Ngwenya and Esabu (2019), who in their study, found that gender had a positive impact on the adoption of conservation

agriculture such as zero tillage. The study found that males were more likely than female to adopt zero tillage as an adaptation strategy since adopting such a strategy requires labour for maintenance and male farmers have more resources in terms of their cultural backgrounds and as compared to female, they are more willing to adopt new technology (Baffoe-Asare, Danquah and Annor-Frempong, 2013).

iii) Marital status

The results in Table 4.2 show that household heads, who were widowed were statistically significant at 1%, 5% and 10%, and had a positive effect on rainwater harvesting (0.000), crop diversification (0.018), and livestock diversification (0.056) respectively. This suggested that households, who had no spouses were more likely to adopt crop diversification, drought diversification and rainwater harvesting as drought adaptation strategies. This finding is in contradiction with a study by Kristjanson *et al.*, (2014) that stated that individuals, who are married in the household are more likely to embrace crop-livestock diversification as a method for adaptation. The study further found that household heads, who were single had a negative effect on zero tillage. This suggests that households with unmarried individuals were less likely to adopt zero tillage as a drought adaptation strategy. This notion was in line with a study by Muthelo *et al.*, (2019) that asserted that households with married heads are more likely to adopt a drought adaptation strategy since they seem to have distinct agricultural contacts, including extension agents and agro-input dealers compared to their unmarried counter parts, who rely mostly on other farmers as their source of agricultural information. Participants in household decision-making had the power to sway adaption tactics and other decisions to their liking. When given the opportunity to make their own decisions, women can directly advance their own interests and prevent the catastrophic effects of drought and other natural disasters (Balehey *et al.*, 2018). As a result, women can influence their husbands' decisions while they are married. In pastoral communities, inheriting cattle is a crucial source of income for children and newly established families.

iii) Education

Table 4.2 also revealed that household heads that were educated were statistically significant at 10% level (0.052) and had a positive impact on the adoption of dry planting as an adaptation technique. This showed that a household head was more likely to adopt dry planting as a method of adaptation to how more educated they were. A study by Lunduka *et al.*, (2019) indicated that educated individuals process information about new technologies more quickly and effectively than uneducated individuals. According to a different study by Nyambese and Jumbe (2013), farmers are more likely to embrace dry planting if they have higher levels of education since educated farmers are more inclined to comprehend and accept new technology. Farmers can gain access to relevant information through education, which stimulates the adoption of new farming technologies (Dang *et al.*, 2019).

iv) Farming experience

The coefficients of households represented in Table 4.2 with farming experience were positive and statistically significant for four adaptation techniques at 5% and 10%. The adaptation strategies included livestock diversification (0.004), crop rotation (0.013), mulching (0.070) and zero tillage (0.012). As a result, the possibility of implementing these four adaptive mechanisms increased with more experience in farming. In accordance with the results of a study by Wang *et al* (2021), crop rotation had a stronger beneficial effect on both yield change and profit change for adopters who had employed it for more than 10 years. Farmers with more experience are more likely to utilize adaptation strategies as they have more knowledge and expertise about the changing climatic conditions as well as the proper crop management and livestock methods to adjust (Fosu-Mensah *et al.*, 2012). Farming experience has been found to be positively correlated with adoption of conservation agriculture such as mulching and zero-tillage. Greater farming experience can lead to better assessment of investment (Pedzisa, 2016). However, research by Ntshangase *et al.* (2018) contradicts these findings, claiming that farmers with more experience are often older and may be less ready to modify agricultural practices like livestock diversification due to their shorter planning horizons in the future.

v) Household size

Table 4.2 represented coefficients that were negative but statistically significant at 10% level for household size. This result implied that household size did not affect the decision to adopt mulching as an adaptation strategy. However, studies have shown that household size is an important factor in adoption decision, A study by Zulu-Mbatha *et al.*, (2017) alluded that a larger household size is more likely to adopt mulching as an adaptation strategy than a smaller household size. This is because larger farm households are more likely to invest in the adoption of labour-intensive sustainable practices (Usman-Oyetunde, 2021).

vi) Drought Information

One of the explanatory variables with positive coefficients and statistical significance is access to drought information. When given knowledge about crop diversity, rainwater harvesting, and delayed planting, household heads are more likely to implement these adaptation techniques than if they are not given drought information at all. A farmer leader with improved weather information made more educated adaption decisions (Belay *et al.*, 2017). This study found that having access to drought information was positively correlated to adopting crop diversification (0.032) and delayed planting (0.060), which were statistically significant at 5% and 10% level. This implied that rural households that had access to drought information were more likely adopt crop diversification and delayed planting as drought adaptation strategies. These findings were in line with a study by Ngigi and Muange (2022), who asserted that lack of access to climate information is a detrimental barrier that affects the adoption of climate smart agricultural technologies such as crop diversification and

delayed planting. Access to climate information is important as it allows for rural households to strengthen their resilience, support climate change adaptation, and improve their livelihoods (World Meteorological Organization, 2021). Access to information on temperature and rainfall, according to Dang *et al.*, (2019), has been demonstrated to boost the likelihood of employing crop diversification as an adaptive approach. Furthermore, access to climatic change information improved the chance of adaptation and influenced the method of adaptation chosen (Ndambiri *et al.*, 2012).

vii) Extension services

Most of the drought adaptation measures used by rural households in the JTGD was statistically significant, according to agricultural extension agency. Crop diversity (0.008), livestock diversification (0.000), rainwater harvesting (0.012), drought tolerant crops (0.004), crop rotation (0.000), dry planting (0.004), delayed planting (0.002), and zero tillage (0.000), all had a positive effect on access to extension services and were statistically significant at 1%, 5% and 10%. These findings are supported by a study by Ahmed (2014), which found access to extension services to be positively correlated with the adoption of various drought adaptation strategies. Extension services significantly increased the likelihood and intensity of employing improved adaptation strategies and implementing better practices. When the relationship between farmers and extension agents is strengthened, more information flows and more technological knowledge is disseminated from extension agents to farmers (Asante *et al.*, 2016).

According to a study by Mustapha *et al.*, (2012), extension agents can provide regionally relevant technology and management approaches that help farmers adapt to climate change by, for instance, spreading local cultivars of drought-resistant agricultural types with information on the crops. Furthermore, extension agents can share their knowledge of climate-resilient cropping and management systems with farmers, this includes intercropping, no-till agriculture, and sequential cropping (Masere, 2015). Through the provision of technical help, loans, input supply, even market intelligence and farmer capacity building, access to extension services has been connected to the diffusion and acceptance of new technologies (Rehima *et al.*, 2015).

Having analysed the results of the MNL, the findings of the study accepts the hypothesis made earlier in the study that drought has a negative impact on rural household welfare. 4.4 Empirical results of two-stage least squares.

4.4 Two-stage least squares model

The effects of drought adaptation techniques on rural households' welfare (consumption) in the JTGD were examined using the two-stage least squares model. The two-stage least squares method is applied when dealing with endogenous explanatory variables in a linear regression framework (Rios-Avil, 2017). In a two-stage least-squares regression model, the dependent variable was regressed against endogenous components and instrumental variables. As the dependent variable

for this reason, a thorough study was done to verify that respondents' comprehension of the effect of drought adaptation strategies was accurate.

This section provided the test for multicollinearity among the variables. The mean VIF was 1.84 in the results. There was no evidence of multicollinearity among the variables, as shown in Table 4.7. The endogenous variable in the regression model had a correlation with the error term. Instrumental variables, however, which were uncorrelated with the error term, were included to the model to estimate its parameters. In contrast to the error term of the model, the endogenous variable is linked to these instrumental variables. Gender, employment, education, farming experience, access to drought information and access to extension services were included as instrumental variables in the regression framework.

4.4.1 Estimated results of the two stage least squares

A two-stage least squares collinearity test was performed before running the two-stage least squares. To rule out the possibility of multicollinearity, VIF were determined. To prevent biased and inaccurate results, multicollinearity was essential since it made sure that no two independent variables had the same information. The VIF values were investigated using the collinearity statistics. After running VIF, the tertiary level of education was not included in running the two-stage least squares as it raised the VIF which indicated high multicollinearity.

Table 4. 4: Results of Two-stage least squares first stage regression.

Per capita expenditure		Coeff.	Std Err.	T	P> t
Age		0.3535455	9.3797	0.04	0.970
Gender		-380.5598	220.9095	-1.72	0.086*
Marital status	Married	-1056.138	262.2005	-4.03	0.000***
	Divorced	-1294.258	538.0817	-2.41	0.017**
	Widow/widower	-874.7748	316.1804	-2.77	0.006**
	Cohabitation	-558.5901	364.9037	-1.53	0.127
Farm experience		9.753917	17.2263	0.57	0.572
Farm type		-277.5851	256.0494	-1.08	0.279
Off farm income		-32.26087	309.4520	-0.10	0.917
Farm activity		-114.0083	458.4873	-0.25	0.804
Education	ABET	38.96094	482.4131	0.08	0.936
	Primary	311.9623	296.7795	1.05	0.294
	Secondary	205.7362	215.3737	0.96	0.340
Income		0.3101314	0.0296	10.48	0.000***
Grant		146.8413	233.0683	0.63	0.529
Loan		226.6099	218.5075	1.04	0.300
Savings		-247.4734	137.9484	-1.79	0.074

Crop diversification		428.0971	317.1571	1.35	0.178
Livestock diversification		37.69854	258.2164	0.15	0.884
Rainwater harvesting		223.7232	352.6503	0.63	0.526
Drought tolerant crops		446.3186	561.5914	0.79	0.427
Crop rotation		-187.7872	513.6162	-0.37	0.715
Constant		1085.92	505.1075	2.15	0.032**
Number of observations		360			
F (22, 337)		12.79			
Prob> F		0.0000			
R-squared		0.4551			
Adjusted R-squared		0.4195			
Root MSE		1655.70			
*, **, ***, Significant at 10, 5, 1% probability level respectively					

Source: Author's computation (2022).

Consumption expenditure served as the dependent variable while age, gender, marital status, farm experience, farm type, education, income, grant, access to credit, savings, crop diversification, livestock diversification, rainwater harvesting, drought tolerant crops and crop rotation constitute of the independent variables. The rest of the drought adaptation strategies such as mulching, dry planting, delayed planting and zero tillage were not included as part of the independent variables as they were omitted after running the model.

Table 4. 5: Two stage least squares (Instrumental variables) second stage regression.

Per capita consumption expenditure		Coeff.	Std Err.	z	P> z
Income		0.3064189	0.0345	8.88	0.000*
Age		1.0334	9.1056	0.11	0.910
Gender		-401.1722	214.1538	-1.87	0.061***
Marital status	Married	-1064.023	254.8067	-4.18	0.000***
	Divorced	-1160.697	513.9697	-2.26	0.024**
	Widow/widower	-839.9753	305.8364	-2.75	0.006**
	Cohabitation	-586.5434	349.7720	-1.68	0.094*
Farming experience		8.2857	16.4372	0.50	0.614
Farm type		-326.3815	172.1528	-1.90	0.058*
Grant		165.8136	220.8062	0.75	0.453
Loan		242.6716	213.0919	1.14	0.255
Savings		-234.2653	132.7244	-1.77	0.078*
Livestock diversification		-50.76003	229.9111	-0.22	0.825
Rainwater harvesting		146.0345	336.8677	0.43	0.665
Drought tolerant crops		362.7463	539.9119	0.67	0.502

Crop rotation		-269.8422	494.1768	-0.55	0.585
Education	ABET	4.624464	473.9578	0.01	0.992
	Primary	275.7894	297.4721	0.93	0.354
	Secondary	212.1347	214.0151	0.99	0.322
Constant		1103.823	520.0227	2.12	0.034**
Number of observations		360			
Wald chi2 (19)		179.74			
Prob> chi2		0.0000			
R-squared		0.4521			
Root MSE		1606.30			
		*, **, ***, Significant at 10, 5, 1% probability level respectively			
Dependent variable	Per capita expenditure				
Independent variable	Age, gender, marital status, farming experience, farm type, grant, loan, savings, livestock diversification, crop diversification, rainwater harvesting, drought tolerant crops, crop rotation, education				
Endogenous variable	Income				
Instrumental variables	Off-farm income, Farm activity				

Source: Author's computation (2022).

4.4.2 Discussion of the results of the two-stage least squares

i) Gender

Table 4.5 show that gender is negative (-401.1722) and statistically significant at $p < 0.10$. This implies that gender relates to per capita consumption expenditure. Therefore, according to the findings of the study, male, more than female are more likely to adopt adaptation strategies, thus improve their welfare. In many rural households, male-headed households are more likely than female-headed households to undertake adaptive measures. This is because men are more likely to control the income from agricultural production and the resources required to implement new adaption measures (Castiglioni, 2020). The adaption options available to women are likewise constrained by social standards. Women, for instance, may be less mobile, which may restrict their access to marketplaces or their capacity to look for outside employment alternatives (Bryan *et al.*, 2015). According to research by Kassens and Rogers (2014), households with female heads are significantly more likely than households with male heads to be in the quintile with the lowest household expenditures. This was because female household heads were less likely to adopt adaptation strategies that could enhance their welfare than male household heads because they had, on average, lower educational attainment than male household heads, were more likely to work on their own accounts and were less likely to be employed for wages.

ii) Marital status

In Table 4.5, marital status was found to be negative to per capita expenditure (married (-1064.023); divorced (-1160.697); widow/widower (-839.9753); cohabitation (-586.5434)) and statistically significant at ($p < 0.01$, $p < 0.05$, $p < 0.01$ and $p < 0.10$) respectively. This implies that marital status has

a relationship with per capita consumption expenditure. This means that the marital status of the household is likely to influence the households' decision to adopt adaptation strategies. Studies by Dunga (2017) and Manajit *et al.*, (2020), asserted that, being married in a household had a positive impact on the welfare (per capita expenditure) of the households. Household heads that were not married were most likely to allocate less money to food expenditure and more money to non-food expenditure. Marriage encourages people to live a good and acceptable lifestyle, which results in a balance of food and non-food expenditure. This is because married people are more likely to have a more stable flow of income, employment, and high educational level. Therefore, married household heads are more likely to improve their welfare if they adopt at least one adaptation strategy.

According to Mortelmans (2020), divorce can cause significant financial losses, especially women, therefore, households with lone parents that have gone through a divorce are potentially at risk of poverty. This goes hand in glove with the findings in subsection 4.4.3 i) in this study that stated that men, more than female, are more likely to adopt adaptation strategies. Therefore, household heads with divorced women are less likely to adopt adaptation strategies. With the financial loss that divorced women would already be facing due to the divorce situation, added with their lack of income improvement due to their less likelihood of adopting adaptation strategies, divorced women are less likely to improve their welfare, as compared to households headed by men. This notion also applies to household heads that are widowed (van de Walle, 2017).

iii) Income

According to the results presented on Table 4.5, income was found to be positive (0.3064189) and statistically significant at $p < 0.05$, which implies that income had influence on per capita consumption expenditure. Access to income means that households can afford to buy nutritious food, pay for education, and pay for health care services (Hone and Marisennayya, 2019). Generally, an increase in income, increases per capita consumption expenditure (Pao and Tsai, 2011). Rural households tend to spend most of their income on food items. However, once they have increased income, they can now afford to adjust their spending to non-food items, and save some money (Paul, Hamdiyah, and Samuel, 2014). The findings of this study were in line with studies from Amare *et al.*, (2016), and Arslan *et al.*, (2016), who claimed that adoption of drought adaptation strategies would improve household income thus improving the welfare. Income of the household is a livelihood indicator that related to drought adaptation and welfare impacts, which implied that adoption of drought adaptation strategies had a positive effect on welfare because adopting an adaptation strategy meant improving household farm production which resulted in improved or high income.

iv) Savings

As illustrated in Table 4.5, household savings were negative (-234.2653) and statistically significant at $p < 0.10$ level. These results show that there's a relationship between savings and per capita expenditure, which implies that lack of adoption of drought adaptation strategies had a negative

impact on savings of the household. These results are in line with the study by Mazengiya *et al.*, (2022) who asserted that rural households are generally characterized by low income, low educational attainment, and high unemployment rates. Therefore, their propensity to save is low. This low propensity to save could lead to failure to adopt an adaptation strategy and as a result welfare would not be improved.

Ismail and Bakar (2012) further stated that income, expenditure, and savings are interrelated. Therefore, when there is an increase in income, and a decrease in per capita consumption expenditure, households will be able to have some money to save. However, when there is a decrease in income and an increase in per capita consumption, households will not have money to save (Luo, 2015). Therefore, having money saved, will allow households to finance those adaptation strategies that need to be funded (Wettel *et al.*, 2018). This notion is in line with a study by Gikonyo, Busienei, Gathiaka *et al.*, (2022) whose results found that the possibility of implementing more adaptation methods, such as climate smart agricultural technologies, increased with household savings and interest earned.

v) Farm type

In Table 4.5, farm type was negative (-326.3815) and statistically significantly to per capita consumption expenditure at $p < 0.10$ level. These findings show that there is a relationship between farm type and per capita consumption expenditure. This implies that the type of farm had a negative impact on the per capita consumption expenditure. This finding is in line with a study by Samuels, Ntombela, Angula *et al.*, (2016) which stated that Farmers who practiced communal farming were viewed as backward and their farming practices as harmful and unprofitable. They consequently do not get enough assistance from the government and extension services. This means that communal farmers do not improve their income which results in rural households not being able to improve their capita consumption expenditure. Ishumael and Godwell (2015) further conducted a study on “*Household Climate Change Adaptation Strategies in Makonde Communal Lands of Zimbabwe*” and found that households on communal land had low adaptive capacity. This meant that food security, malnutrition, illness, and poverty were becoming more common in the homes as well as crop and livestock failures. The reason for this was that since communal land belonged to the community rather than a single person, it was discovered to be difficult to control pests and diseases, there are no incentives to conserve land, it may be challenging to make a sound farm plan, challenging to control breeding in livestock, and challenging to also obtain a loan (Dube-Mngomezulu, Green, and Chimonyo, 2018). As a result, adopting adaptive strategies could be challenging. especially in the absence of drought knowledge and assistance from extension personnel. This will have an impact on the households' capacity to enhance its welfare.

The findings of this study therefore accept the hypothesis that adoption of at least one adaptation strategy has a positive impact on rural household welfare (consumption expenditure).

4.5 Empirical results of propensity score matching

4.5.1 Propensity score matching

When doing empirical analysis for biasedness correction, the PSM technique is used to account for systematic variations between two groups (adopters and non-adopters) of people, who have chosen to use distinct adaptation strategies. This approach is frequently used in impact assessment studies, where it is used to estimate the anticipated treatment effect on the treated population (Faisal *et al.*, 2021).

The nearest neighbour matching (NNM), radius matching (RM), kernel-based matching (KBM), and PSM methods were used to determine the average treatment impacts on the treated (ATT). Studies by Christian (2017) and Hein, Vijitsrikamol, Attavanich et al, (2019) employed these three matching methods to confirm the resilience of the ATT.

4.5.2 Estimated results of propensity score matching.

Table 4.6 presents the impacts of the number of adaptation methods used on welfare (consumption expenditure) based on propensity score matching. Households who adopted at least one adaptation strategy had a lower propensity to consume, meaning that households would improve their income, as a result would have money to save even after spending on household necessities (Kenton, 2022). This means that households would improve their welfare.

Table 4. 6: Estimated results of propensity score matching average treatment effects.

Adaptation strategies	Outcomes	Matching methods	Treated	Control	ATT	Std. Err	T-stat
Crop diversification	Total Consumption Expenditure (Welfare)	PSM	200	160	0.076*	0.019	4.02
		NNM	198	156	-0.052*	0.055	-0.94
		KBM	36	324	-0.044**	0.093	-0.47
		RM	179	153	-0.030**	0.024	-1.25
Livestock diversification		PSM	200	160	0.434	0.225	1.93
		NNM	198	156	0.434	0.026	16.81

	Total Consumption Expenditure (Welfare)	KBM	90	270	0.554	0.045	12.33
		RM	179	153	0.448	0.028	15.92
Rainwater harvesting	Total Consumption Expenditure (Welfare)	PSM	200	160	0.040**	0.163	0.25
		NNM	200	160	-0.053*	0.039	-1.36
		KBM	198	156	-0.207	0.113	-1.84
		RM	29	331	-0.68	0.048	-1.42
Drought tolerant crops	Total Consumption Expenditure (Welfare)	PSM	200	160	0.040**	0.014	2.88
		NNM	198	156	0.024**	0.017	1.43
		KBM	10	350	0.314	0.141	2.23
		RM	179	153	0.038**	0.006	6.52
Crop rotation	Total Consumption Expenditure (Welfare)	PSM	200	160	0.040**	0.163	0.25
		NNM	198	156	0.058*	0.020	2.85
		KBM	15	345	0.353	0.099	3.56
		RM	179	153	0.054*	0.018	2.95
Mulching	Total Consumption Expenditure (Welfare)	PSM	200	160	0.015**	0.009	1.74
		NNM	198	156	0.015**	0.011	1.411
		KBM	3	357	0.490	0.079	6.24
		RM	179	153	0.017**	0.012	1.41
Dry land planting	Total Consumption Expenditure (Welfare)	PSM	200	160	0.071*	0.018	3.87
		NNM	198	156	0.024**	0.025	0.977
		KBM	22	338	0.046**	0.113	0.41
		RM	179	153	-0.005	0.028	-0.165
Delayed planting	Total Consumption Expenditure (Welfare)	PSM	200	160	0.076*	0.019	4.02
		NNM	198	156	0.007*	0.030	0.230
		KBM	21	339	0.125	0.112	1.12
		RM	179	153	0.035**	0.011	3.22
Zero tillage	Total Consumption Expenditure (Welfare)	PSM	200	160	-0.025	0.163	-0.16
		NNM	198	156	0.028**	0.012	2.37
		KBM	8	352	0.387	0.158	2.45
		RM	179	153	0.034**	0.012	2.70

*, ** and *** indicates statistical significance of 10%, 5% and 1% levels.

Propensity Score Matching, NNM signifies Nearest neighbour matching, KBM signifies Kernel Based Matching and RM signifies Radius matching.

Source: Author's computation (2022).

4.5.3 Discussion of the results of propensity score matching (PSM)

The ATT results in Table 4.6 of PSM indicated that adopting crop diversification as an adaptation strategy was positive and statistically significant (0.076) at $p < 0.10$ level. This suggested that adopting crop diversification had a certain impact on rural households' welfare. Meaning, when rural households adopt crop diversification as an adaptation strategy, they would significantly improve their consumption expenditure as this means that when there are diversified crops, the household would be able to consume a variety of crops as well as sell a variety of crops which would improve their income as compared to household that did not adopt crop diversification as an adaptation strategy. An increase in income generally causes an increase in consumption expenditure (Kenton, 2020).

The ATT results from the NNM (-0.052), KBM (-0.044) and RM (-0.030) were negative but statistically significant at $p < 0.05$ level for crop diversification. These findings showed that households that did

not adopt crop diversification adaptation strategy would not improve their incomes therefore their consumption expenditure would also not improve. The findings by research conducted by Mango *et al.* (2018) and Mengistu *et al.* (2021) were in line with the findings of this study. The researchers found in their studies that adoption of crop diversification as an adaptation strategy increased the food diversity and income of households, which meant that households' consumption expenditure would also increase.

Results for ATT of PSM (0.434), NNM (0.434), KBM (0.554) and RM (0.448) were positive for livestock diversification. This showed that adopting livestock diversification as an adaptation strategy increased the household welfare. Adopting livestock diversification as an adaptation strategy meant that rural households would have a variety of livestock options would assist them in smoothing their consumption. This could be achieved by selling some livestock for profits and saving a different type of livestock for household consumption (Sheikh and Valdivia, 2009). According to a study by Ngigi *et al.*, (2021), small ruminants, poultry, and cattle significantly contribute to household food consumption and income, which ultimately would result in increased consumption expenditure.

At a level of $p < 0.05$, the results for rainwater harvesting were positive and statistically significant (0.040). As a result, if a rural home used rainwater harvesting to cope with the negative drought effects, their wellbeing will undoubtedly increase (Kumar, Ramilan, Ramarao *et al.*, 2016). Having access to an alternative source of water meant that households would be able to increase farm productivity. Farm productivity results in increased farm profits and additionally household consumption expenditure (Danso-Abbeam, Ehiakpor, and Aidoo, 2018). Kimutai *et al.*, (2015) asserted that implementing rainwater harvesting led to less dependence on municipal water, which is sometimes not available altogether, making rural communities less vulnerable to the consequences of drought, and decreased their dependence on outside assistance during dry seasons.

The findings of the study showed that using drought tolerant crops as a drought adaptation strategy was positive and statistically significant for PSM (0.040), NNM (0.024) and RM (0.038) at $p < 0.05$ level. These results were in alignment with studies by Martey *et al.*, (2020) and Ogada *et al.*, (2020), who found that using drought tolerant crops improved household income and asset accumulation. When a household had improved income, they had an increase in buying power. This meant that the households would be able to increase their consumption expenditure and thus improve their welfare.

The results for practicing crop rotation as a drought adaptation strategy were positive and statistically significant with PSM (0.040), NNM (0.058) and RM (0.054) and statistically significant and $p < 0.05$, $p < 0.10$ and $p < 0.10$ respectively. Crop rotation helps to control weeds, diseases, and pests while enhancing soil fertility. This could lead to increased farm productivity and increased profits as better-quality crops may be harvested and sold at a good price (Volosi, Higashi, Bordin, *et al.*, 2022.). This will then increase household consumption.

Mulching as a drought adaptation approach produced positive and statistically significant benefits at $p < 0.05$ level for PSM (0.015), NNM (0.015) and RM (0.017). In comparison to households, who did not embrace mulching as an adaptation strategy, Akinola and Sofoluwe (2012) found that adopting mulching as a drought adaptation strategy considerably enhanced output supply and net returns from household production. Mulching prevents weed growth in agricultural plants, improves soil nutrients, controls erosion, and conserves soil moisture (Iqbal *et al.*, 2020). Due to these favourable growing circumstances, crop yields rise, increasing household income returns and consumption expenditure.

According to research, planting on dry land might be a challenging adaptation method since seeds need enough moisture to promote germination and seedling development (Elmore, 2013). However, it should be a profitable endeavour when combined with crops that can withstand drought. Dry land planting yielded favourable outcomes that were statistically significant at the $p < 0.10$ level for PSM (0.071) and the $p < 0.05$ level for NNM (0.024) and KBM (0.046). These findings demonstrated that rural households could dramatically raise their standard of living by engaging in dry land planting. This is so that crops would not be dependent on rainfall for water.

Additionally, delayed planting as a strategy for drought adaptation produced good and statistically significant results at $p < 0.10$ level for PSM (0.076) and NNM (0.007) and 5% level for RM (0.035). These findings were in line with those of Stahl (2020), who investigated the effects of delaying the planting of several crops and discovered that planting soybeans and maize later boosted yields by 95% and 94%, respectively. This is a desirable outcome since it may raise household income, which would increase consumption and raise household welfare. However, this discovery contrasted with a study by Geist (2022), who contends that delayed planting limited the actual growing season of maize, increasing the risk of exposure to erratic unfavourable weather conditions.

For adopting zero tillage, the results were positive and statistically significant at $P < 0.05$ level for NNM (0.028) and RM (0.034). These findings supported studies by Kuntashula *et al.*, (2014) that showed the use of crop rotation and limited tillage on land enhances soil health, breaks the cycles of pests and diseases, and increases biodiversity on the production area in addition to recovering nutrients from the soil. In this way, any crops that would be grown on those fields would yield more, increasing the income and consumption expenditure of households.

The results of the PSM therefore accepts the hypothesis made earlier in the study that there is a relationship between welfare and each adaptation strategy.

4.6 Chapter summary

In this chapter, findings of the descriptive analysis of the JTGD measured and discussed results of households, who chose to adopt and those that did not adopt various drought adaptation strategies. Descriptive statistics were utilized in this chapter, including means, frequencies, percentages, charts, and graphs. Age, gender, marital status, number of years in education, and other socioeconomic

factors, such as years of farming, employment, access to knowledge about droughts, and access to extension support, were all covered in the demographic characteristics section.

The findings of this study allowed for several recommendations about drought adaptation measures that could improve per capita consumption expenditure of rural households in the JTGD. According to the findings of the study, households could greatly increase their household income from selling their produce by using at least one drought adaptation method, which would also improve their consumption expenditure and enhance their welfare.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter offers an overview, a conclusion, and suggestions based on the results presented by the study about drought adaptation strategies and the welfare effects on rural households in the JTGD, in the Northern Cape, South Africa. Based on research questions in the beginning of the chapter of the study about drought adaptation strategies and welfare impact, the summary of the findings includes a quantitative approach that was employed in the empirical analysis.

The goal of this study was to better understand how drought adaptation techniques affected the well-being of rural households in JTGD in terms of total household consumption. The chapter concludes by examining the policy implications of the chapter, suggestions, and areas for additional research.

5.1 Summary

This study aimed to analyse the impact that drought adaptation strategies had on the welfare of rural households of JTGD, Northern Cape Province. The research questions stipulated in Chapter One were addressed.

The results from the analysis showed that majority of the household heads (35%) were of an older age group, which was between 60 years and older. About 63% of the rural household heads were male and woman comprised of 37%. Majority of the household heads (51%) had a household size between 5 – 6 individuals per household. In terms of farming experience, 34% had more than 5 years of farming experience and about 23% of the farmers farm on communal land. About 94% of the rural households had education above ABET level. An analysis of the household heads showed that about 33% of the household heads are either unemployed or self-employed and that 47% of them were pensioners. About 65% of the household heads depended on grants received from the government for survival. Majority of the household heads (75%) had access to credit of which 37% of that credit was obtained from relatives and family members. It was discovered in the results of the study that total consumption expenditure of the household heads was 14.4%, where household heads spent approximately R2000 per month on food and non-food items. In terms of drought adaptation strategies, 65% of the rural households adopted at least one drought adaptation strategy to help smooth consumption. In addition, 63% of household heads had no access to both extension services and information about the drought.

According to empirical results from the MNL, the adoption of at least one drought adaptation strategy was found to be statistically significantly influenced by age, gender, marital status, education, farming experience, access to information about the drought, and access to extension services. Gender (0.068), marital status (0.018), access to drought information (0.032) and access to extension

services (0.008) were positive and statistically significant at $p < 0.10$, $p < 0.05$, $p < 0.05$ and $p < 0.05$ respectively for crop diversification. Marital status (0.056), farming experience (0.004) and extension services (0.000) were statistically significant at $p < 0.10$, $p < 0.05$ and $p < 0.01$ level respectively for livestock diversification. Gender (0.025), marital status (0.000) and access to extension services (0.012) were found to be statistically significant at $p < 0.05$, $p < 0.01$, $p < 0.05$ respectively for rainwater harvesting.

To adopt drought tolerant crops as an adaptation strategy, it was found that access to extension services (0.004) were statistically significant at $p < 0.05$ level. For crop rotation to be considered as an adaptation strategy, it was found that farming experience (0.013), income (0.036) and extension services (0.000) were statistically significant at $p < 0.05$, $p < 0.05$ and $p < 0.01$ level respectively. For mulching, household size (0.062) and farming experience (0.070) were statistically significant at $p < 0.05$ and $p < 0.10$ level respectively. For dry land planting, education (0.052) and extension services (0.004) were statistically significant at $p < 0.05$ level. Delayed planting was also one of the adaptation options and for a household to adopt delayed planting, access to drought information (0.060) and access to extension services (0.002) were found to be statistically significant at $p < 0.10$ and $p < 0.05$ level respectively.

Lastly, the results of the MNL found that, age (0.090), gender (0.076), marital status (0.095), farming experience (0.012) and access to extension services (0.000) were statistically significant at $p < 0.10$ (for age, gender and marital status), $p < 0.05$ (for farming experience) and $p < 0.01$ (for access to extension services). The results of the MNL implied that being married, age, gender, educated, household size, having experience in farming and access to drought information and extension services are important factors that determined which adaptation strategies were adopted by the household. The findings of the MNL showed that indeed drought did have a negative effect on the welfare of rural households, and those rural households that adopted at least one adaptation option were able to smooth consumption.

Empirical results of the two-stage least squares (2SLS) showed that the relationship and effects of drought adaptation strategies on welfare were marital status related: divorced (0.023), widowed (0.043), farming experience (0.045), access to drought information (0.044) and access to extension services (0.000) for the first stage regression. For the second stage regression, the results were positive and statistically significant for farming experience (0.071), access to drought information (0.029) and access to extension services (0.000) at $p < 0.10$, $p < 0.05$ and $p < 0.01$ respectively. Therefore, adopting at least one drought adaptation strategy had a positive effect on total household consumption expenditure, which in turn had a positive effect on the welfare of rural household.

Empirical results for propensity score matching (PSM) showed that adopting crop diversification (0.076), livestock diversification (0.434), rainwater harvesting (0.040), drought tolerant crops (0.040), crop rotation (0.040), mulching (0.015), dry land planting (0.071), and delayed planting (0.076) were positive and statistically significant. These results revealed that there was indeed a relationship with

each adaptation option, where adopting at least one adaptation option had a positive impact on rural households that chose to adopt, therefore, significantly enhanced the welfare of rural households in the face of drought.

5.2 Conclusion

The purpose of this study was to analyse how the adoption of drought adaptation strategies affect the welfare of rural households in JTGD in terms of consumption expenditure. To guide the systematic process of the study, the study used primary data that consisted of quantitative information. All the methods of data analysis employed the quantitative approach. This approach was used to analyse the data in terms of frequencies, the type of drought adaptation strategies that rural households adopted, and the kind of impact that each adaptation strategy had on the welfare of rural households. The study collected data from books, journal articles, and government documents to compile a well-structured literature review. Questionnaires were also used to collect information in three hundred and sixty rural households. A mixture multistage and simple random sampling were used to gather data, and the statistical software for data science, STATA 15.1, was the statistical programme utilized to analyse the data.

The research work was motivated by the severe drought occurrences in South Africa that have been ongoing since 2015. Projections of this study showed that rural households who adopted at least one drought adaptation would improve their welfare significantly as compared to households who do not adopt any drought adaptation strategy. The occurrence of drought made majority of rural households, who derived their livelihoods from farming vulnerable to decreased income and consumption. This situation was worsened by the fact that some of the farming households had no disposable assets. Those that had disposable assets ended up having to sell all their assets with the aim of smoothing income and consumption.

As a response to the negative effects of drought, rural households employed a variety of drought adaptation measures, according to the MNL data. The findings showed that the decision to implement a drought adaptation strategy is significantly influenced by factors like age, marital status, education, farming experience, access to drought information, and extension services. These variables were discovered to significantly affect the likelihood of adopting or not. For access to information on the drought and access to extension services, the likelihood that crop diversification will be used as an adaptation strategy was $p < 0.05$ for marital status, access to drought information and access to extension services; and $p < 0.10$ for gender. The probability of adopting livestock diversification as an adaptation strategy was statistically significant at $p < 0.05$ for farming experience and extension services and $p < 0.10$ for marital status. The chances that a household could adopt rainwater harvesting as an adaptation strategy was statistically significant at $p < 0.01$ for marital status and $p < 0.05$ for access to extension services and gender. The probability that drought tolerant crops

may be adopted as an adaptation strategy was statistically significant at $p < 0.05$ level. The probability of adopting crop rotation as an adaptation strategy was statistically significant at $p < 0.05$ level for farming experience, income, and access to extension services. For mulching, the probability of adopting this adaptation strategy was statistically significant at $p < 0.05$ level. The probability of adopting dry planting and delayed planting as adaptation strategies was statistically significant at $p < 0.05$ for education, access to drought information and access to extension services. For zero tillage to be adopted as an adaptation strategy, it was found to be statistically significant at $p < 0.01$, $p < 0.05$ and $p < 0.10$ level.

The effects of drought adaptation techniques on rural households' welfare were examined using the two-stage least squares approach. The results of the first stage regression showed that adopting different drought adaptation measures had a positive influence on well-being, and that this was true regardless of farming experience, access to information on droughts, and access to extension services. The second stage of the regression showed that adopting at least one drought adaptation strategy increases the total expenditure consumption of the household thus increasing the welfare of rural households.

The welfare enhancement impacts connected to each adaptation strategy were then computed using PSM. The ATT results from the PSM were positive and statistically significant for crop diversification, livestock diversification, drought tolerant crops, crop rotation, dry land planting, mulching, and delayed planting. As a result, adopting any of these adaptation strategies could potentially enhance the income and consumption (welfare) of rural households.

5.3 Recommendations

In view of the above conclusion, the study made the following recommendations for policy implications:

5.3.1 Youth involvement in agriculture

In rural homes, the age of the household heads is a key factor in decision-making. The majority (35%) of household heads are older people (60 years and older). This means that most household heads are elderly. It follows that farmers are no longer in their prime. This demonstrates that youth were not engaged in farming or the adoption of any adaption techniques. The study recommended that youth could be involved in agriculture as they are more inventive and more likely to implement drought adaptation strategies since they are still young and capable of making wise decisions.

5.3.2 Active participation of women in agriculture

The study reveals that the majority (62.80%) of household heads were men. As male household heads predominate in rural areas, this result was anticipated. It is recommended that government, non-governmental organizations, or private businesses should push programmes encouraging and promoting women to become interested in farming and enhance their involvement in farming by

implementing policies that accommodate female farmers. In this approach, married people can work together with their partners, and single people can advocate for themselves in the agricultural sector, adopt adaptation techniques, and enhance their standard of living.

5.3.3 Educational attainment on various drought adaptation strategies

The study revealed that majority of the household heads have education level between Grade 8 to Grade 12. Of these individuals that are educated, only 40% took agriculture as a subject and only 46% know about drought, drought adaptation strategies and its impacts on rural households. It is therefore recommended that policy makers should aspire to improve or implement adaptation strategies that are necessary for farmers to improve their household welfare. The Department of Agriculture ought to consider educating smallholder farmers and giving them access to educational material that will increase their understanding of what drought is, its causes, the severity of drought, its implications and the various drought adaptation strategies that are needed to smooth consumption. This way rural households will be able to devise the relevant adaptation strategies and will be able to anticipate the amount of effort needed to cope with the adverse effects of drought.

5.3.4 Access to drought information

Rural households had access to information on the drought in about 36.9% of cases. This result demonstrated that just a small proportion of rural households were informed about drought, its effects, and the several adaptation options accessible to them. Information on the drought should be made available to rural households for this purpose, whether it is by radio stations, television, posters, or meteorological platforms. It is recommended that the tribal kings of the villages, which made up the majority of JTGD, could host awareness-raising events for their communities. They could work together with extension personnel to instruct different households.

5.3.5 Access to extension services

The study further recommends that extension officers should receive training on a variety of adaption techniques that could benefit rural households and improve their wellbeing. Additionally, extension agents should regularly visit rural households to provide information on current agricultural issues, new agricultural technology developments, issues related to climate change and variability, as well as training on new agricultural techniques to lessen the adverse effects of drought on the welfare of rural households. Furthermore, extension officers can further have a consultation office where they will be readily available when needed by the residents of JTGD. Extension agents, who provide information to farmers, must train farmers to increase their understanding of climate change and variability.

5.3.6 Adoption of crop and livestock diversification

Crop-livestock diversification is the best feasible method of generating income for rural households. This is so that diverse farms can assure food security, preserve biodiversity, enhance dietary

preferences, boost household income, lessen sensitivity to shocks, and generate employment opportunities. Systems of mixed farming also increase the efficiency of water use and increase land yield. As a result, the study recommended that crop-livestock diversification could aid the Northern Cape Province in achieving the goal of ending hunger set forth in the National Development Plan Vision 2030, as it enhances food security without having a negative impact on biodiversity and ecosystem health. This might be accomplished by introducing it into rural households' current crop planting and livestock rearing for food and jobs programme. Therefore, rural households can successfully increase their total household consumption by using crop-livestock diversification as an adaptation measure, which will raise the standard of living of rural households.

5.3.7 Adoption of rainwater harvesting

It is important to promote rainwater gathering among rural homes as well. The water that would be captured can then be used during times when there is not enough water for irrigation, household use, or animal consumption. All rural households should have access to well-built water collection infrastructure because this will enable them to engage in other activities that will increase their income and consumption, such as irrigation and other commercial ventures that enhance human welfare, in addition to satisfying their domestic water needs. The study recommends that water harvesting would be helpful when the government or non-governmental organizations (NGOs) start an initiative to encourage rural households to have their own water source in the form of secure deep wells. This would lessen the strain on public boreholes and the distances people must travel to find clean drinking water. To complement their diet, households can water their gardens with a variety of crops using the same deep well water. This will increase the number of meals that households consume each day and lower the rate of malnutrition, thus, improving the welfare of rural households.

5.3.8 Policy implication

From a policy point of view, understanding the factors that influence drought adaptation could help with the formulation and implementation of policies that improve farmers' welfare at the community, district, and regional levels. The various effects of adaptation on household income, expenditure, and saving show that local features should be considered in national policy on adaptation.

Generally, the findings of the study suggested that governments and non-governmental organizations should concentrate on strengthening rural households' social, economic, and human capital resource bases to improve the welfare of rural households.

5.4 Suggested areas for future research

The following recommendations for further research should be considered:

The study focused only on one district which is JTGD in the Northern Cape. Since drought affected the whole Province severely, future studies could be conducted on the same topic on all the other districts of the Northern Cape Province.

The study recommends that in future, research should analyse the cost implications of drought adaptation and the effects that it has on rural households' welfare. This is because most researchers focus on suggesting and encouraging the adoption of adaptation strategies but neglect to analyse what the cost implications of adopting those adaptation strategies are and what effect does the cost implications have on rural households' welfare.

REFERENCES

- Abazinab, H., Duguma, B., and Muleta, E. 2022. Livestock farmers' perception of climate change and adaptation strategies in the Gera district, Jimma zone, Oromia Regional State, southwest, Ethiopia. *Heliyon*. 8(12): 1 – 13, Doi:10.1016/j.heliyon.2022.e12200
- Abid, M., Scheffran, J., Schneider, U.A. and Ashfaq, M. 2015. Farmers' Perceptions of and Adaptation Strategies to Climate Change and their Determinants: The Case of Punjab Province. *Earth System Dynamics*. 6(1): 225 – 243. DOI:10.5194/esd-6-225-2015
- Abdu-Raheem, K.A., and Worth, S.H. 2011. Household Food Security in South Africa: Evaluating Extension's Paradigms Relative to the Current Food Security and Development Goals. *South African Journal of Agricultural Extension*. 39 (2): 91 – 103, ISSN 0301-603X
- Adger, W.N., Barntte, J, Brown. K., Marshall. N, and O'Brian. K. 2012. Cultural Dimensions of Climate Change Impacts and Adaptation. *Journal of National Climate Change*. 3(1): 112-117, <https://doi.org/10.1038/nclimate1666> , Date accessed [03 August 2019]
- Adzawla, W., Azumah, S. B., Anani, P. Y., and Donkoh, S. A. 2020. Analysis of farm households' perceived climate change impacts, vulnerability, and resilience in Ghana. *Scientific African* 8, (e00397): 1 – 11, Doi:10.1016/j.sciaf.2020.e00397
- African People's Democratic Union of Southern Africa (APDUSA). 2016. *The Impact of Drought in the Northern Cape Province*. <https://www.apdusa.org.za/the-impact-of-drought-in-the-northern-cape/> , Date accessed [23 January 2021].
- Agency for Statistics of Bosnia and Herzegovina. 2017. Basic consumption and income-based indicators of economic inequalities in Bosnia and Herzegovina: evidence from household budget surveys. Conference proceedings. Conference of European Statisticians (2017). Working Paper 13. Budva, Montenegro. 1 – 14.
- Akamigbo, F., and Nnaji, G. 2011. Climate Change and Nigerian Soils: Vulnerability, Impact and Adaptation. *Agro-Science*, 10(1): 80 – 90, Doi:10.4314/as.v10i1.68723
- Akinagbe, O.M., and Irahibe, I.J. 2014. Agricultural adaptation strategies to climate change impacts in Africa: A review. *Bangladesh Journal of Agricultural Research*. 39(3), Doi:10.3329/bjar.v39i3.21984
- Ajak, B.J, Kyazze, F.B., and Mukwaya, P.I. 2018. Choice of adaptation strategies to climate variability among smallholder farmers in the Maize Based Cropping System in Namutumba District, Uganda. *American Journal of Climate Change*. 7: 431 – 451, Doi:10.4236/ajcc.2018.73026
- Alam, M.G.M., Alam, K., Mushtaq, S. 2017. Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. *Climate Risk Management*. 17: 52–63. Doi:10.1016/j.crm.2017.06.006

- Alarima, C.I. 2018. Factors influencing rural-urban migration of youth in Osun State, Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extension*. 17(3): 34 – 39, DOI:10.4314/As.V17i3.6
- Alexander, M.C. 2018. *Infographic: Local government in the Northern Cape, South Africa Getaway*, <https://southafrica-info.com/land/infographic-local-government-municipalities-northern-cape-province-south-africa/> , Date accessed [03 May 2019]
- Alexandri, C., Luca, L., and Kevorchian, C. 2015. Subsistence Economy and Food Security – The Case of Rural Households from Romania. *Procedia Economics and Finance*. 22: 672–680, Doi:10.1016/s2212-5671(15)00282-8
- Alhassan, H., Kwakwa, P.A., and Adzawla, W. 2019. Farmers' choice of adaptation strategies climate change and variability in arid region of Ghana. *Review of Agricultural and Applied Economics*. 1(2019): 32 – 40. Doi:10.15414/raae.2019.22.01.32-40.
- Ali, A., and Erenstein, O. 2017. Assessing Farmer Use of Climate Change Adaptation Practices and Impacts on Food Security and Poverty in Pakistan. *Climate Risk Management*. 16(2017): 183 – 194, Doi:10.1016/j.crm.2016.12.001
- Ali, U., Ormal, L., and Ahmad, F. 2018. Impact of free cash flow on probability of the firms in automobile sector of Germany. <https://kardan.edu.af/data/public/files/usmanali-lidaormal.pdf> , Date accessed [23 October 2020]
- Amare, M., Cisse, J.D., Jensen, N.D., and Shiferaw, B. 2016. *The impact of agricultural productivity on welfare growth of farm households in Nigeria: A panel Data Analysis*, <https://www.fao.org/3/bp143e/bp143e.pdf> , Date accessed [10 April 2020]
- Antwi-Agyei, P and Stringer, L.C. 2021. Improving the Effectiveness of Agricultural Extension Services in Supporting Farmers to Adapt to Climate Change: Insights from North Eastern Ghana. *Climate Risk Management*. 32(100304): 1 – 13, Doi:10.1016/j.crm.2021.100304
- Augustyn, A., Bauer, P., Duignan, B., Eldridge, A., Gregersen, E., Luebering, J.E., Mckenna, A., Petruzello, M., Rafferty, J.P., Ray, M., Royers, K., Tikkanen, A., Wallenfeldt, J., Zeidan, A., and Zelazko, A. 2019. *Northern Cape Province South Africa*, *Encyclopaedia Britannica*. www.britannica.com/place/Northern-Cape , Date accessed [03 May 2019]
- Austin, W.D. 2008. *Drought in South Africa: lessons lost and/or learnt from 1990 to 2005*, Faculty of Science. University of Witwatersrand: Gauteng. (Thesis – Masters).
- Austin, P.C. 2011. An Introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate Behavioural Research*. 46(3):399 – 422, <https://doi.org/10.1080/00273171.2011.568786> , Date accessed [04 November 2019]

- Austin, P. C. 2018. Assessing the performance of the generalized propensity score for estimating the effect of quantitative or continuous exposures on binary outcomes. *Statistics in Medicine*. 37(11), 1874–1894. Doi:10.1002/sim.7615
- Apraku, A., Morton, J. F., and Apraku Gyampoh, B. 2021. Climate change and small-scale agriculture in Africa: Does indigenous knowledge matter? Insights from Kenya and South Africa. *Scientific African*. 12 (e00821): 1 – 36, Doi:10.1016/j.sciaf.2021.e00821
- Asfaw, S., Shiferaw, B., Simtowe, F., and Lipper, L. 2012. Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food Policy*. 3(37): 283–295, Doi:10.1016/j.foodpol.2012.02.013
- Assan, E., Suvedi, M., Olabisi, L.S., and Allen, A. 2018. Coping with and Adapting to Climate Change: A Gender Perspective from Smallholder Farming in Ghana. *Environments*. 5(8): 86, Doi:10.3390/environments5080086
- Asrat, P. and Simane, B. 2018. Farmers' Perception of Climate Change and Adaptation Strategies in the Dabus Watershed, North-West Ethiopia. *Ecological Processes*. 7 (7), Doi:10.1186/s13717-018-0118-8
- Atube, F., Malinga, G.M., Nyeko, M., Okello, M.D., Alarakol, S.P., and Okello-Uma, I. 2021. Determinants of Smallholder Farmers' Adaptation Strategies to the Effects of Climate Change: Evidence from northern Uganda. *Agriculture and Food Security*. 1(10): 1-14, Doi:10.1186/s40066-020-00279-1
- Awotide, B.A., Abdoulaye, T., Ailene, A and Manyang, V.M. 2015. Impact of Access to Credit on Agricultural Productivity: Evidence from Smallholder Cassava Farmers in Nigeria, A Contributed Paper Prepared for Oral Presentation at the International Conference of Agricultural Economists (ICAE). Milan, Italy, August 9 – 14, pp 1 – 34, DOI: 10.22004/ag.econ.210969
- Ayinde, K., Apata, E.O., and Alaba, O.O. 2012. Estimation of linear regression model and prediction under some assumptions violations. *Open Journal of Statistics*. 2(5): 1 – 13, Doi:10.4236/ojs.2012.25069
- Bahta, Y.T and Myeki, V.A. 2022. The impact of agricultural drought on smallholder livestock farmers: Empirical evidence insights from Northern Cape Province, South Africa. *Agriculture*. 12(4): 442, Doi:10.3390/agriculture12040442
- Barbier, E.B., and Hochard, J.P. 2018. Poverty, Rural Population Distribution and Climate Change, *Environment and Development Economics*. 3(23): 234 – 256, <https://doi.org/10.1017/s1355770x17000353> , Date accessed [12 August 2019].
- Bascle, G. 2008. Controlling for endogeneity with instrumental variables in strategic management research. *Strategic Organization*, 6(3): 285–327. Doi:10.1177/1476127008094339

- Belay, A., Recha, J.W., Woldeamanuel, T., and Morton, J.F. 2017. Smallholder's adaptation to climate change and determinants of their adaptation decisions in Central Rift Valley of Ethiopia. *Agricultural Food Security*. 6(1): 24 Doi: 10.1186/s40066-017-0100-1
- Berhe, M., Hoag, D., Tesfay, G., Tadesse, T., Oniki, S., Kagatsume, M., and Keske, C. M. H. 2017. The effects of adaptation to climate change on income of households in rural Ethiopia. *Pastoralism*. 7(1): 1 - 15. Doi:10.1186/s13570-017-0084-2
- Berhanu, W., and Beyene, F. 2015. Climate Variability and Household Adaptation Strategies in Southern Ethiopia. *Sustainability*. 7(6): 6353–6375. doi:10.3390/su7066353
- Bettis. R., Gambardella. A., Helfat. C. and Mitchell. W. 2014. Quantitative empirical analysis in strategic management. *Strategic Management Journal*. 35(7): 949-953. Doi:10.1002/smj.2278
- Beyene, Y., Gowda, M., and Suresh, L.M.I. 2017. Genetic Analysis of Tropical Maize Inbred Lines for Resistance to Maize Lethal Necrosis disease. *Euphytica*. 224(2017), Doi:10.1007/s10681-017-2012-3
- Bhorat, H., Cassim, A., and Hirsch, A. 2014. Policy co-ordination and growth traps in a middle-income country setting: The case of South Africa. WIDER Working Paper 2014/155. World Institute for Development Economics and Research. <https://www.wider.unu.edu/sites/default/files/wp2014-155.pdf> , Date accessed [20 April 2021].
- Bierbaum, R., Smith, J. B., Lee, A., Blair, M., Carter, L., Chapin, F. S., and Verduzco, L. 2012. A comprehensive review of climate adaptation in the United States: more than before, but less than needed. *Mitigation and Adaptation Strategies for Global Change*. 18(3): 361–406, Doi:10.1007/s11027-012-9423-1
- Botai, C.M., Botai, J.O., Adeola, A.M. 2018. Spatial distribution of temporal precipitation contrasts in South Africa, *Souh African Journal of Science*. 114(7/8): 1 – 9, <https://dx.doi.org/10.17159/sajs.2018/20170391>, Date accessed [25 October 2019].
- Botai, C.M., Botai, J.O., de Wit, J.P., Ncongwane, K.P., Murambadoro, M., Barasa, P.M., Adeola, A.M. 2021. Hydrological Drought Assessment Based on the Standardized Streamflow Index: A Case Study of the Three Cape Provinces of South Africa. *Water* 2021. 13 (3498): 1 – 23, <https://doi.org/10.3390/w13243498>, Date accessed [23 March 2022].
- Boudet, A.M.M., Buitrago, P., De La Briere, L.B., Newhouse, D.L., Rubiano, M.E.C., Scott, K., and Suarez-Becerra, P. 2018. Gender differences in poverty and household composition through the life cycle: A Global Perspective. World Bank Policy Research Working Paper No. 8360, SSRN: <https://ssrn.com/abstract=3135590>
- Bracken, S.J. 2008. Defining rural community(ies): Future considerations for informal and nonformal adult education in rural communities. 2008(117): 83–92. Doi:10.1002/ace.288

- Baramo, G.B.V. 2022. Factors Affecting Adaptation Strategies of Smallholder farmer's to Climate Changes: Evidence from Dale Woreda in Sidama Regional State: Ethiopia. *International Journal of Applied Agricultural Sciences*. 8(6): 225 – 236. Doi: 10.11648/j.ijaas.20220806.15
- Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., and Herrero, M. 2013. Adopting agriculture to climate change in Kenya: Household strategies and determinants. *Journal of Environmental Management*. 114: 26 – 35. Doi: 10.1016/j.jenvman.2012.10.036.
- Bryman, A., and Cramer, D. 2011. *Quantitative Data Analysis with IBM SPSS 17, 18 & 19: A Guide for Social Scientists* (1st ed.). Routledge. Doi:10.4324/9780203180990
- Carter, M.R and Lybbert, T.T. 2012. Consumption vs Asset Smoothing: Testing the Implications of Poverty Trap Theory in Burkino Faso. *Journal of Development Economics*. 99(2012): 255 – 264, Doi:10.1016/j.jdeveco.2012.02.003
- Castaneda, A., Doan, D., Newhouse, D., Nguyen, M.C., Uematsu, H., and Azevedo, J.P. 2016. *Who are the Poor in the Developing World, Policy Research Working Paper No. 7844*. World Bank, Washington, DC. © World Bank. <https://openknowledge.worldbank.org/handle/10986/25161> License: CC BY 3.0 IGO.”, Date accessed [21 September 2022]
- Cervigni, R. and Morris, M. 2016. *Confronting Drought in Africa's Drylands: Opportunities for Enhancing Resilience*. World Bank: Washington, DC.
<https://openknowledge.worldbank.org/handle/10986/23576> Date accessed [29 April 2019].
- Chaudhary, P.K., and Pasa, R.B. 2015. Agricultural education for rural development in Nepal. *Journal of Training and Development*. 1(1): 39 – 45, Doi: 10.3126/jtd.v1i1.13089
- Cheema, A.R., and Sial, M. 2012. Poverty, Income inequality, and growth in Pakistan: A pooled regression analysis. *The Lahore Journal of Economics*. 17(2): 137 – 157, Doi:10.35536/lje.2012.v17.i2.a6
- Cheteni, P., Khamfula, Y., and Mah, G. 2019. Gender and poverty in South African rural areas. *Cogent Social Sciences*. 5(1): 1- 19, Doi:10.1080/23311886.2019.1586080
- Christian, M. 2017. *Analysing of the impact of smallholder irrigation schemes on the choice of rural livelihood strategy and household food security in Eastern Cape Province*. Alice: University of Fort Hare. (Thesis – PhD).
- Cliff, K.R, and Billy, K.M. 2017. Estimation of the parameters of a linear regression system using the simple averaging method. *Global Journal of Pure and Applied Mathematics*. 13(11): 7749 – 7758. ISSN:0979-1768
- Cloete, R. 2022. *Here are the SASSA Grant Increases for 2022*, <https://www.skillsportal.co.za/content/here-are-sassa-grant-increases-2022> , Date accessed [26 May 2021]

Crétat, J., Vizy, E. K., and Cook, K. H. 2013. How well are daily intense rainfall events captured by current climate models over Africa? *Climate Dynamics*. 42(9-10): 2691–2711. Doi:10.1007/s00382-013-1796-7

Cromartie, J., von Reichert, C., and Arthun, R. 2015. Factors affecting former residents returning to rural communities. *Economic Research Report*. 185: 1 – 30, https://www.ers.usda.gov/webdocs/publications/45361/52906_err185.pdf?v=0 , Date accessed [20 March 2021]

Daniels, S. 2017. Enabling smallholder farmers to improve their incomes. <https://sustainablefoodlab.org/wp-content/uploads/2017/09/BFP-Improving-Incomes-WEB.pdf> , Date accessed [30 November 2022]

Danso-Abbeam, G., Ehiakpor, D. S., and Aidoo, R. 2018. Agricultural extension and its effects on farm productivity and income: insight from Northern Ghana. *Agriculture & Food Security*. 7(1): 1 – 10, Doi:10.1186/s40066-018-0225-x

Daoud, A.I. 2017. Multicollinearity and regression analysis. *Journal of Physics*. 949(012009): 1 – 7, Doi:10.1088/1742-6596/949/1/012009

Davidson, D.J., Rollins, C., Lefsrud, L., Anders, S., and Hamann, A. 2019. Just don't call it climate change: Climate skeptic farmer adoption of climate mitigative practices. *Environmental Research Letters*. 14(3), DOI:10.1088/1748-9326/aafa30

Davis, B., Di Giuseppe, S., and Zezza, A. 2017. Are African households (not) leaving agriculture? Patterns of households' income sources in rural Sub-Saharan Africa. *Food Policy*. 67: 153–174. Doi:10.1016/j.foodpol.2016.09.018

Davis, R. 2020. *In drought-ravaged Northern Cape, government assistance may be too little, too late*. *Daily Maverick*, <https://www.dailymaverick.co.za/article/2020-01-22-in-drought-ravaged-northern-cape-government-assistance-may-be-too-little-too-late/> , Date accessed [21 March 2021].

Deressa. T.T, Hassan. M.R, Ringler. C, Alemu.T and Yusef.M, 2009, Determinants of Farmer's Choice of Adaptation Methods to Climate Change in the Nile Basin of Ethiopia, *Global Environmental Change* 19, pp 248-255, <https://doi.org/10.1016/j.gloenvch.2009.01.002> , Date accessed [20 August 2022]

Destaw, F., and Fenta, M.M. 2021. Climate Change Adaptation Strategies and their Predictors amongst Rural Farmers in Ambassel District, Northern Ethiopia. *Journal of Disaster Risk Studies*. 13(1): 974, Doi:10.4102/jamba.v13i1.974

Dewen, C. 2010. Can social security boost domestic consumption in the people's Republic of China?. ADBI Working Paper 215. Tokyo: Asian Development Bank Institute. <http://www.adbi.org/Working-paper/2010/05/17/3822.social.security.domestic.consumption.prc> , Date accessed [20 March 2022]

- Di Falco, S., Veronesi, M., and Yesuf, M. 2011. Does adaptation to climate change provide food security? A micro perspective from Ethiopia. *American Journal of Agricultural Economics*. 93(3): 829 - 846, Doi:10.1093/ajae/aar006
- Dube-Mngomezulu, S., Green, M., and Chimonyo, M. 2018. Information needs of communal cattle farmers in conservation and trans frontier areas: Republic of South Africa. *South African Journal of Agricultural Extension*. 46(1): 71 – 82, Doi:10.17159/2413-3221/2018/v46n1a442
- Duriex, M. 2012. *The Role of Social Grants in Supporting Local Economic Development (LED)*. Studies in Poverty and Inequality Institute, Policy Brief, <http://spii.org.za/wp-content/uploads/2013/12/The-role-of-social-grants-in-supporting-local-economic-development-LED-Policy-Brief-January-2012.pdf> , Date accessed [22 May 2022].
- Dzavo, T., Zindove, T. J., Dhliwayo, M., and Chimonyo, M. 2018. Effects of drought on cattle production in sub-tropical environments. *Tropical Animal Health and Production*. Doi:10.1007/s11250-018-1741-1
- Eeswaran, R., Nejadhashemi, A.P., Faye, A., Min, D., Prasad, P.V.V., Ciampitti, I.A. 2022. Current and Future Challenges and Opportunities for Livestock Farming in West Africa: Perspectives from the Case of Senegal. *Agronomy* 12 (1818): 1 – 23, Doi.org/10.3390/ agronomy12081818
- El Chami. D and El Moujabber. M, 2016, Drought. Climate Change and Sustainability of Water in Agriculture: A Roadmap towards the NWRS2. *South African Journal of Science*. 112(9 & 10): 1 - 4, Doi:10.17159/sajs.2016/20150457
- Elum, Z. A., Modise, D. M., and Marr, A. 2017. Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. *Climate Risk Management*. 16: 246 – 257. Doi:10.1016/j.crm.2016.11.001
- Epaphra, M. 2014. Empirical Investigation of the Determinants of Tanzania's National Savings. *Journal of Economics and Development Studies*. 2(4): 223 – 241, DOI: 10.15640/jeds.v2n4a16
- Eyisi.D. 2016. The usefulness of qualitative and quantitative approaches and methods in researching problem-solving ability in science and education curriculum. *Journal of Education and Practice*. 7(15): 91 – 100. ISSN:2222-288X
- Fahad, S., Bajwa, A. A., Nazir, U., Anjum, S. A., Farooq, A., Zohaib, A., and Huang, J. 2017. Crop Production under Drought and Heat Stress: Plant Responses and Management Options. *Frontiers in Plant Science*. 8 (1147): 1 - 16. Doi:10.3389/fpls.2017.01147
- Fan, S., and Rue, C. 2020. The role of smallholder farms in a changing world. In: Gomez, P.Y., Riesgo, S.L, and Louhichi, K. (eds). *The role of smallholder farms in food and nutrition security*. Springer, DOI:10.1007/978-3-030-42148-9_2

- Feinstein, N. W., and Mach, K. J. 2019. Three roles for education in climate change adaptation. *Climate Policy*, 1–6. Doi:10.1080/14693062.2019.1701975
- Fichera, E. 2010. An analysis of Households' Credit Markets in Ethiopia and Malawi. England: University of Nottingham. (Thesis – PhD).
- Food and Agriculture Organization of the United Nations (FAO). 2011. *The role of women in agriculture*. ESA Working Paper No. 11-02, prepared by the SOFA Team and Cheryl Doss. Rome, <https://ageconsearch.umn.edu/record/289018/files/a-am307e.pdf> , Date accessed [18 May 2021]
- Food and Agriculture Organization of the United Nations (FAO). 2012. Smallholders and family farmers. [https://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Factsheet SMALLHOLDE RS.pdf](https://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Factsheet_SMALLHOLDE_RS.pdf) , Date accessed [11 November 2020].
- Fusco, A., and Islam., N. 2017. Household size and poverty. http://www.ecineq.org/ecineq_nyc17/FILESx2017/CR2/p243.pdf , Date accessed [14 May 2021]
- Giannakis, E., Efstratoglou, S., and Antoniadis, A. 2018. Off-farm employment and economic crisis: Evidence from Cyprus. *Agriculture*. 8(3): 41, Doi:10.3390/agriculture8030041
- Gikonyo, N.W, Busienei, J.R, Gathiaka, J.K., and Karutu, G.N.2022. Analysis of household savings and adoption of climate smart agricultural technologies: Evidence from smallholder farmers in Nyando Basin, Kenya. *Heliyon*. 8(e09692). Doi:10.1016/j.heliyon.2022.e09692
- Giller, K.E., Delaune, T., Silva, J.V., van Wijk, M., Hammond, J., Descheemaeker, K., van de Ven, G., Schut, A.G.T., Taulya, G., Chikowo, R., and Andersson, J.A. 2021. Small farms and development in sub-Saharan Africa: Farming for food, for income or for lack of better option?. *Food Security*. 13: 1431 – 1454, Doi: 10.1007/s12571-021-01209-0
- Geist, L. 2022. Delayed planting can affect Missouri corn yields. <https://extension.missouri.edu/news/delayed-planting-can-affect-missouri-corn-yields-5606>, Date accessed [02 October 2022]
- Gomez y Paloma, S., Riesgo, L., and Louhichi, K. (Eds.). (2020). *The Role of Smallholder Farms in Food and Nutrition Security*. doi:10.1007/978-3-030-42148-9
- Global Assessment Report on Disaster Risk Reduction (GAR), 2011, *Revealing risk, redefining development*, <https://www.undrr.org/publication/global-assessment-report-disaster-risk-reduction-2011#:~:text=The%202011%20Global%20Assessment%20Report,progress%20in%20disaster%20risk%20reduction.> , Date accessed [11 May 2021]
- Guedes, G. R., Brondízio, E. S., Barbieri, A. F., Anne, R., Penna-Firme, R., and D'Antona, Á. O. 2011. Poverty and Inequality in the Rural Brazilian Amazon: A Multidimensional Approach. *Human Ecol.* 40(1): 41–57. Doi:10.1007/s10745-011-9444-5

- Gutura, P. 2015. *Social Grants and Poor Rural Households in South Africa Paperback*, <https://www.amazon.com/Social-grants-rural-households-Africa/dp/3659634913> , Date accessed [22 May 2021]
- Goedde, L., Ooko-Ombaka, A., and Pais, G. 2019. Winning in Africa's agricultural market. <https://www.mckinsey.com/industries/agriculture/our-insights/winning-in-africas-agricultural-market> , Date accessed [30 November 2022].
- Hänke, H., Barkmann, J., Coral, C., Enfors Kaustky, E., and Marggraf, R. 2017. Social-ecological traps hinder rural development in southwestern Madagascar. *Ecology and Society*. 22(1). Doi:10.5751/es-09130-220142
- Handunnetti, D. 2016. *Drought 'Worsens' Poverty, Vulnerability, Inequality*. <https://www.scidev.net/asia-pacific/news/droughts-worsen-poverty-vulnerability-inequality/> Date accessed [21 April 2019].
- Harris, D. 2018. Intensification Benefit Index: How much can rural households benefit from agricultural intensification? *Experimental agriculture*. 55(2): 1 – 15. Doi:10.1017/s0014479718000042
- Harvey, C.A., Rakotobe, Z.L., Rao, N.S., Dave, R., Razafimahatratra, H., Rabarijohn, R.H., Rojaofara, H., and Mackinnan, J.L. 2014. Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. *Philosophical Transactions of the Royal Society*. 369(1639): 1 - 12. DOI:10.1098/rstb.2013.0089
- Hein, Y., Vijitsrikamol, K., Attavanich, W., and Janekarnkij, P. 2019. Economic assessment of climate change adaptation options in Myanmar rice-based farming system. *Journal of Agricultural Science*. MPRA Working Paper No. 93587, <https://mpra.ub.uni-muenchen.de/93587/>, Date accessed: [20 June 2020].
- Herrero, M., Grace, D., Njuki, J., Johnson, N., Enahoro, D., Silvestri, S., and Rufino, M. C. 2012. The roles of livestock in developing countries. *Animal*. 7(s1): 3–18. Doi:10.1017/s1751731112001954
- Hirpha, H. H., Mpandeli, S., and Bantider, A. 2020. Determinants of adaptation strategies to climate change among the smallholder farmers in Adama District, Ethiopia. *International Journal of Climate Change Strategies and Management*. 12(4), 463–476. Doi:10.1108/ijccsm-01-2019-0002
- Huang, S., Leng, G., Huang, Q., Xie, Y., Lui, S., Meng, E., and Li, P. 2017. The Assymmetric Impact of Global Warming on US Drought Types and Distributions in a Large Ensemble of 97 Hydroclimatic Simulations, *Scientific reports*, 7(1): 5891, <https://doi.org/10.1038/s41598-017-06302-z> , Date accessed [19 July 2019]

- Human, L. 2022. *Finance Minister Announces 2022 Social Grant Increases*. Ground Up, <https://www.groundup.org.za/article/finance-minister-announces-2022-social-grant-increases/> , Date accessed [26 May 2021]
- Hussam, R., Kelley, E.M., Lane, G., and Zahra, F. 2021. The psychosocial value of employment. https://bfi.uchicago.edu/wp-content/uploads/2021/08/Employment_Paper_D7.pdf, Date accessed [13 May 2022].
- Iheke, O.R., and Agodike, W.C. 2016. Analysis of factors influencing the adoption of climate change mitigating measures by smallholder farmers in Imo State, Nigeria. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*. 16(1): 213 – 2020. ISSN: 2285-3952
- International Federation of Red Cross and Red Crescent Societies, 2021, *Emergency Plan of Action*, Namibia: Angolan Migrants, <file:///C:/Users/apple/OneDrive/Documents/MDRNA012do.pdf> , Date accessed [05 October 2021]
- Intergovernmental Panel on Climate Change (IPCC). 2013. *Climate Change 2013: The physical science basis, contribution of working group one to the fifth assessment report to the Intergovernmental Panel on Climate Change, United Kingdom and New York*, www.unfccc.int/science/workstream , Date accessed [09 June 2019].
- Integrated Food Security Phase Classification, 2020, *Prolonged Drought in Namibia Drives Over 400 000 People into Food Crisis*, IPC Acute Food Insecurity Analysis, October 2019 – September 2020, <https://www.ipcinfo.org/ipc-country-analysis/details-map/es/c/1152360/?iso3=NAM> , Date accessed [21 May 2021]
- International Labour Organization (ILO). 2017. Employment – rich economic growth. <https://www.ilo.org/global/topics/dw4sd/themes/employment-rich/lang--en/index.htm> , Date accessed [18 June 2021]
- Jha, C.K., Gupta, V., Chattopadhyay, U. and Sreeraman, B.A. 2018. Migration as adaptation strategy to cope with climate change: A study of farmers' migration in rural India. *International Journal of Climate Change Strategies and Management*. 10(1): 121 – 141, 10.1108/IJCCSM-03-2017-0059
- John Taolo Gaetsewe District Municipality. 2016. *Strategic objectives: Section C – 2016 Review*. <https://taologaeetsewe.gov.za/wp-content/uploads/2020/07/IDP-Review-2016-Part-C-Strategic-objectives.pdf> , Date accessed [23 November 2021]

Jordaan, A.J. 2012. *Drought Risk Reduction in the Northern Cape, South Africa*. Bloemfontein: University of the Free State. (Thesis – PhD).

Karnani, A. 2011. *Fighting Poverty Together: rethinking strategies for business, governments, and civil society to reduce poverty*, Palgrave MacMillan, New York, 297 Pages ISBN: 978-0-230-10587-4

Kaur, P., Stoltzfus, J., and Yellapu, V. 2018. Descriptive Statistics. *Biostatistics*. 4(11): 60 – 63, Doi:10.4103/IJAM.IJAM7_18

Katusiime, J. 2015. Building resilience: Water-smart agriculture through adoption of drought-tolerant crops. In: Nicol, A., Langan, S., Victor, M. and Gonsalves, J. (eds), *Water-smart agriculture in East Africa*. Colombo, Sri Lanka: IWMI and CGIAR research programme on WLE; Kampala, Uganda: GWI EA. 61-66.

Kenton, W. 2020. Consumption function: Formula, assumptions, and implications. <https://www.investopedia.com/terms/c/consumptionfunction.asp> , Date accessed [30 June 2021]

Kenton, W. 2022. Average Propensity to consume (APC) meaning and example. <https://investopedia.com/terms/a/average-propensity-to-consume.asp> , Date accessed [08 December 2022].

Khaled, W., Lin, J., Han, Z., Zhao, Y., and Hao, H. 2019. Test for heteroscedasticity in partially linear regression models. *Journal of Systems Science and Complexities*. 32(2019): 1194 – 1210, Doi:10.1007/s11424-019-7374-2

Khapayi, M., and Celliers, P.R. 2016. Factors Limiting and Preventing Emerging Framers to Progress to Commercial Agricultural Farming in King William's Town Area of Eastern Cape Province, South Africa. *South African Journal of Agricultural Extension*. 44(1): 25 – 41.

Doi: 10.17159/2413-3221/2016/v44n1a374

Kidanu, A., Kibret, K., Hajji, J., Mohammed, M., and Ameha, Y. 2016. Farmer's Perception towards Climate Change and their Adaptation Measures in Dire Dawa Administration, Eastern Ethiopia. *Journal of Agricultural Extension and Rural Development*. 8(12): 269 – 283, DOI: 10.5897/JAERD2016.0800

Kom, Z., Nethengwe, N.S., Mpandeli, N.S., and Chikoore, H. 2020. Determinants of Small-scale Farmers' Choice and Adaptive Strategies in Response to Climate Shocks in Vhembe District. *Geo Journal*. 87(2022), Doi:10.1007/s10708-020-10272-7

Kumar, S., Ramilan, T., Ramarao, C.A, Rao, S., and Whitbread, A. 2016. Farm level rainwater harvesting across different agro climatic regions of India: Assessing performance and its determinants. *Agricultural Water Management*, 176:55-66. <http://oar.icrisat.org/9814/> , Date accessed [20 June 2020]

- Kunguma, O. 2020. *South African Disaster Management Framework Assessing the Status and Dynamics of Establishing Information Management and Communication Systems in Provinces*. University of Free State South Africa: Free State. (Thesis – PhD).
- Kuntashula, E., Chabala, L. M., and Mulenga, B. P. 2014. Impact of Minimum Tillage and Crop Rotation as Climate Change Adaptation Strategies on Farmer Welfare in Smallholder Farming Systems of Zambia. *Journal of Sustainable Development*. 7(4), Doi:10.5539/jsd.v7n4p95
- Kurosaki, T. 2015. Vulnerability of Household Consumption to Floods and Droughts in Developing Countries: Evidence from Pakistan. *Environment and Development Economics*. 20(02): 1 – 27, Doi:10.1017/S1355770x14000357
- Lavery, M. R., Acharya, P., Sivo, S. A., and Xu, L. 2017. Number of predictors and multicollinearity: What are their effects on error and bias in regression? *Communications in Statistics - Simulation and Computation*. 48(1): 1–12. Doi:10.1080/03610918.2017.137175
- Lekobane, K. R., and Seleka, T. B. 2016. Determinants of Household Welfare and Poverty in Botswana, 2002/2003 and 2009/2010. *Journal of Poverty*. 21(1), 42–60. Doi:10.1080/10875549.2016.114138
- Litchfield, J., and McGregor, T. 2008. Poverty in Kagera, Tanzania: Characteristics, causes, and constraints. PRUS Working Papers 42, Poverty Research Unit at Sussex, University of Sussex. England
- Liu, Q.-Q., Yu, M., and Wang, X.L. 2015. Poverty reduction within the framework of SDGs and Post-2015 Development Agenda. *Advances in Climate Change Research*. 6(1): 67–73, Doi:10.1016/j.accre.2015.09.004
- Lottering, S.J., Mafongoya, P., and Lottering, R. 2020. The impacts of drought and the adaptive strategies of small-scale farmers in uMsinga, KwaZulu-Natal, South Africa. *Journal of Asian and African Studies*, 56(2): 267-289, DOI:10.1177/0021909620916898
- Lowder, S. K., Scoet, J., and Raney, T. 2016. The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide. *World Development*. 87: 16–29. Doi:10.1016/j.worlddev.2015.10.041
- Lu, G., Ding, X.D., Peng, D.X. and Chuang, H.H.C. (2018). Addressing Endogeneity in Operations Management Research: Recent Developments, Common Problems, and Directions for Future Research, *Journal of Operations Management*, 64, 53-64. Doi:10.16/j.jom.2018.10.001
- Magnan, A. K., Schipper, E. L. F., Burkett, M., Bharwani, S., Burton, I., Eriksen, S., and Ziervogel, G. 2016. Addressing the risk of maladaptation to climate change. *Wiley Interdisciplinary Reviews: Climate Change*. 7(5). 646–665. Doi:10.1002/wcc.409

- Mahlalela, P.T., Blamey, R.C., Hart, N.C.G., and Reason, C.J.C. 2020. Drought in the Eastern Cape Region of South Africa and Trends in Rainfall Characteristics. 2020. *Climate Dynamics*, 55(2020): 2743-2759, <https://doi.org/10.1007/s00382-020-05413-0> , Date accessed [23 March 2021]
- Majbauddin, A., Otani, S., Tsunekawa, A., Haregeweyn, N., Abeje, M. T., Nigussie, Z., and Kurozawa, Y. 2020. The Influence of Income and Livelihood Diversification on Health-Related Quality of Life in Rural Ethiopia. *International Journal of Environmental Research and Public Health*, 17(8):1 – 12, Doi:10.3390/ijerph17082709
- Maka, L., Ighodaro, I.D., and Ngcobo-Ngotho, G.P.T. 2019. Capacity Development for Scaling Up Climate -Smart Agriculture (CSA) Innovations: Agricultural Extension's Role in Mitigating Climate Change Effects in Gqumashe Community, Eastern Cape, South Africa. *South African Journal of Agricultural Extension*. 47(1): 45 - 53, Doi:10.17159/2413-3221/2019/v47n1a488
- Malomane, M.A. 2019. The role of smallholder farmers' cooperatives in rural development: A case of Umgungundlovu district municipality, Kwazulu Natal. Bloemfontein: University of the Free State. (Thesis – Masters).
- Maluleke, I. 2020. *The effects of drought on agriculture*. Grain SA, <https://www.grainsa.co.za/the-effects-of-drought-on-agriculture> , Date accessed [21 March 2021]
- Mandleni, B., and Anim, F.D.K. 2011. Climate Change Awareness and Decision on Adaptation Measures by Livestock Farmers in South Africa. *Journal of Agricultural Science*. 3(3): 258 – 268, Doi:10.5539/jas.v3n3p258
- Manganhele, A.T. 2010. Improving Access to Credit for Smallholder Farmers in Mozambique: Lessons from Government Efforts in Developing Countries of Africa and Asia. Pretoria: University of Pretoria. (Thesis – Masters).
- Maponya, P., and Mpandeli, S. 2013. Perception of Farmers on Climate Change and Adaptation in Limpopo Province of South Africa. *Journal of Human Ecology*. 42(3): 283–288. doi:10.1080/09709274.2013.1190660
- Marengo, J.A., Torres, R.R., and Alves, L.M. 2017. Drought in northeast Brazil: past, present, and future. *Journal of Theoretical and Applied Climatology*, 129 (3-4): 1189 – 1200, DOI:10.1007/s00704-016-1840-8
- Marginean, S.C. 2014. Youth Unemployment in Romania: Post-Crisis Challenge. *Procedia Economics and Finance*. 16(2014): 613 - 620, Doi:10.1016/S2212-5671(14)00848-X
- Marias, S. 2022. Global market forces keep South Africa's food prices high. Farmer's weekly. <https://www.farmersweekly.co.za/agri-news/south-africa/global-market-forces-keep-south-africas-food-prices->

[high/#:~:text=South%20Africa's%20food%20prices%20are,local%20consumers%2C%20industry%20stakeholders%20say](#), Date accessed [20 August 2022].

Marie, M., Yirga, F., Haile, M., and Tquabo, F. 2020. Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. *Heliyon*. 6(4): 1 - 10. Doi:10.1016/j.heliyon.2020.e03867

Marotta, D., and Yemtsov, R. 2010. Determinants of households' income mobility and poverty dynamics in Egypt. The World Bank. https://conference.iza.org/conference_files/worldb2010/marotta_d6001.pdf , Date accessed [20 July 2021]

Mashala, P. 2014. Communal farming under threat. Farmer's weekly. <https://www.farmersweekly.co.za/rural-insight/communal-farming-under-threat/> , Date accessed [21 April 2021]

Masereka, E. M., Ochieng, G. M., and Snyman, J. 2019. Frequency analysis of agricultural drought of maize in Sabie River catchment in South Africa. *Jàmbá Journal of Disaster Risk Studies*. 11(1): 1 – 11, Doi:10.4102/jamba.v11i1.549

Masipa, T. S. 2017. The impact of climate change on food security in South Africa: Current realities and challenges ahead. *Jàmbá: Journal of Disaster Risk Studies*, 9(1). Doi:10.4102/jamba.v9i1.411

Mathebula, J., Molokomme, M., Jonas, S., and Nhemachena, C. 2017. Estimation of household income diversification in South Africa: A case study of three provinces. *South African Journal of Science*. 113(1/2): 1 – 9, Doi:10.17159/sajs.2017/20160073

Matlou, R.C. 2019. Resilience of households to agricultural drought in the Northern Cape, South Africa. Bloemfontain: University of Free State. (Thesis – Masters).

Matlou. R., Bahta. Y.T., Owusu-Sekyere, E., and Jordaan, H. 2021. Impact of Agricultural Drought Resilience on the Welfare of Smallholder Livestock Farming Households in the Northern Cape Province of South Africa. *Land*. 10(6): 562. Doi.org/10.3390/land10060562

Meque, A., Pinto, I., Maure, G., and Beleza, A. 2022. Understanding the variability of heatwave characteristics in Southern Africa. *Weather and Climate Extremes*. 38(100498): 1 – 13, Doi:10.1016/j.wace.2022.100498

Misachi, J. 2017. *Longest River in South Africa*. The World Atlas, <https://www.worldatlas.com/articles/longest-rivers-in-south-africa.html> , Date accessed [03 May 2019]

Mmatlou, K. 2019. *How Drought will Affect South Africa's Broader Economy*, The Conversation, <https://theconversation.com/how-droughts-will-affect-south-africas-broader-economy-111378> , Date accessed [23 January 2019].

- Mmbengwa, V., Nyhodo, B., Myeki, L., and van Schalkwyk, H. 2015. Communal livestock farming in South Africa: Does this farming system create jobs for poverty stricken rural areas. *SYLWAN*. 159(10): 176 – 192.
- Mortelmans, D. 2020. Economic consequences of divorce: A review. In: Kreyenfeld, M., Trappe, H. (eds). *Parental life courses after separation and divorce in Europe*. Life Course Research and Social Policies. 12. Springer, Cham. Doi:10.1007/978-3-030-44575-1_2.
- Mothiba, C. 2019. Effects of market access on income of cattle farmers in the Capricorn district of Limpopo province, South Africa. North West: North West University. (Thesis – Masters).
- Municipalities of South Africa. 2019. *John Taolo Gaetsewe District Municipality (DC45)*. <https://municipalities.co.za/overview/135/john-taolo-gaetsewe-district-municipality> , Date accessed [03 May 2019].
- Mtintsilana, O and Akinyemi, B.E. 2020. Determinants of adaptation to climate change among farming households in Tyhume Valley communities, Eastern Cape Province, South Africa. *International Journal of Climate Change Strategies and Management*. 13(2). ISSN:1756-8692
- Mugari, E., Masundire, H., and Bolaane, M. 2020. Adapting to Climate Change in Semi-Arid Rural Areas: A Case of the Limpopo Basin Part of Botswana. *Sustainability* 12(8292): 1 - 34, Doi:10.3390/su12208292
- Mupakati, T., and Tanyanyiwa, V.I. 2017. Cassava production as an ultimate change adaptation strategy in Chilonga Ward, Chiredzi District, Zimbabwe. *Journal of Disaster Risk Studies*. 9(1). Doi:10.4102/jamba.v9i1.348
- Mushore, T.D., Mhizha, T., Manjowe, M., Mashawi, L., Matandirotya, E., Mashonjowa, E., Mutasa, C., Gwenzi, J., and Mushambi, G.T. 2021. Climate change adaptation and mitigation strategies for smallholder farmers: A case of Nyanga District in Zimbabwe. *Frontiers in Climate*. 3(676495): 1 – 11, Doi: 10.3389/fclim.2021.676495.
- Mutekwa, C.J. 2016. *Drought Risk Effects on Livelihoods of Rural Communities in Chipinge South, Zimbabwe*. University of Free State: Free State. (Thesis – Masters).
- Muthelo, D. 2019. *Perception and adaptation strategies of smallholder farmers to drought in the Free State Province*, Faculty of Natural and Agricultural Sciences, Free State, <https://scholar.ufs.ac.za/bitstream/handle/11660/9913/MutheloD.pdf?sequence=1&isAllowed=y> , Date accessed [14 October 2021].
- Muthelo, D., Owusu-Sekyere, F., and Ogunedeji. A.A. 2019. Smallholder farmers' adaptation to drought: Identifying effective adaptive strategies and measures. *Water*. 11(10): 2069, Doi:10.3390/w11102069

- Muzamhindo, N., Mtabheni, S., Jiri, O., Mwakiwa, E., and Hanyani-Mlambo. 2015. Factors influencing smallholder farmers' adaptation to climate change and variability in Chiredzi District of Zimbabwe. *Journal of Economics and Sustainable Development*. 6(9): 1 – 10, ISSN 2222-2855
- Nairizi, S. 2017. *Irrigated agriculture development under drought and water scarcity*, https://www.icid.org/drought_pub2017.pdf , Date accessed [15 October 2021]
- National Agricultural Marketing Council (NAMC). 2015. Markets and Economic Research Centre. <https://www.namc.co.za/wp-content/uploads/2017/10/NAMC-Food-Price-Monitor-February-2015.pdf> , Date accessed [20 May 2020].
- Neamtu and Laurentia. 2013. Education, welfare, and economic growth. Conference: 20th International Economic Conference – IECS 2013.161-169. Conference proceedings of the 20th International Economic Conference “Post Crises Economy: Challenges and Opportunities”, Editura Universitatea Lucian Blaga Sibiu. 2344 – 1682, ISSN 2344 – 1682, ISSN–L
- Nelson, G.C., Rosegrant, M.W, Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R., Ewing, M, and Lee, D. 2009. Climate Change: Impact on agriculture and costs of adaptation. IFPRI Food Policy Report, No. 21. *International Food Policy Research Institute*, Washington DC. <https://econpapers.repec.org/paper/fprfprepo/21.htm> Accessed [21 May 2019].
- Ndamani, F and Watanabe, T. 2016. Determinants of farmers' adaptation to climate change: A micro level analysis in Ghana. *Scientia Agricola*. 73(3). Doi:10.1590/0103-9016-2015-0163
- Ngubane, S.J. 2010. Gender roles in the African culture: Implications for the spread of HIV/AIDS. Cape Town: Stellenbosch University. (Thesis – Masters).
- Ngumbi, E. 2019. *Becoming drought resilient: Why African farmers must consider drought tolerant crops*, <https://www.ipsnews.net>2019/03> , Date accessed [21 July 2021].
- Ngqakamba, S. 2019. *Northern Cape Needs R688M to Battle Massive Drought*. News24, <https://www.news24.com/news24/SouthAfrica/News/northern-cape-needs-r688m-to-battle-massive-drought-20191208> , Date accessed [05 May 2021].
- Nkosi, S., and Faku, D. 2015. Drought pushes up food prices. <https://www.iol.co.za/business-report/economy/drought-pushes-up-food-prices-1940037> , Date accessed [20 June 2021].
- Nkwanyana, F. 2022. From backyard farming to commercial farming. *Farmers Review South Africa*. <https://farmersreviewafrica.com/from-backyard-farming-to-commercial-farming/> , Date accessed [20 November 2022].
- Nishimwe-Niyimbanira, R., and Meyer, D.F. 2016. The impact of household size on poverty: An analysis of various low-income townships in the Northern Free State region, South Africa. *African population studies*. 30(2): 2283 – 2295, <http://aps.journal.ac.za> , Date accessed [16 May 2021]

- Norman, D. 2017. Empowering smallholder farmers to improve their incomes. Climate Justice. <https://businessfightspovetry.org/empowering-smallholder-farmers-to-improve-their-incomes/> , Date accessed [30 November 2022].
- Nwosu, C.O., and Ndinda, C. 2018. Gender-based household compositional changes and implications for poverty in South Africa. *Journal of International Women's Studies*. 19(5), <https://vc.bridgew.edu/jiws/vol19/iss5/6>, Date accessed [02 March 2021].
- Nyamushamba, G.B., Mapiye, C., Tada, O., Halimani, T.E., and Muchenje., V. 2017. Conservation of indigenous cattle genetics resources in Southern Africa's smallholder areas: turning threats into opportunities – A review. *Asia-Australa Journal of Animal Science*. 30(5): 603 – 621, Doi:10.5719/ajas.16.0024
- Odiwuor, F. 2022. Women smallholder farmers: What is the missing link for the food system in South Africa?. <https://africaupclose.wilsoncenter.org/women-smallholder-farmers/> , Date accessed [30 November 2022]
- Oduro-Ofori, E., Aboagye, A.P., and Acquaye, N.A.E. 2014. Effects of education on the agricultural productivity of farmers in the Offinso municipality. *International Journal of Development Research*. 4(9): 1951 – 1960, ISSN: 2230-9926
- Ogunpaimo, O.R., Oyetunde-Usman, Z., and Surajudeen, J. 2021. Impact of climate change adaptation on household food security in Nigeria: A difference-in-difference approach. *Sustainability*. 13(3): 1444, Doi:10.3390/su13031444.
- Ojo, T. O., and Baiyegunhi, L. J. S. 2019. Determinants of climate change adaptation strategies and its impact on the net farm income of rice farmers in south-west Nigeria. *Land Use Policy*, 103946. Doi:10.1016/j.landusepol.2019.04
- Oluwatayo, I.B.2019. Towards ensuring food security in South Africa: Smallholder farmers as drivers. *AIMS Agriculture and Food*. 4(2): 485 – 500, Doi: 10.3934/agrifood.2019.2.485
- Osarfo, D., Senadzo, B., and Nketiah-Amponsah, E. 2016. The impact of nonfarm activities on rural farm household income and food security in the upper East and upper West regions of Ghana. *Theoretical Economics Letter*. 6(3): 388-400, Doi:10.4236/tel.2016.63043
- Ortiz, I. 2014. Pensions and other social protection benefits for older persons: Insights from the ILO World Social Protection Report 2014/2015. *Social Protection for all Policy Brief*. 3(2014): 1 – 4, <https://www.social-protection.org/gimi/gess/RessourcePDF.action?ressource.ressourceld=48037> , Date accessed [20 March 2020]
- Ortiz-Ospina, E., and Roser, M. 2018. Economic inequality by gender, <https://ourworldindata.org/economic-inequality-by-gender> , Date accessed [29 July 2021]

- Palm, K. 2018. *30 000 Jobs Lost in WC Agriculture Sector due to Drought*, Eye Witness News, <https://ewn.co.za/2018/12/21/drought-costs-30-000-their-jobs-in-agriculture-sector-in-wc> , Date accessed [23 January 2019].
- Pao, H.T., and Tsai, C.M. 2011. Modelling and forecasting the CO2 emissions, energy consumption, and economic growth in Brazil. *Energy*. 36(5): 2450–2458. Doi:10.1016/j.energy.2011.01.032
- Paul, K. N., Hamdiyah, A., and Samuel, A. D. 2014. Food expenditure and household welfare in Ghana. *African Journal of Food Science*. 8(3): 164–175, Doi:10.5897/ajfs2013.1120
- Pattanayak, C. W., Rubin, D. B., and Zell, E. R. 2011. Propensity Score Methods for Creating Covariate Balance in Observational Studies. *Revista Española de Cardiología (English Edition)*. 64(10): 897–903. Doi:10.1016/j.rec.2011.06.008
- Pienaar, P.L.2013. Typology of smallholder farming in South Africa’s former homelands: Towards an appropriate classification system. Cape Town: Stellenbosch University. (Thesis – Masters).
- Pienaar, P.L., and Traub, L.N. 2015. Understanding the Smallholder Farmer in South Africa: Towards a Sustainable Livelihood Classification Agriculture in an Interconnected World. Conference proceedings. 29th International Conference of Agricultural Economists. Milan, Italy: 1 -37
- Phiri. T, 2021, *Hunger worsens in Angola due to drought*, World Food Programmeme, <https://www.wfp.org/news/hunger-worsens-angola-due-drought> , Date accessed [05 October 2021].
- Prates. M, 2021, *Digging to survive – how people are facing drought in Angola*, Unicef, <https://www.unicef.org/angola/en/stories/digging-survive-how-people-are-facing-drought-angola> , Date accessed [05 October 2021].
- Qazi, M. 2017. *India’s Bitter Seeds: The Plight of Small Farmers*, The Diplomat, <https://thediplomat.com/2017/02/indias-bitter-seeds-the-plight-of-small-farmers/#:~:text=Yet%20despite%20their%20contributions%2C%20small,of%20total%20households%20in%20India> , Date accessed [23 January 2019].
- Ramafoko, E.M., Lekunze, J.N, and Luvhengo, U. 2021. Revising the National Framework for the Management of Drought (NFMD) to enhance vegetable farmers’ vulnerability to drought in the Northern Cape Province of South Africa. In: Yildirim, E., and Ekinci, M (Eds). *Vegetable Crops – Health Benefits and Cultivation*, Doi: 10.5772/intechopen.95704.
- Rapsomanikis, G. 2015. Small Farms Big Picture: Smallholder agriculture and structural transformation. *Development*. 58(2-3): 242–255. Doi:10.1057/s41301-016-0028-y.
- Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T., and Woznicki, S. A. 2017. Climate change and livestock: Impacts, adaptation, and mitigation. *Climate Risk Management*16: 145–163. doi:10.1016/j.crm.2017.02.001

Rosopa, P.J., Schaffer, M.M., and Schroeder, A.N. 2013. Managing heteroscedasticity in general linear models. *Journal of Psychological Methods*. 18(3): 335-351, Doi:10.1037/a0032553.

Sajjad, F. 2019. *The Role of Education in Rural Communities*, Rural Development Institute, https://medium.com/@rdi_77976/the-role-of-education-in-rural-communities-b478ed01b9d6 , Date accessed [23 May 2021]

Samuels, I., Ntombela, K., Angula, M., Swarts, M., and Cupido, C. 2016. Climate Change Adaptation Strategies in the Communal Areas of Namibia and South Africa. <https://grassland.org.za/events/annual-congress/gssa-congress-2017/27-july-2017/communal-livestock-farming-systems/048-samuelsi-climatechangeadaptationstrategiesincommunalareasnamibia.pdf> , Date accessed [20 May 2021]

Schanzenbach, D.W., Nunn, R., Bauer, L., and Mumford, M. 2015. Where does all the money go: Shifts in household spending over the past 30 years. https://www.brookings.edu/wp-content/uploads/2016/08/where_does_all_the_money_go.pdf , Date accessed [21 April 2021].

Sejian, V., Gaughan, J.B., Bhatta., and Naqvi, M. 2016. Impact of climate change on livestock productivity. FAO food and nutrition series. <http://www.feedipedia.org/content/impact-climate-change-livestock-productivity> , Date accessed [20 October 2021].

Seleiman, M. F., Al-Suhaibani, N., Ali, N., Akmal, M., Alotaibi, M., Refay, Y., and Battaglia, M. L. 2021. Drought Stress Impacts on Plants and Different Approaches to Alleviate Its Adverse Effects. *Plants*. 10(2): 259. Doi:10.3390/plants10020259.

Schatz, E., Gómez-Olivé, X., Ralston, M., Menken, J., and Tollman, S. 2012. The impact of pensions on health and wellbeing in rural South Africa: Does gender matter? *Social Science and Medicine*. 75(10): 1864–1873. Doi:10.1016/j.socscimed.2012.07.004

Shah, M and Steinberg, B.M. 2015. *Drought of opportunities: Contemporaneous and Long-Term Impacts of Rainfall Shocks on Human Capital*. IZA Discussion Paper No.9440. <https://ftp.iza.org/dp9440.pdf> , Date accessed [04 November 2019]

Sheikh, D and Valdivia, C. 2009. Climate Variability, Location and Diversification: Livestock Assets in Consumption Smoothing in Shock and Non-shock Seasons in two Regions of Kenya. International conference. Institute of Development Studies. 2009.UK

Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B. M., and Menkir, A. 2014. Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. In: *Weather and Climate Extremes*, 3: 67 – 79. Elsevier BV, <https://doi.org/10.1016/j.wace.2014.04.004> , Date accessed [19 May 2019]

Schreiner, B.G., Mungatana, E.D, and Baleta, H. 2018. Impacts of drought induced water shortages in South Africa: Economic analysis. Report to the Water Research Commission. Pegasys Institute. ISBN978-0-6398-0055-2

- Shah, M, and Steinberg, B.M. 2015. *Drought of opportunities: Contemporaneous and Long-Term Impacts of Rainfall Shocks on Human Capital*. IZA Discussion Paper No.9440. <https://ftp.iza.org/dp9440.pdf> , Date accessed [04 November 2019]
- Sifolo, P. 2015. A tourism theoretical gap: the case of the Northern Cape Province in South Africa. *Journal of Hospitality, Tourism and Leisure*. 4(1): 1 – 12. ISSN:2223-814X
- Sihlobo.W, 2015. The youth are agriculture's future. GrainSA, <https://mg.co.za/article/2015-06-18-the-youth-are-agricultures-future/> , Date accessed [5 September 2020]
- Sikhakhane, J. 2017. *Why Social Grants Matter in South Africa: They Support 33% of the Nation*. The Conversation, <https://www.sowetanlive.co.za/news/2017-02-17-why-social-grants-matter-in-south-africa-they-support-33-of-the-nation/> , Date accessed [22 May 2022]
- Singh, J. 2014. Role of women in the agricultural sector. *The Indian Journal of Political Science*. 75(2): 411 – 420. <http://www.jstor.org/stable/24701148>, Date accessed [14 May 2021].
- Skoufias, E., Vinha, K, and Conroy, H.V. 2011. The Impact of Climate Variability on Welfare in Rural Mexico, *Journal of Population and Environments*, 34(3): 370 – 399, <http://www.jstor.org/stable/42636676>, Date accessed [11 November 2019].
- Sithole, B.E. 2014. *Municipal disaster management in South Africa: Intergovernmental relations as a planning instrument*. Central University of Technology: Free State. (Thesis – PhD).
- Smith, C. 2019. The growing fight in South Africa over land and identity. ABC News. <https://abcnews.go.com/International/growing-fight-south-africa-land-identity/story?id=62280577> , Date accessed [20 May 2022]
- Smit, B. and Pilifosova, O. (2001) Adaptation to Climate Change in the Context of Sustainable Development and Equity. In: Working Group II: Impacts, Adaptation and Vulnerability, IPCC Assessment Report, IPCC.
- Sozibilir, F. 2018. The Interaction Between Social Capital, Creativity and Efficiency in Organizations. *Journal of Thinking, Skills, and Creativity*. 27(2018): 92 – 100, <https://doi.org/10.1016/j.tsc.2017.12.006>, Date accessed [4 August 2019]
- Statistics South Africa Community Survey. 2016. *Municipal Demarcation Board*. www.cs2016.statssa.gov.za , Date accessed [03 May 2019].
- Statistics South Africa (StatsSA). 2017. Poverty on the rise in South Africa, <https://www.statssa.gov.za/?p=10334> , Date accessed [29 April 2020].
- Sumaryanto, Susilowati, S.H., Saptana, S., Ashri, Suryani, E., and Suryadi, M. 2021. The effects of rural development on main source of farm household. *IOP Conference Series Earth and Environmental Science*. 892(1): 012089, Doi:10.1088/1755-1315/892/1/012089

- Tadele, E. 2021. Land and heterogenous constraints Nexus income diversification strategies in Ethiopia: Systematic Review. *Agriculture and Food Security*. 37(2021): Doi:10.1186/s40066-021-00338-1
- Tandwa, L. 2018. *Drought Crisis: 3 Provinces Declared National Disasters*. News24, www.news24.com/SouthAfrica/News/drought-crisis-3-provinces-declared-national-disaster , Date accessed [6 August 2019].
- Tang, S., Guan, Z., and Jin, S. 2010. Formal and Informal Credit Markets and Rural Credit Demand in China. Selected Paper Prepared for Presentation at the Agricultural and Applied Economics Association 2010 AAEA, CAES, and WAEA Joint Annual Meeting, Denver, Colorado, July 25 – 27: 1 – 26
- Twongyirwe, R., Mfitumukiza, D., Barasa, B., Naggayi, B. R., Odongo, H., Nyakato, V., and Mutoni, G. 2019. Perceived effects of drought on household food security in South-western Uganda: Coping responses and determinants. *Weather and Climate Extremes*. 24(100201): 1 – 11, Doi:10.1016/j.wace.2019.100201
- Umdale, P., Ichikawa, Y., Manandhar, H., Ishidaira, H., and Kiem, A.S. 2014. Farmers' Perception of Drought Impacts, Local Adaptation and Administrative Migration Measures in Maharashtra state, India. *International Journal of Disaster Risk Reduction*, 10 (2014): 250 – 269, DOI: 10.1016/j.ijdrr.2014.09.011
- Van der Rheede, C. 2016. *Thousands benefit from Drought Relief Fund*, Grain SA, <https://www.grainsa.co.za/thousands-benefit-from-drought-relief-fund> , Date accessed [15 October 2021].
- Van de Ven, P. 2018. Measuring economic welfare: A practical agenda for the present and future, <https://www.imf.org/-/media/Files/Conferences/2018/6th-stats-forum/session-2-peter-van-de-ven-imf-statistical-forum-measuring-economic-welfare-paper.ashx>, Date accessed [22 March 2021]
- Van de Walle, D. 2017. Divorce, widowhood and women's welfare in Africa. Development Research Group. World Bank. <https://thedocs.worldbank.org/en/doc/190371512510360386-0050022017/original/MSWelfareinAfrica.pdf> , Date accessed [23 October 2021].
- Van Niekerk, D. 2014. A Critical Analysis of the South African Disaster Management Act and Policy Framework, *Journal of Disasters*, 38(4): 858 – 877, <https://doi.org/10.1111/disa.12081> , Date accessed [25 November 2018].
- VanWey, L and Vithayathi, T. 2013. Off-farm work among rural households: A case study in the Brazilian amazon. *Rural Sociology*. 78(1): 29 – 50. Doi:10.1111/j.1549-0831.2012
- Vatcheva, P.K., and Lee, M. 2016. Multicollinearity in Regression Analyses Conducted in Epidemiologic Studies. *Epidemiology: Open Access*. 06(02): 1 – 20, Doi:10.4172/2161-1165.1000227

- Verhofstadt, E., and Maertens, M. 2014. Can agricultural cooperatives reduce poverty? Heterogeneous impact of cooperative membership on farmers' welfare in Rwanda. *Applied Economic Perspectives and Policy*. 37(1): 86–106, Doi:10.1093/aep/ppu021
- Visser, M., and Ferrer, S. 2015. Farm workers' living and working conditions in South Africa: Key trends, emergent issues, and underlying and structural problems. Research Report. https://www.ilo.org/wcmsp5/groups/public/---africa/documents/publication/wcms_385959.pdf , Date accessed [25 September 2021].
- Vogel, C., Koch, I, and Van Zyl, K, 2010, A Persistent Truth"—Reflections on Drought Risk Management in Southern Africa. *Journal of Weather, Climate, and Society*, 2(1): 9 - 22, <https://www.jstor.org/stable/24907334> , Date accessed [15 October 2021]
- Volosi, B., Higashi, G.E., and Bordin, I., and Telles, T.S. 2022. The diversification of species in crop rotation increases the profitability of grain production systems. *Scientific Reports*. 12(19849): Doi:10.1038/s41598-022-23718-4.
- Vynck, M. 2017. Heteroscedasticity in linear models: an empirical comparison of estimation methods. Belgium: Ghent University. (Thesis – Masters).
- Waaswa, A., Nkurumwa, A.O., Kibe, A.M., and Ng'eu, J.K. 2021. Understanding the socioeconomic determinants of adoption of climate smart agricultural practices among smallholder potato farmers in Gilgil Sub-Country, Kenya. *Sustainability*. 41(2021), Doi:10.1007/s43621-021-00050-x
- Wan, J., Li, R., Wang, W., Liu, Z., and Chen, B. 2016. Income Diversification: A Strategy for Rural Region Risk Management. *Sustainability*, 8(10): 1064. Doi:10.3390/su8101064
- Wang, T., Jin, H., Fan, Y., Obembe, O., and Li, D. 2021. Farmer's adoption and perceived benefits of diversified crop rotations in the margins of U.S corn belt. *Journal of Environmental Management*, 293(112903): 1 - 13, www.elsevier.com/locate/jenvman , Date accessed [16 October 2021].
- Wanka, F.A. 2014. The impact of educational attainment on household poverty in South Africa: A case study of Limpopo Province. Cape Town: University of the Western Cape. (Thesis – Masters).
- Wanka, F. A., and Rena, R. 2019. The impact of educational attainment on household poverty in South Africa: A case study of Limpopo province. *African Journal of Science, Technology, Innovation and Development*. 1–13, Doi:10.1080/20421338.2018.155736
- West, L.2018. *The Effects of Drought*. www.liveabout.com/effects-of-drought-1203684 , Date accessed [07 August 2019].
- Wattel, C., van Asseldonk, M., van Wesenbeeck, L., Oostendorp, R., Recha, J., Radeny, M., Gathiaka, J., Mulwa, R. 2018. Financial landscape mapping for climate-smart agriculture in the Nyando Basin, Western Kenya. CCAFS Info Note. Wageningen, The Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

- Weindl, I., Lotze-Campen, H., Popp, A., Müller, C., Havlík, P., Herrero, M., and Rolinski, S. 2015. Livestock in a changing climate: production system transitions as an adaptation strategy for agriculture. *Environmental Research Letters*. 10(9): 1 – 13, Doi:10.1088/1748-9326/10/9/094021
- Wilcox, W.B. 2015. *How Strong Families Can Help Create Prosperous States*, Institute for Family Studies, <https://ifstudies.org/blog/how-strong-families-help-create-prosperous-states> , Date accessed [27 May 2021].
- World-Wide Fund for Nature, 2018, *Water doesn't come from a tap*, www.wwf.org.za , Date accessed [16 March 2019].
- Wu, S. 2020. Multicollinearity in regression, <https://towardsdatascience.com/multi-collinearity-in-regression-fe7a2c1467ea> , Date accessed [25 September 2021]
- Yila, O.J., and Resurreccion, B. P. 2013. Determinants of smallholder farmers' adaptation strategies to climate change in the semi-arid Nguru Local Government Area, Northeastern Nigeria. *Management of Environmental Quality: An International Journal*. 24(3): 341–364. doi:10.1108/14777831311322659
- Yung, L, and Phear, N. 2015. Drought Adaptation and Climate Change Beliefs among Working Ranchers in Montana. *Journal of Weather, Climate and Society*. 7(4): 281 – 293, <https://doi.org/10.1175/WCA5-D-14-0039.1> , Date accessed [10 August 2019]
- Yusuf, O.j., and Adisa, B.O. 2012. Gender Analysis of Livelihood Strategies of Household Heads in Rural Areas of Uson State, Nigeria. *Nigerian Journal of Rural Sociolog.*, 13(1): 58 – 67, DOI: 10.22004/ag.econ.287439
- Zakari, S., Ibro, G., Moussa, B., and Abdoulaye, T. 2021. Adaptation strategies to climate change and impacts on income and food security: Evidence from Sahelian Region of Niger. *Sustainability*.14(5): 2847, Doi:10.3390/su14052847
- Zhang, Z., Uddin, M.J., Cheng, J., and Huang, T. 2018. Instrumental variable analysis in the presence of unmeasured confounding. *Annals of Translational Medicine*. 6(10): 182. 10.21037/atm.2018.03.37
- Zhao, M., Huang, S., Huang, Q., Wang, H., Leng, G., and Xie, Y.2019. Assessing socio-economic drought evolution characteristics and their possible meteorological driving force. *Journal of Geomatics, Natural Hazards, and Risk*, 10(1): 1084 – 1101, <https://doi.org/10.1080/19475705.2018.1564706> , Date accessed [14 May 2020]
- Zho, D and Li, L. 2022. Farming experience, personal characteristics, and entrepreneurial decisions of urban residents: Empirical evidence from China. *Frontiers Psychology*. 13. Doi:10.3389/fpsyg.2022.859936

APPENDIX 1

Variance inflation factor - MNL

In this study, the multicollinearity among independent variables was tested using the VIF technique. If VIF is higher than 5, multicollinearity among explanatory variables can be reported. It is preferable if the value is as low as possible. VIF scores between 1 and 5 show that the association is not serious enough to call for corrective action. VIF that is greater than 5 shows multicollinearity at critical levels, in which the coefficient estimates cannot be trusted, and statistical significance is debatable (Analytics Vidhya, 2021). Table 4.7 shows that VIF for all independent variables were less than 5. This indicates that the explanatory variables were not multicollinear.

Table 4. 7: Results of variance inflation factor to test for multicollinearity (N= 360).

Variable	Codes	VIF	1/VIF
Employed	(EMPLD)	3.25	0.307372
Income	(INC)	2.74	0.365030
Age	(AGE)	2.28	0.438256
Marital status: Single	(MRTSSIN)	2.03	0.492511
Self-employed	(SELFEMPLOYED)	2.00	0.499923
Marital status: Widow/widower	(MRTSWID)	1.79	0.557968
Unemployed	(UNEMPLOYED)	1.57	0.637839
Farming experience	(FARMEXP)	1.52	0.659718
Access to extension services	(EXTNS)	1.49	0.670204
Gender	(GENDER)	1.49	0.671670
Household size	(HHS)	1.33	0.749896
Education: Primary	(EDUPRI)	1.25	0.797499
Marital status: Cohabitation	(MRTSCOHAB)	1.23	0.814797
Education: ABET	(EDUABET)	1.20	0.835709
Access to drought information	(DRTINFO)	1.19	0.841840
Marital status: Divorced	(MRTSDIV)	1.16	0.862441
Education: No education	(EDUNO)	1.07	0.936076
Mean VIF		1.68	

Source: Author's computation (2021).

Heteroscedasticity test - MNL

When the p-value is less than 5%, the null hypothesis can be rejected, and heteroskedasticity can be inferred (Zach, 2020). The null hypothesis could not be rejected in this study since the p value was greater than 5%, indicating that there was no evidence of heteroskedasticity in the data. Table 4.8 shows how heteroscedasticity was assessed.

Table 4. 8: Table showing the heteroskedasticity test.

Ho: Constant variance	
Variables: Fitted values of Drought adaptation strategies	
Chi2(1)	3.32
Prob> chi2	0.0685

Source: Author's computation (2021).

The Heteroskedasticity test in Table 4.8 showed that p value is greater than 5%. Therefore, there was no evidence of heteroskedasticity.

Multicollinearity test – 2SLS

A two-stage least squares collinearity test must be performed before the two-stage least squares. To rule out the possibility of multicollinearity, VIF were determined. To prevent biased and inaccurate results, multicollinearity was essential since it made sure that no two independent variables had the same information. The VIF values were investigated using the collinearity statistics. The Table 4.9 shows these values.

Table 4. 9: Table showing VIF values of collinearity statistics.

Variables	Codes	VIF	1/VIF
Farm type	(FARMTYP)	6.98	0.143207
Farming experience	(FARMEXP)	3.40	0.294221
Age	(AGE)	2.26	0.443450
Income	(INC)	2.23	0.448408
Marital status: Widow	(MRTSWUD)	2.14	0.466435
Marital status: Married	(MRTSMARR)	2.11	0.474001
Education: Primary	(EDUPRI)	1.67	0.598817
Grant	(GRANT)	1.65	0.605600
Livestock diversification	(LIVSTCKDIVERS)	1.64	0.609095
Gender	(GENDER)	1.50	0.665754
Education: Secondary	(EDUSEC)	1.48	0.674141
Education: ABET	(EDUABET)	1.38	0.727240
Marital status: Cohabitation	(MRTSCOHAB)	1.30	0.772105
Marital status: Divorced	(MRTSDIV)	1.23	0.816211
Crop diversification	(CROPDIVERS)	1.22	0.820930
Rainwater harvesting	(RWHARVESTING)	1.17	0.853640
Savings	(SAVINGS)	1.15	0.866631
Drought tolerant crops	(DTCROPS)	1.12	0.894026
Crop rotation	(CROTATION)	1.12	0.895821
Loan	(LOAN)	1.10	0.906709
Mean VIF		2.14	

Source: Author's computation (2022).

All the VIF values for the independent variables were lower than 10, and the mean VIF value is lower than 5 as shown in Table 4.9. This indicated that multicollinearity was not a substantial presence in the equation system.

Heteroscedasticity test – 2SLS

Table 4. 10: The white test for heteroskedasticity.

White's tests for Ho: homoskedasticity against Ha: unrestricted heteroskedasticity			
Chi2 (213) = 243.82 Prob > chi2 = 0.0723			
Cameron & Trivedi's decomposition of IM test			
Source	chi2	df	p
Heteroskedasticity	243.82	213	0.0723
Skewness	63.21	22	0.0000
Kurtosis	10.26	1	0.0014
Total	317.29	236	0.0003

Source: Author's computation (2022).

To determine whether the data were heteroscedastic, the White test was applied based on the information presented in Table 4.10. The White test is a versatile functional form that may be used to identify practically any type of heteroskedasticity pattern. It provides for a nonlinear and interactive effect of the independent variable on the error variance (Pedace, 2016). Since the P value was greater than 0.05, it may be said that heteroskedasticity was not present. Given that the residuals were homoscedastic, the null hypothesis could not be disproved. According to the results of the White test, Table 4.10 shows a chi square of 243.82 with a p value of 0.0723.

APPENDIX 2

Rural households' adaptation to drought and welfare impacts in John Taolo Gaetsewe district, Northern Cape Province

My name is Palesa Applegreen, I am a master's student in Agricultural Economics from the North-West University, Mahikeng campus. I am conducting a survey on Rural Households' Adaptation to Drought and Welfare Impacts in John Taolo Gaetsewe district, Northern Cape Province and your assistance would be much appreciated. Your participation in this investigation is completely voluntary. Should you decide to participate, I will go through the questionnaire with you, and this will take approximately 15 minutes to complete.

You may end your participation at any point should you wish to not continue with the interview.

All the information provided will be kept confidential and will not be shared with anyone.

The information obtained will assist in understanding how drought affects the agricultural production, income distribution, expenditure consumption, education, health status, food security and employment status of rural households in the Northern Cape Province. It will also assist in the development of adaptation strategies to help rural households of the John Taolo Gaetsewe district to better deal with the drought and build adaptive capacity.

Are you interested in participating in the questionnaire?

Yes

No

If yes, I will proceed with the questionnaire.

Household number: _____

Province: Northern Cape Province

District: John Taolo Gaetsewe district

Local Municipality: _____

Village Name: _____

Date: _____

SECTION A

1. Household characteristics

1.1 Gender of household head?

Male		Female	
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1.2 What is the household size? _____

1.3 Marital status of household head:

Single		Married		Divorced		Widow/Widower	
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1.4 Age of household head: _____ years

1.5 Farming Experience (if any) _____ years

2.1 Furthest level of education of household head

No education	
ABET (Level 1 – 4)	
Primary (Grade 0 to Grade 7)	
Secondary (Grade 8 to Grade 12)	
Tertiary (TVET college/ university)	

2.2 Are there any children that go to school or creche in the household?

Yes		No	
-----	--	----	--

2.3 If yes:

How many go to creche? _____

How many go to school? _____

2.4 Did any children drop out of school since the drought started?

Yes		No	
-----	--	----	--

2.5 What is the reason for dropping out of school?

Child not performing well due to health reasons	
No money to take children to school (due to decreased income)	
No money to take children to school (loss of job)	
Children needed to go look for a job to help in the house	
Child not performing well due to hunger	
Crime	
Other	

2.6 If other, please state

3.1 Is the household head employed?

Yes		No	
-----	--	----	--

3.2 If yes, is the jobs seasonal, permanent, part-time?

Seasonal		Part-time		Full-time	
----------	--	-----------	--	-----------	--

3.3 Are there any other people employed in the household?

Yes		No	
-----	--	----	--

3.4 If yes, how many people are employed? _____

3.5 Are the jobs seasonal, permanent, part-time?

Seasonal		Part-time		Full-time	
----------	--	-----------	--	-----------	--

3.6 Are there any children under 18 years that work? (On-farm/off-farm)

Yes		No	
-----	--	----	--

3.7 If no one in the household is employed, please give a reason for unemployment

4.1 Are you suffering from any chronic disease?

Yes		No	
-----	--	----	--

4.2 Has the drought affected collection of chronic medication at the clinic/ doctor?

Yes		No	
-----	--	----	--

SECTION B

1. Income

1.1 What is the estimated monthly income of the household head? _____ Rands

1.2 What is the main source of income of the household head?

Crop farming		Livestock farming		Off-farm employment		Grant	
Self-Employment		Other					

1.3 Does the household head have any other source of income?

Yes		No	
-----	--	----	--

1.4 If yes, what is the source of income?

Crop farming		Livestock farming		Off-farm employment		Grant	
Self-Employment		Other					

1.5 How did drought have an impact on your main source of income?

No Impact		Slight		Moderate		Severe	
-----------	--	--------	--	----------	--	--------	--

1.6 Did you experience any income reductions due to drought?

Yes		No	
-----	--	----	--

1.7 If yes, how did the household cope with the reductions in the main source of income?

Rely on second source of income		Find new employment		Reduced non-food expenses		Reduced food expenses	
Other							

1.8 Any loans taken?

Yes		No	
-----	--	----	--

If yes, what is your reason for taking loan?

1.9 Source of loan

Relative/Friends		Bank		Loan Shark		Other	

1.10 Households' financial situation (Before drought)

Save lots of money		Save little money		Unable to save money	
--------------------	--	-------------------	--	----------------------	--

1.11 Households' financial situation (After drought)

Save lots of money		Save little money		Unable to save money	
--------------------	--	-------------------	--	----------------------	--

1.12 If Unable to save, state why you can't save any money?

1.13 How many people in the household receive grants?

1.14 What type of grant is received?

Disability grant		Child grant		Old age pension	
Foster child grant		Care dependency grant		Other	

1.15 How much are the grants?

Type of Grant	(R)	Type of Grant	(R)
Disability grant	1980	Old age pension	R1980 (Below 75 years) R2010 (Above 75 years)
Foster child grant	1070	Care dependency grant	1860
Child grant	720	War veteran grant	2000

1.16 Total number of grant money received:

1.17 Are there any changes in income or employment status in the household due to drought?

Yes		No	
-----	--	----	--

1.18 If yes, how has the changes in income or unemployment affected the household?

2.1 Household expenditures per month

Expenditure	Monthly money spent (R)
-------------	---------------------------

Food	
e.g Groceries, Fruit, Meat	
Personal	
e.g Transport, Cell phone data/airtime, Alcohol, Tobacco, Insurance, Policies	
Utilities	
e.g Water, Electricity, Petrol	
Clothing	
e.g Purchase of new clothes, paying clothing credit debt	
Health	
e.g Transportation, Medicine	
Education	
e.g Tuition fees, Books, Allowance	
Housing	
e.g Rent, Bond	
Furniture	
e.g Appliances, Household items	
Crop production	
e.g Seeds, Fertilizer, Packaging	
Livestock production	
e.g Feed, Medication, Herdsmen	
Total	

2.2 Tick crops produced in the household and state if you sell, use it for household consumption or both

Crop type	Yes, I grow	Sell	Consume
Onions			
Tomatoes			
Potatoes			
Spinach			
Green Pepper			
Pumpkin			
Cabbage			
Citrus (Oranges, Lemons, Nartjie etc)			
Apples			
Nectarines (Peaches, Apricots etc)			
Other			

2.3 Have you experienced any reduction in crop quality or yield?

Yes		No	
-----	--	----	--

--	--	--	--

2.4 If yes, what is the reason?

Inadequate water supply (Leading to death of crops)	
Pests and disease infestation (Leading to death of crops)	
Poor water quality (Leading to death of crops)	
Reduction in soil fertility (Leading to poor quality crops)	
Other (Please specify)	

2.5 Tick livestock/animal reared in the household and state if you sell, use for household consumption or both

Livestock type	Yes, I raise	Sell	Consume
Chicken			
Cows			
Sheep			
Goats			
Pigs			
Duck			
Turkey			
Donkey			
Horses			
Other			

2.6 Have you experienced any reduction in livestock units?

Yes		No	
-----	--	----	--

2.7 If yes, what is the reason?

Inadequate water supply (Therefore had to sell animals)	
Pests and disease infestation (Therefore had to sell animals)	
Poor water quality (Therefore had to sell animals)	
Heat Stress (Leading to death)	
Other (Please specify)	

3.1 How many meals do you have per day? _____

3.2 Did the number of meals consumed per day:

Increase		Stay the same		Decrease	
----------	--	---------------	--	----------	--

3.3 If the number of meals per day decreased, what is the reason for the decrease in the number of meals eaten per day?

3.4 Do you receive any food aid? (At school or at home)

Yes		No	
-----	--	----	--

SECTION C

1. Infrastructure

1.1 Are there any tarred roads?

Yes		No	
-----	--	----	--

1.2 If no, how far is the nearest tar road? (In Km)

2.1 Do you have electricity?

Yes		No	
-----	--	----	--

2.2 Do you have access to water?

Yes		No	
-----	--	----	--

2.3 Which water sources are available?

Bore hole/ Hand pipe		Public tap		Tap in the yard	
River		Other			

If Other, please specify:

2.4 Where there any changes in drinking water source during drought?

Yes		No	
-----	--	----	--

2.5 If yes, what were the changes?

3.1 What type of shelter do you live in?

Shack		Brick house	
RDP house		Other	

3.2 Is the shelter rented or owned by you?

Live at home		Live with extended family members	
Rented		Live with friends	
Owned by me		Other	

SECTION D

1. Access to information

1.1 Do you have access to any information regarding drought and adaptation strategies?

Yes		No	
-----	--	----	--

1.2 Does the government assist with any type of drought relief?

Yes		No	
-----	--	----	--

2.1 Do you have access to any extension services?

Yes		No	
-----	--	----	--

2.2 If yes, how often do you get visits from extension officers?

Daily		Weekly		Monthly	
-------	--	--------	--	---------	--

3.1 Do you rely on any family members and formal or informal community organizations for agricultural production, housework, or childcare?

Yes		No	
-----	--	----	--

3.2 Are you a part of any social networks (a member of any formal or informal group)?

Yes		No	
-----	--	----	--

SECTION E

1. Drought information

1.1 Which year did you experience the most severe drought? _____

1.2 Have you observed an increase in temperature?

Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
-----	--------------------------	----	--------------------------

1.3 Have you observed a decrease in rainfall?

Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
-----	--------------------------	----	--------------------------

1.4 Do you have access to land for farming purposes?

Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
-----	--------------------------	----	--------------------------

SECTION F

1. Adaptation information

1.1 On the table below, tick which coping strategy you apply to try to combat the effects of drought

Coping Strategy	Yes
Rely on less expensive food	
Rely on help from family members	
Reduce number of meals eaten per day	
Reduce portion sizes of meals	
Restricted consumption for adults so that the young can eat	
Sold more animals than usual	
Sold household assets (e.g furniture, household appliances, jewellery etc.)	
Sold productive assets (e.g Car, sewing machine, tractor, wheelbarrow etc.)	
Food purchased on credit	
Reduced expenses on health and education	
Spent savings	
Withdrew children from school	
Sold house or land	
Borrowed money from people or made bank loan	
Receive or depend on remittances	
Drought Adaptation Strategies	
Crop diversification (planting different crops)	
Livestock diversification (rearing different animals e.g goats and cows)	
Drought tolerant crops	
Zero tillage	
Crop rotation	
Mulching	
Delaying plantation date	
Dry planting	
Adopting agricultural tools	
Rainwater harvesting and storage	
Livestock reduction rate	
Migration	

THE END, THANK YOU!