THE EFFECT OF CLIMATE CHANGE ON THE FARMING BUSINESS IN NWANEDI IRRIGATION SCHEME IN MUSINA LOCAL MUNICIPALITY, LIMPOPO PROVINCE

by

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DEDICATION

This dissertation is dedicated to my all of family, for supporting me throughout the studies and to my mother – who is very courageous when it comes to education. Also to my four brothers, namely: Joseph, Freddy, Aaron and Enos. I would not forget Lerato – the love of my life and our two children: Oritonda and Mukona-Zwothe. To them I say: through hard work and determination, you can conquer any obstacle that seems impossible to annihilate. Remember to take education earnestly.

DECLARATION

I declare that the mini-dissertation hereby submitted in partial fulfilment for the degree of Master of Business Administration has not been submitted hitherto by me at any other academic institution for a degree; that it is the craft of my own hands and all sources used have been indubitably and accurately acknowledged.

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FULUFHELO MARUBINI **DATE**

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ABSTRACT

Nwanedi Irrigation Scheme (NIS) is situated at the far north of Limpopo. It is comprised of both livestock and crop farmers. Currently, the total number of farmers in the scheme is 160. Noteworthy is that the majority of farmers grow and harvest crops. The dominant crop produced in the area is jam tomato with a few of people who cultivate table tomato and other vegetables such as cabbage and eggplant (Mashala, 2013). The irrigation scheme covered an area of about 2000 hectares land, which belongs to the state and part of it belongs to the Communal Property Association (CPA). Moreover, agriculture is considered as one of the most sensitive to weather and climate variables, which include temperature, precipitation, light and weather extremes such as droughts, floods and severe storms. The aim of the study was to evaluate the impact brought about by climate change on farming business. Moreover, to evaluate the problems that were associated with climate change that affected farming, crop production and eventually the profit generation at NIS. Considering greenhouse gas emissions, it is believed that they are one of the causes of the change in global climate. Again, most food production means rely on inputs to some or all tillage, seeds, fertilisers, irrigation, feed for animals, pest and disease control. Henceforth, the study has collected primary data. The study employed both qualitative and quantitative paradigms. The 160 crop farmers, as a sample size of 32 (20% of the population) respondents, were randomly selected and interviewed. The study found out that drought was real and had been experienced in NIS. Meanwhile, in crop farming, water is more important just as a growth media such as fertilised soil. Without water, no farming activity could take place. The drought experienced had led farmers not to plant anything on their farms, which meant that no income was generated in the entire drought period. Furthermore, most of the farmers in the area had no alternative means of acquiring water to irrigate their crops. Few farmers who managed to plant had used a very small scale than usual because there was not enough water. Drought affected job loss in the farming business where many employees had to be ceased from coming to work. The study also found that NIS had experienced high temperature, which were never experienced before. Musina is best known for its excessive heat, but the recent heat wave that has been experienced in the area of the study was extreme to a point that crop farming was very difficult because the little moisture in the soil had quickly depleted. Crops could no longer absorb it as it dried up rapidly. Usually, when it is extremely hot, the condition favours pests and diseases. Later, it was found that a new pest referred to as Eelworm (Tuta Tundra), which was not found in the area before had been

discovered. Consequently, the introduction of the new pests in the area was a challenge because farmers did not know which insecticides to apply in order to control the manifestation and prevent the damage it caused on the crops, tomato in particular. Eelworm has affected the tomato crop as it damaged the leaves of their plants. That had negatively affected the fruit production. Most farmers who have experienced Eelworm in their tomato fields, had their fruits severely attacked to be unusable.

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Table of contents **Page**

Chapter 1

Chapter 2

List of figures **Page**

List of tables **Page**

List of abbreviations

SA	South Africa
CPA	Communal Property Association
NIS	Nwanedi Irrigation Scheme
CO2	Carbon Dioxide
SST	Sea Surface Temperature
EMS	Emergency Medical Services
SAWS	South African Weather Services
NGOs	Non-Governmental Organizations
CEC	Cation Exchange Capacity
SOC	Soil Organic Carbon
GHG	Greenhouse Gas
N2O	Nitrous Oxide
GDP	Gross Domestic Product
VDM	Vhembe District Municipality
HIV	Human Immunodeficiency Virus
AIDS	Acquired Immune Deficiency Syndrome
TTH	Temperature-Heat Index
SPSS	Statistical Package for the Social Science

CHAPTER ONE: INTRODUCTION, STATEMENT OF THE PROBLEM, PURPOSE OF THE STUDY AND CLARIFICATION OF CONCEPTS

1.1. INTRODUCTION

Limpopo is the breadbasket and agricultural engine of South Africa and produces about 60% of all fruit, vegetables, maize, wheat, and cotton (Development, 2016). The province is also known to rear different types of livestock. It contributes about 65% of the papayas produced in the country, 36% of tea, 25% of its citrus fruit, bananas, and litchis, 60% of its avocados, 60% of its tomatoes (40% by one company alone), and 35% of its oranges. The agricultural sector contributed about 2.2% to the province's annual average Gross Domestic Product (GDP) in 2014 (Statistics South Africa, 2015). Therefore, agriculture is imperative in Limpopo province as it is a source of food security, a contributor to exports, and it further contributes to the state's economy through income and employment (Development, 2016).

In the Sub-Saharan Africa agriculture contributes about 17% of GDP whilst in other countries, it can subsidise up to 50% (Schlenker and Lobell, 2010). The climate change over the next few years is expected to reduce yield in some countries. That could be as much as 50% inhibition by 2020. In that case, there is a need to understand some of the possible responses of Sub-Saharan Africa (SSA) crops to the phenomenon. Hence, African agriculture is likely to suffer from unmerciful climate impacts but various outcomes might differ in places or crops. It is expected that the yields could be reduced by a minimum of 5% to a maximum of 50% (Schlenker and Lobell, 2010).

On the other hand, Sub-Saharan Africa is the most vulnerable region to the aftermaths of global climate change as it relies profoundly on agriculture (Kotir, 2011). Agriculture is greatly sensitive to weather and climate variables such as temperature, precipitation and light and low capacity for adaptation. Nonetheless, the forthcoming length of growing seasons and potential of the yield are viewed to decrease. The fallouts will affect food security by inhibiting food availability, food accessibility, food utilisation and food stability, hence; increase the risk of famine in the region (Kotir, 2011).

In a study conducted in Ghana, it has been found that climate change is anticipated to have serious environmental, economic and social inimical consequences more especially, on rural farmers who solely depend on rainfall (Fosu-Mensa *et al.*, 2012). Noticeably, climate change could adversely

sway agricultural production, as it remains the main source of income for most rural communities. According to a study that was conducted in Europe, the influence of climate change was observed through increases in temperature and different patterns of precipitation (Olesen *et al*., 2011).

In addition, there is evidence of climate shifts in Africa, shown by changing rainfall patterns, temperatures and increased fire incidences (Zengeni *et al*., 2016). There are concerns globally regarding changes in the climate that are threatening to change the livelihoods of the vulnerable population. The climate of the earth has warmed at an average of about 0.7% over the past 100 years with decades of the 1990s and 2000s (Watson, 2010). The agricultural sector in South Africa contributes 3.4 % of the GDP and it employs 30% of the labour force. Meanwhile, the primary agriculture contributes about 3% to the GDP of South (Chamuka, 2011). Thus, climate change reduced the contribution of agriculture to the GDP from 9.1% in 1965 to 4.0% in 1998 (Madzwamuse, 2010).

Numerous studies and scientific reports on the historical evolution of global temperatures has found that climatic change is inclined towards warming (Hope, 2011). Remarkably, global warming is a major threat to sustainable development and growth in all regions around the world (Hope, 2011). The greenhouse gas emissions significantly cause change in global climate and, as such, it is viewed to change in future (Allen *et al*., 2010). Chiefly, increases in the severity of drought and heat stress are associated with climate change and that could bring change in the composition, structure and biogeography of forests in many regions. Drought is a considered to be a huge limiting factor in maize production, more especially on the rain-fed agriculture of Sub-Saharan Africa (Lunduka *et al*., 2017). For farmers to continue producing food, the adaptation measures to climate change need to be conformed (Fosu-Mensah *et al*., 2012).

1.2. BACKGROUND OF NWANEDI IRRIGATION SCHEME

Nwanedi Irrigation Scheme is located at the north of the Soutpansberg mountains, which is about 40 kilometres (km) northeast of Tshipise in the Vhembe District of Limpopo Province (Nell, 2013). The scheme falls under business farmers as one of the forms of irrigation systems. NIS has about 160 farmers. It has occupied an area of about 2000 hectares piece of land, which belongs to state, and part of it belongs to Communal Property Association (CPA). The farming business in this area entails both livestock and crop production. However, the prevailing farming activity

appears to be crops. Jam tomato is currently the main production, with few people planting table tomato and other vegetable such as cabbage, eggplant (Mashala, 2013).

Furthermore, farmers in possession of livestock rear either cattle and goats or both, in some instances. NIS is located near Nwanedi River – the mainstream source of water for the farming activities. The nearest town is about 130km away, where they market their products at organisations such as NAMPAK and Tiger Brands.

Limpopo has plentiful agricultural resources and is one of the country's prime agricultural regions, noted for the production of livestock, fruits and vegetables, cereals and tea. Agriculture is a critical economic sector in the province in terms of its contribution to the state's economy and the number of employment opportunities it creates within local communities. However, in South Africa, smallholder irrigation schemes are of importance. In 2010, smallholder irrigation schemes covered 47 667 ha (Van der Stoep, 2011).

The province produces about 60% of the country's measured quantity of fruit, vegetables, maize, wheat, and cotton. Livestock farming is also a significant contributor to the its agricultural sector. Within the province, there is the main tomato growing area – one of South Africa's largest production of nearly 66% of the total annual tonnage of tomatoes (Department of Agriculture, Fisheries and Forestry, 2010). Agriculture in Musina provides about 54% of employment opportunities followed by mining industry, with 18%. Thus far, Musina provides 11% of the total GDP of Vhembe District Municipality (Barbour, and van der Merwe, 2012).

1.3. PROBLEM STATEMENT

The purpose of the study is to determine the impact of climate change on the farming business in NIS. The extreme weather events such as heat waves, droughts and heavy precipitation increase the risks of crop failure and enhance yield variability. Climate change could cause significant changes in the quality and availability of water resources for crop irrigation affecting food production and security. It also influences crop production in various ways at different levels, scales and it is dependent on local natural crop growing limitations (Eitzinger *et al.*, 2013). Climate change is also expected to increase the frequency and magnitude of extreme weather events such as droughts and floods, which directly affect agriculture. The condition has a negative reward on the agricultural state of both livestock and crop production. Mindfully, heavy rains cause flooding

whilst eroding the top fertile soils. That exacerbates the difficulty of farmers to produce food and to sustain their farming activities. Most farmers seem not to know or fathom the effect of climate change on agriculture and its drawbacks on the farming business.

1.4. RATIONALE OF THE STUDY

The researcher has chosen NIS to conduct the study because the area is one of the leading irrigation schemes in the Vhembe District Municipality (VDM). There are a few researches that pursued the NIS, but the current researcher wanted to investigate the challenges that the area is experiencing pertaining to the effect of climate change in accord to farming influences. That is, how the agri-business activities respond to the weather condition.

1.5. SIGNIFICANCE OF THE STUDY

NIS is one of the important sources of food and it offers employment opportunities whilst boosting the GDP in Musina Local Municipality, Vhembe District in Limpopo. The importance of the study is to exhibit how climate change affects the farming business through high or low temperature and drought. The study was essential to both the farmers and the researcher. The findings of the study will be available for public access, for both knowledge and to, possibly, follow some of the recommendations of farming practices.

1.6. AIM OF THE STUDY

The climate is a perpetually fluctuating phenomenon and, therefore, it is imperative to assess the current condition *versus* the previous in order to detect whether there is a noticeable transition in farming or not. The study intends to find out how the climate change perturbs the farming business in terms profit generation. Hence, it was observed that a high temperature caused by climate change affected crop production in different ways. With that being so, a quick depletion of moisture after irrigation, introduction of new pests and diseases and a creation of conducive environment for pests to multiply in a large number were revealed. The study attempts to find out how the conditions uncomforted the production and profit generation whilst determining how the dreadful blip of climate change could be minimised.

1.7. RESEARCH OBJECTIVES

- To assess the effect of climate change on the crop production in Nwanedi Irrigation Scheme.
- To evaluate the loss or profit gained as a result of climate change.
- To explore the impact of high temperatures on the production of crop farming.

1.8. RESEARCH QUESTIONS

- Are the farmers in Nwanedi aware of the climate change?
- Does the high temperature in Nwanedi irrigation affect the production and farming in general?
- Does water shortage affect fruits and vegetables at Nwanedi Irrigation Scheme?

1.9. DEFINITION OF KEY CONCEPTS

1.9.1. Irrigation

In this study, irrigation is referred to as the artificial application of water to land for the purpose of agricultural production. An effective irrigation influences the growth process from seedbed preparation, germination, root growth, nutrient utilisation, plant growth, yield and quality (Agriculture Victoria, 2017). All plants need water for photosynthesis to occur. Photosynthesis is a process in which a crop makes its own food to grow in order to produce fruits and vegetables. For that motive, water is essential for plants' survival, should there not be any photosynthetic action, they will lose their lives. Accordingly, irrigation is the process of artificially supplying crops with water (Amanda, 2017). The technique is mostly applied in areas that receive little or irregular rainfall.

There are different types of irrigation methods for farmers to select from – based on the geographical location. The first category is known as surface irrigation, which uses gravity to distribute water over the field. In this procedure, water flows from an area of a higher elevation downhill to be accessed by all the crops. Secondly, localised irrigation, as described, uses a system of tubes to pump water throughout the field. The mechanism includes drip irrigation, which delivers water droplets directly to the roots of the plants. In the third place, sprinkler irrigation involves a system of pressurised tubes that expel water onto the crops. The sprinklers are habitually used to supply water to a lawn. Another irrigation type is the central pivot that also uses sprinklers. These are mounted on mechanical tracks that move them in a circular motion as they spray water on the crops (Amanda, 2017). Water is the most important input for agricultural production in

irrigated farming systems. Again, irrigation can be defined as replenishment of soil water storage in plant root zone, through artificial methods other than natural precipitation. The goal of irrigation management is to use water in the most profitable way at sustainable production levels. In agricultural production, the means supplements precipitation with irrigation (OMICS, 2015).

1.9.2. Climate change

This is the change in the state of the climate that can be identified by alterations in the mean and the variability of its properties that persists for an extended period, typically decades or longer (IPCC, 2014). It creates a serious threat to nature and the people in the current and the future periods. About 95% of climatological damage has been observed to be caused by human activities since the mid-20th century. The state is a long-term challenge, but it requires an urgent action – given the pace and the scale by which greenhouse gases are accumulating in the atmosphere, and the risks of more than 2% temperature rise. Recently, there is a necessity to focus on the fundamentals and the actions of saving the climate to avoid the yearly increment of temperature (Stocker, 2014).

Furthermore, climate change can also be defined as a change of climate that is attributed directly or indirectly to human activities. It modifies the composition of the global atmosphere. Human activities include the pollution that arises from industrial wastes and other sources that produce greenhouse gases. The gases have the ability to absorb the spectrum of infrared light and contribute to the warming of the atmosphere. When such gases are produced, they can remain trapped in the atmosphere for many years (Wired, 2017).

1.9.3. Global warming

According to Stocker (2014), global warming is a gradual increase in the average temperature of the atmosphere on the earth and its oceans which believed to be caused by the increased volumes of carbon dioxide and other greenhouse gases, released by the burning of fossil fuels, land clearing, agriculture, and other human activities. Karl *et al*. (2015) attest that the impact of larger warming rates in high latitudes on the overall global trend. To estimate the magnitude of the additional warming, a large-area interpolation was applied over the poles using the limited observational data. The results indicated that additional global warming of a few hundredths of degree Celsius per decade over the 21st century is real.

That a rising change which is believed to be permanently varying the climate of the earth. The effects of global warming are more substantial and rapid. The climatic change related to global warming is that the average temperature of the earth has risen from 0.4℃ to 0.8°C over the past 100 years. That is noted to have been caused by an increased volume of carbon dioxide and other greenhouse gases released by the burning of fossil fuels, land clearing, agriculture, and other human activities, which lead to the situation, studied over the past 50 years. It is predicted that average global temperatures could increase between 1.4℃ and 5.8 °C by the year 2100 (Livescience, 2017).

1.9.4. Drought

Drought is a prolonged absence of precipitation that results in water shortage for a period of time. It is an abnormal dryness of weather which leads to and extends the lack of precipitation that eventually causes a serious hydrological imbalance (Trenberth *et al*., 2014). It occurs frequently in the areas affected by desertification and is generally a natural feature of the climate of such regions. Drought can occur occasionally due to seasonal variations in rainfall. Long-term drought can be severe and is often caused by the influence of man on the environment, by reducing vegetation cover. Again, human activities could accelerate desertification and aggravate its negative consequences on people. Land degradation fastens the effects of drought by reducing the chances of local people to face difficult and dry periods (FAO, 2017).

Additionally, drought is also considered to be a naturally hazard which occurs naturally and has a negative effect on people and the land. It desperately exacerbates the need for immediate water supply. The occurrence of droughts is complex because not only are they dependent on the atmosphere but also on the hydrologic processes within the atmosphere (Mishra and Singh, 2010). When dry hydrologic conditions are established, the positive feedback mechanism of droughts sets in, where the moisture depletion from upper soil layers decreases evapotranspiration rates which, reversibly, lessen the atmospheric relative humidity. The lesser the relative humidity, the lower the probable the rainfall becomes, as it will be harder to reach saturation conditions for a regular low pressure system over the region (Mishra and Singh, 2010).

1.10. CHOICE OF RATIONALE OF THE RESEARCH DESIGN

The researcher has chosen both the qualitative and quantitative research designs. The two methods have their own advantages, which the researcher find to be crucial in order to achieve the objective of the study (Wahyum, 2012). The benefit of using the merged methods is that the researcher will be able to analyse and comprehend the contradictions between the quantitative findings and qualitative responds. In terms of data collection, these methods give a pavement to study participants and to ensure that study findings are grounded in the participants' experiences. A mixed method is flexible and can adapt to many study designs such as observational studies and randomised trials (Wisdom and Creswell, 2013).

The core characteristics of a well-designed mixed method study are: collecting and analysing both quantitative closed-ended and qualitative open-ended data. It uses rigorous procedures in collecting and analysing data appropriately to the traditional method by ensuring the suitable sample size for both the analyses. Moreover, it integrates the data during data collection, analysis, or discussion. A mixed method uses procedures that implement qualitative and quantitative components either concurrently or sequentially (Wisdom and Creswell, 2013).

The qualitative method addresses best the aspects of a topic that are intensive and nonlinear, which require interaction for a better understanding (Albright *et al*., 2013). The approach may involve an inductive, subjective, contextual survey, values, and opinions of stakeholders, participants, or consumers in their own words. It is mostly useful when the study attempts to understand whether the evidence-based practice was successful or not. Consider that the quantitative method also emphasises a deductive, objective and a generalising tactic which is widely used to the measure of intervention. An involvement of testing and confirming hypotheses based on an existing conceptual model to obtain a breadth of understanding of the predictors of successful implementation, needs not to be neglected (Albright *et al*., 2013).

1.11. RESEARCH METHODOLOGY

Williams (2011) argues that research methodology is the general approach that the researcher takes in carrying out the research project. The term 'methodology' refers to a model to conduct a research

within the context of a particular paradigm. That comprises of the underlying sets of beliefs which guide a researcher to choose at least two research methods over various adoptions. Research methodology focuses on the research process, tools and procedures to be used. Thus, there should be effective provision of answers to the research question (Van Wyk, 2012).

On the other hand, quantitative research is been defined as a formal objective and systematic process in which knowledge about the world is acquired and presented statistically (Muijs, 2010). It emphasises objective measurements and the mathematical or numerical analysis of data collected through polls, questionnaires and surveys. It can also be done by manipulating pre-existing statistical data using computational techniques. The research focuses on gathering numerical data and generalising it across groups of people or to explain a particular phenomenon (Muijs, 2010). The researcher has employed the use of questionnaires to gather both qualitative and quantitative data pertaining to the effect of climate change in NIS.

A quantitative research involves the collection of data so that the information can be enumerated and subjected to statistical treatment in order to support alternative knowledge claims (Williams, 2011). The practice also uses data collection that is numeric and the researcher tends to use mathematical models as the methodology of data analysis. Again, the researcher may use the inquiry methods to ensure that there is an alignment, supported by a statistical data collection methodology (Williams, 2011). That type of research typically commences with a problem statement, involving the formation of a hypothesis and a summary literature review.

A research method is made up of a theoretical framework that narrows the gathering and analysis of data. However, a research design is important to connect methodology to an appropriate set of research methods in order to address research questions or hypotheses, that are established to examine the social phenomena. A research method that facilitates a deep investigation of a real-life and contemporary phenomenon in its natural context is a case study (Yin, 2013).

Furthermore, a quantitative research creates meaning through the objectivity uncovered in the collected data. Both the qualitative and quantitative paradigms have been employed in the study (Wahyuni, 2012).

There is the necessity to understand the effect of climate change on farming business in the study. The qualitative research focuses on understanding the perceptions of individuals. It seeks an

insight and it is concerned with processes rather than outcomes (Wahyuni, 2012). The style is suitable for the study because reality, as perceived by the participants, is subjective. The enquiry, therefore, focuses on the way in which the participants interpret and make sense of their experiences with climate change and crop production.

1.12. ETHICAL CONSIDERATION

Ethical consideration refers to a system of principles which can critically change previous considerations about choices and actions (Fouka and Mantzorou, 2011). Ethics deals with the dynamics of decision making on what is right and wrong. Research ethics involves the requirements on daily work, the protection of dignity of subjects and the publication of the information in the research (Fouka and Mantzorou, 2011).

The major ethical issues when conducting research are: informed consent, respect for anonymity and confidentiality and respect for privacy (Fouka and Mantzorou, 2011). According to Resnik (2015), the following is a general summary of ethical codes:

(a) Honesty – the researcher must strive for trustworthiness in all scientific communications. He or she must honestly report data, results, methods and procedures and publication status. The person must not fabricate, falsify, or misrepresent data,

(b) Objectivity – it is crucial to avoid biasness in experimental design, data analysis, data interpretation, peer review, personnel decisions, grant writing, expert testimony and other aspects of research, where objectivity is expected or required,

(c) Integrity – keeping a promise and agreement needs to be considered. The investigator must conduct himself or herself with sincerity, and consistency of thought and action are foremost,

(d) Carefulness – the scholar must avoid careless errors, negligence and an examination of the work and the work of peers is essential,

(e) Respect for intellectual property – honour of patents, copyrights and other forms of intellectual properties is the prerequisite. Unpublished data, methods, or results without permission must not be utilised. Again, a proper acknowledgement or credit for all contributions to the research is highly recommended and

(f) Confidentiality – researchers must protect communications such as papers or grants submitted for publication, personnel records, trade or military secrets and patient records

The researcher has requested permission to conduct research from the Department of Agriculture in Musina Local Municipality. The information obtained has only been used for the purpose of the study. Farmers who participated were informed and their approval was requested before conducting interviews. Not even a single individual was forced to participate. The researcher has given the participants an assurance that their identity would remain anonymous and their information would be kept confidential.

1.13. OUTLINE OF THE STUDY

The study has been structured as follows:

Chapter 1- This chapter targets at introducing and giving a background of the study. It also provides the aim, objectives and the methodology that were followed.

Chapter 2- The chapter provides a detailed literature review. The review covers all aspects on the effect of climate change and its impact on the farming the business in the area of the study and other parts of the world.

Chapter 3- In this chapter, an outlined method that is used to collect data for the study is presented. It has also outlined how the data was analysed.

Chapter 4- This chapter outlines the research results from the collected data in NIS.

Chapter 5- The last chapter presents the summary of results, findings from literature, empirical studies and interviews as well as recommendations and conclusions.

2. CONCLUSION

This chapter has briefly presented the background of the study and the historical contextualisation of NIS. Relevant theoretical approaches and methods of data collection have also been summed.

The outline of the chapters included in the study has been respectively arranged according to the structure of the research.

CHAPTER TWO: LITERATURE REVIEW

2.1. INTRODUCTION

This chapter focuses on the literature that is related to the research topic. It outlines how the climate change impacts on agricultural production through high temperature, drought, low and heavy rainfall. The coping strategies that can assist farmers to produce, even under harsh weather conditions caused by climate change, are also highlighted. Again, the environmental impacts that are caused by climate change are exhibited, indicating how they affect the lack of food and drinking water for both animals and crops and poor soils. Rainfall patterns in NIS are highlighted as well as the major crop and livestock produced.

2.2. CLIMATE CHANGE IMPACTS ON AGRICULTURE

2.2.1. High temperature in South Africa (SA)

Sub-Saharan Africa is considered to be the highest proportion of malnourished populations in the world which have famished people who depend agricultural production for economy (Schlenker and Lobell, 2010). Agricultural production is sensitive to weather and it is directly affected by climate change. When the climate change alters weather conditions, it has biophysical effects on agricultural production (Nelson *et al*., 2014). Climate change has the potential to interrupt progress towards shortage of food. It also has an impact on crop productivity that could have consequences for food availability (Wheeler and Von Braun, 2013). The effects of high temperatures lead to an increased climate variability and of several limiting factors which affect soil nutrients, pests and weeds (Soussana *et al*., 2010).

In South Africa, a detailed analyses of trends in annual and seasonal minimum and maximum temperatures was conducted to investigate temperature range in Limpopo Province – between 1950 and 1999. It was found that there was an increase of 0.12°C per decade in the mean annual temperature for the 30 catchments, over the 50-year period (Tshiala *et al*., 2011). Research has shown that there was a relatively rapid increase in average temperatures in the early 1960s which caused the general increase in temperature for the full period from 1960 to 1990. The trend in annual mean temperatures of 0.13ºC per decade for 1960 to 2003 was significant (Tshiala *et al*., 2011).

The water holding capacity of air can increase up to 7% per 1°C warming. Changes and fluctuations in Sea Surface Temperature (SST) around the South African coast were investigated between 1982 and 2009 and it has been found that there is a statistically significant negative trend of up to 0.5 °C per decade in the Southern Benguela from January to August and a cooling trend of lesser magnitude along the South Coast and in the Port Elizabeth (Rouault *et al*., 2010). Climate change has direct impacts on the yield and the global effect on the commodity prices. It has an influence on the increase in the atmospheric Carbon Dioxide (CO^2) and Ozone (O^3) levels (Lobell and Gourdji, 2012).

When the climate and CO^2 continue to trend, they raise questions on food security and farming business in general. According to Lobell and Gourdji (2012), the warming or high temperature is likely to reduce global yields by approximately 1.5%. Conversely, heat stress poses a serious threat to global food supply (Teixeira *et al*., 2013). When there is a high temperature, there is an increase in crop water demand because of the increase in 'evapo-transpiration' which affects crop development. Historically, the high incoming radiation and optimal seasonal temperatures were considered to maximise the yield. However, with the increase in the frequency of extreme temperature events, there is a probability of overlapping peaks of temperature and the flowering period. Radiation interception and photosynthesis increase under the heat stress which reduces the final yields (Teixeira *et al*., 2013).

South Africa has been getting hotter over the past four decades with average minimum monthly temperature at 13° C and an average maximum of monthly temperature at 26°C (Maponya and Mpandeli, 2012). The country has also been experiencing an increase in the number of warmer days whilst cooler days are decreasing. Agriculture is expected to be the mostly affected by these changes because it is highly dependent on climate variables such as temperature, humidity and precipitation.

South Africa is located in one of the three regions of the African continent, that will most likely suffer significant adverse impacts progressively warmer and drier summers, wetter and milder winters and more frequent extreme weather, particularly heavy rainfall and heat waves (Development, 2016). Limpopo province is already experiencing some changes to its climate and it is expected that it will be experiencing warm and wet winters and also hot and dry summers. Extreme weather such as heat waves and very heavy rainfall are estimated to become more

frequent and intense. Winter is ordinarily viewed to be very cold but it will less frequent. The change in climate conditions will have a negative impact on the economy of Limpopo, natural resources and community livelihoods (Development, 2016).

2.2.2. Drought in South Africa

According to Trenberth *et al*., (2014) drought is defined as prolonged absence or deficiency of precipitation that results in water shortage. It can also be defined in a number of ways as Trenberth (2014) states:

> Agricultural drought which is deficit of moisture in the soil (the root zone) can impact on crops and as meteorological drought which is a prolonged deficit of precipitation and also hydrologic drought which is related to below-normal streamflow, lake and groundwater levels.

Droughts can have direct bearings on water supply, crop production and rearing of livestock. These situations lead to famine, malnutrition, epidemics and displacement of large populations from one area to another (Rojas *et al*., 2011). Previously, Limpopo was faced with crop failures and rural people increasingly turned to the black market to cope with drought. They have used informal market activities as agricultural households struggle to cope with drought. They experienced economic hardship and their cattle stocks were extremely low. In that case, people were unable to farm due to drought and war (Silva *et al*., 2010).

The economic impacts of drought on employment, value added, and sector output need not to be neglected. Drought leads to job losses in agriculture and are estimated to be nearly 10100 seasonal jobs (Howitt *et al*., 2014). Limited studies were conducted in South Africa but in other countries such as USA, it was found that when the farmers are experiencing drought, they cut down a number of jobs and in some instances, they may even shut down the production until rain season comes. The direct economic disturbances are crop failures and pasture losses due drought within the agricultural sector. Production losses cause negative supply shocks. The economic distribution of losses depends on the market structure and interaction between the supply and demand of agricultural products (Ding *et al*., 2011).

Drought-induced losses are not completely borne by farmers because a portion of the losses are passed onto consumers through increased prices. When the cost of production increases, the losses will be felt by consumers as the prices will increase. It is not easy for farmers to be off from the

drought impact because the price increases by a higher percentage than the supply decreases (Ding *et al*., 2011). Drought can cause long-term consequences on perennial crops and livestock productions. The brutal blips might occur for a longer period. Considering these lagged glitches of drought, it is important to set a time frame when assessing the economic impacts of drought (Ding *et al*., 2011).

Limpopo province is a drought prone province. The province has experienced reduced grazing and water for livestock and irrigation which impacted the agricultural sector negatively. It is important for farmers to gain access of information about drought. Some of the information can be available through; radios, television, newspapers and magazines. The province is getting drier and there is a decrease in rainfall caused by climatic changes. This shortage of water has an impact on agricultural production and in food scarcity, thereof (Maponya and Mpandeli, 2012).

Drought can be quantified and described in absolute terms such as the amount of soil moisture or the level of the lake (Trenberth *et al*., 2014). It can also be defined as one tail of the probability distribution function of a drought measure such as soil moisture content and a small reduction in the mean will translate into a much larger increase in drought frequency based on other drought definitions. The extra heat from global warming increases the rate of drying which establishes drought more quickly (Trenberth *et al*., 2014).

The global warming leads to declines in annual rainfall in south-eastern Africa and also has a strong influence on water resource availability which might also increase the livelihood risk (Love *et al*., 2010). In a study conducted in the northern part of the Limpopo, Basin and Zimbabwe, it was determined that rainfall and discharge decline notable since 1980 in terms of annual rainfall and annual unit runoff. It was also found that there is temporal availability of water and it was observed that there is a decline in number of rainy days, increases in dry spells and escalations in days without flow. The rising risk of dry spells is associated with the decrease in crop yields and an increasing probability of annual discharge. Increasing food shortages are a likely consequence of the impact of this declining water resource availability on rain-fed and irrigated agriculture (Love *et al*., 2010). The semi-arid Limpopo River basin has experienced severe droughts in the past, which have led to crop failures, high economic losses and the need for humanitarian aid (Trambauer *et al*., 2015). The severe drought experienced has reduced grazing land, water for livestock and irrigation which has negatively impacted the agricultural sector. The province was

hit hard by drought which affected dams. Dams were only 50% full compared with 84% in late nineties (Maponya and Mpandeli, 2012).

2.2.3. Rainfall in Nwanedi irrigation scheme

Southern Africa receives most of its rainfall in summer except for a region in the southwest that experiences austral winter rainfall (Philippon *et al*., 2012). Climate change is a serious threat to crop productivity in regions that are already food insecure (Knox *et al*., 2012). The NIS is located close to the Limpopo River Basin in north of South Africa where it is semi-arid area with an altitude of greater than 800m above sea level and has a mean total annual rainfall ranging between 300mm and 600mm. About 85% of the rainfall over the eastern interior of the Limpopo river basin occurs in the summer months. However, more rainfall occurs between November and December as well as January and February (Malherbe *et al*., 2012).

The Limpopo River Basin is located in north eastern South Africa, southern Zimbabwe and southern Mozambique, and is a semi-arid area with an altitude of greater than 800m above sea level, with a mean total annual rainfall ranging between 300mm and 600 mm. Within this climatic context, however, the region supports a large rural population dependent on rain-fed agriculture as well as large national parks. The region is, therefore, vulnerable with regard to the impact of rainfall variability (Malherbe *et al*., 2012).

Rainfall amount and variability is important for improved decisions concerning choice of crops and crop varieties to be grown in a particular area. The knowledge of monthly rainfall distribution is also vital because it tells how much water is available for the biomass in rain-fed areas (Mzezewa *et al*., 2010). Nonetheless, Musina was previously affected by floods after heavy rain that has devastated some parts of Limpopo as well as across the country. It has left so many people stranded that the team which was comprised of police divers, the fire brigade, officials from the South African National Defence Force (SANDF), the South African Air Force (SAAF), the Red Cross, the provincial disaster management office and Emergency Medical Services (EMS) had to intervene to save the people's lives. That has led to a temporary closure of point of entry, borders gates such as Pontdrift, Zanzibar and Platjan on the Botswana border and Pafuri in the northern Kruger National Park on the Mozambican border. Farmers who were on the low-lying areas of the Limpopo river had lost their entire winter crop (Masinga, 2014).

2.3. COPING STRATEGIES FOR CLIMATE CHANGES IMPACTS IN SOUTH AFRICA

Climate change is estimated to have a negative impact on the agricultural production in Africa. There is a wide range of climate models in Africa which suggest that the mean temperature will increase between 3°C and 4°C by the end of the 21st Century. This will negatively affect the yield on staple crops such as maize, sorghum, millet, groundnut, and cassava by at least 8-22% by 2050. But it can be prevented by improving agricultural productivity under climate risk (Schlenker and Lobell, 2010).

Adaptation to climate change in farming by making changes in entails:

(a). Crop management practices such as good choice of fields, planting dates, planting densities and crop varieties,

(b). Adaptation of livestock management practices such as livestock choice, feeding and animal health and

(c). Adaptation of land use and land management such as fallowing, tree planting, irrigation and water harvesting, soil and water conservation measures, tillage practices and soil fertility management (Bryan *et al*., 2013).

By adapting above mentioned practices, there can be a great reduction of vulnerability to climate change. An understanding of the perception of the farmers with regard to climate change, ongoing adaptation measures and the process of making the decision is central when promoting successful adaptation of the agricultural sector (Bryan *et al*., 2013). The success of adaptation can be made possible through the participation of different stakeholders such as farmers, policymakers, extension agents, Non-Government Organizations (NGOs), researchers, communities and the private sectors (Bryan *et al*., 2013).

2.4. ENVIRONMENTAL IMPACTS CAUSED BY CLIMATE CHANGE

2.4.1. Increase in diseases in wild animals due to reduced food and water supplies in South Africa

Scientists have predicted that there will be huge scale responses of infectious diseases to climate change (Altizer *et al*., 2013). Climate change has increased the occurrence of diseases in some natural and agricultural systems and that depends on the form of climate change and details of the host-pathogen system. There is a need for researchers to identify the progress and gaps that have emerged during the past decade and develop a predictive framework that integrates knowledge from ecophysiology and community ecology with modelling approaches. Future studies have to continue to anticipate and monitor pathogen biodiversity and disease trends in natural ecosystems and identify opportunities to mitigate the impacts of climate-driven disease emergence (Altizer *et al*., 2013).

According to Perry *et al*. (2013), endemic diseases continue their historic decline in wealthy countries, poor countries experience static or deteriorating animal health and epidemic diseases show both regression and expansion. Diseases such as bluetongue, Lyme disease found in West Nile virus exist as the results of climate change and that is illustrated by a highly pathogenic avian influenza. The major drivers of change in disease dynamics include ecosystem change, ecosystem incursion and movements of people and animals (Perry *et al*., 2013).

According to Perry *et al*. 2013, there are three trajectories of global disease dynamics namely:

(a) The worried well in developed countries,
(b) The intensifying and market-orientated systems of many developing countries, where there is a complex of disease patterns that create hotspots for disease shifts, and
(c) The neglected cold spots in poor countries, where there is a rapid change in disease dynamics is less likely but smallholders and pastoralists continue to struggle with largely preventable and curable livestock diseases.

2.4.2. Increase stress on livestock in Limpopo province

Livestock is an important measure for sustainable land use and can have both positive and negative environmental impacts (Moyo and Swanepoel, 2010). Noteworthy is that the trends and drivers of livestock production and their implications are one of the fastest growing agricultural subsectors and a major contributor to food and nutrition security. That being so, livestock serves as a profound source of livelihood for about a billion of poor people in developing countries (Moyo and Swanepoel, 2010). Furthermore, there is growing evidence that climate changes will cause damage

to the agricultural sector in the whole world. One of the drawbacks of climate change on the livestock is mild stress, experienced in cows along the north borders of South Africa (Nesamvuni *et al*., 2012).

In a study undergone in Limpopo, it was found that for maximum daily climate conditions, severe and mild stress are likely to be experienced in the Eastern interior of the province. However, severe stress could possibly take place within the whole of South Africa considering the future climate conditions. In addition, extremely severe stress is projected to occur in parts of the Northern and Eastern borders as well as other parts of the Limpopo. For dairy cattle under severe stress, it is foreseen that they will experience a reduction in milk production of about 10 to 25% and as well as decline of livestock reproductive performance (Nesamvuni *et al*., 2012). The predicted future heat stress on dairy cattle suggests that climate change will have an undeviating impact on the dairy industry as it will affect the intensity and frequency of cattle heat stress. That will sabotage both the milk production and reproduction. The management of livestock under heat stress should, therefore, involve adoption of measures to minimize the effects on production (Nesamvuni *et al*., 2012).

2.4.3. Water erosion of soils and soil quality in South Africa

Ravi *et al*., (2010) argue that soil erosion is the detachment and transport of soil particles and subsequent redeposition in near or distant areas mainly by the action of wind and water. Conversely, the major biophysical limitations to agricultural production in the continent are poor soil fertility and nutrient availability. According to Tittonell and Giller (2013), there is need to intensify African agriculture which has led agricultural research for development in promoting the use of mineral fertilisers, hybrid seeds, new crops and irrigation.

Soil erosion is a major threat to sustainable agriculture in Southern Africa yet difficult to quantify. The Orange River is considered to be the principal source of sediment to the Western margin of South Africa with an estimated mean mud flux over the last 11 - 500 years (the Holocene epoch) of 5.1 (3.2–7.4) million metric tons per year (Mt/yr). A total of 43 gigatons (Gt; 1015 g) which represent 72% of the Holocene mud flux (Compton *et al*., 2010).

Climate change might also lead to a higher frequency and magnitude of extreme weather events such as droughts and floods which put a pressure on land productivity more especially in tropical

and sub-tropical regions of the world (Vlek *et al*., 2010). The also adds a layer of complexity to the already highly complicated dynamics of land degradation because of the increased atmospheric fertilisation by CO^2 resulting from the variation of the weather. Land degradation exists as a result of land mismanagement and may have a negative impact on the soil resources. Vlek *et al*. (2010) view that the human impact on the productive capacity of agricultural land in Sub-Saharan Africa is related to soil mismanagement such as elimination of fallows, removal and burning of crop residues, produce exports and shifts to more demanding crops.

Water quality in rural areas is affected negatively affected by build-up of traffic-generated organic compounds on road surfaces which will lead to water runoff and sediments (Nekhavhambe *et al*., 2014). A clean and safe water supply is important and it helps poor households to generate income through a wide range of productive activities such as subsistence agriculture. Water is a medium through which climate change exhibits its environmental, economic and social impacts. The unavailability of enough, clean and safe water is a global calamity which is widely experienced by developing countries. Remarkably, there is a wide range of water pollutants in South Africa such as mining operations, industrial and domestic effluents, runoff of biocides, nutrients and pathogens from agricultural lands, urban areas and informal settlements (Edokpayi *et al*., 2014).

Some of the techniques of restoring soil quality are: conservation agriculture, integrated nutrient management, continuous vegetative cover (mulching and cover cropping and controlled grazing at appropriate stocking rates). The strategies are used to reduce and increase losses of soil, water and nutrient usage efficiency. Soil quality can be improved by integrated soil fertility management that combines the use of amounts of mineral fertilisers and soil amendments such as manure, crop residues, compost, leaf litter, lime and phosphate rock (Winterbottom *et al*., 2013).

2.4.4. Causes of climate change: greenhouse effect in South Africa

Menyah and Wolde-Rufael (2010) contest that pollutant emissions and energy consumption for South Africa for the period 1965–2006 in a multivariate framework has found a short-run as well as a long-run relationship among the variables with a positive and a statistically significant relationship between pollutant emissions and economic growth. The econometric evidence suggests that South Africa has to sacrifice economic growth or reduce its energy consumption per unit of output or both in order to reduce pollutant emissions.

The amassment of greenhouse gases (GHGs) in the earth's surface is recently adversely affecting the nations across the world in both developing and developed countries (Shahbaz *et al*., 2013). The success of international efforts to reduce world CO^2 emissions depends on the commitment of people who contribute to the challenge. South Africa is one of the major emitter of CO^2 with 1% of the world emissions. That is due to that the country uses coal, a major ingredient of CO^2, when producing energy (Shahbaz *et al*., 2013).

On the other hand, GHG may be produced both naturally and through human activities. Firstly, the sources of methane that come from the decomposition of organic matter, for instance, in landfills and in agriculture (Paustian *et al*., 2016). Secondly, another large source is from the digestion of ruminants (cows and goats). However, methane is regarded as a stronger GHG than CO^2 because it can absorb more heat. Another powerful greenhouse gas is heavily produced in the agriculture sector, more especially during production and also where they use of organic fertiliser (Thomas *et al*., 2016). The gas can also be produced when burning fossil fuels. There are also man-made compounds which are produced for industrial use such as refrigerants and air conditioners which have a negative effect on the Ozone layer. Since the beginning of the 20th century, industrial activity grew 40-fold and the emissions of greenhouse gases grew 10-fold (Paustian *et al*., 2016).

Agricultural ecosystems hold large reserves of carbon and release significant amounts of CO^2, CH4 and N2O to the atmosphere. Annihilating emissions involves the reduction of the fluxes of these gases by managing more efficiently the flow of carbon and nitrogen in agricultural ecosystems.

The estimation of GHG releases from the energy supply sector for Limpopo are based on Tier 1 with country-specific emission factors (Development, 2016). The electricity in Limpopo is dominated by coal based electricity generation, operated by Eskom. The Eskom Matimba power station generated a total of gross electricity of 24000 GWh for the base year 2013, which adversely contributes to the emissions (Development, 2016).

Emissions of greenhouse gases are also produced on agricultural lands as a result of a number of natural and human-induced processes (Development, 2016). The emissions are from burning of biomass, feed digestion by ruminant livestock, the addition of nitrogen fertiliser and animal manure, crop residues returned to the soil, nitrogen fixation, nitrogen leaching and runoff,

atmospheric deposition and the anaerobic decomposition of organic matter during flood irrigation. The main agricultural sources of CH4 are the digestion of feed by livestock, manure management and by burning Savannah grass. Conversely the primary agricultural source of N2O is soils – predominantly as a result of the use of nitrogen-based fertilisers on crops and pastures (Development, 2016).

2.5. EFFECT OF CLIMATE CHANGE ON THE ECONOMIC ACTIVITIES IN SOUTH AFRICA

The evidence that climate change will adversely affect agriculture in Sub-Sahara Africa has become a crucial challenge for sustainable development on the continent (Juana *et al*., 2013). This challenge is composed of the likely bearings on ecosystem services, agricultural production, and livelihoods. Generally, losses in the agricultural sector due to climate change have great economic consequences. Those could be the loss in gross domestic output, a decline in the income or consumption of the most vulnerable population; hence, a general deterioration in households' welfare. Sub-Sahara Africa is among the most vulnerable continents or regions to climate change impacts. The majority of the Sub-Sahara African population lives in abject poverty, and are heavily dependent on rain-fed agriculture for their economic and livelihood sustenance. Therefore, variations in rainfall patterns and temperature adversely impact their economic and social survival (Juana *et al*., 2013).

Poor households in South Africa are the most vulnerable population group to climate change (Juan *et al*., 2012). The transition in the climate leads to general deterioration in households, more especially, the poor or rural households who their economy depend on agriculture. The Western Cape and Gauteng provinces are less vulnerable to climate change because of low shares of agriculture in total GDP (Gbetibouo *et al*., 2010). The highly vulnerable provinces in South Africa are Limpopo, Kwazulu-Natal and the Eastern Cape because they are densely populated rural areas with large numbers of small-scale farmers who depend on rain-fed agriculture and high land degradation (Gbetibouo *et al*., 2010).

A climate change may lead to loss of amounts, to a 0.26%, in world's GDP. The total GDP from agriculture is about 3.2% of the whole world. However, in South Africa, it is about 30 – 40% of the Africa's total GDP. That is the main driver of the economy which provides a source of

livelihood to 65% of the population (World Bank, 2012). The increase in temperature prolongs livestock revenues for small farmers and the overall effect is losses in billions of dollars from livestock revenues since large farmers dominate the sector (Huho and Kosonei, 2014).

In South Africa, the agricultural sector plays a significant role in the country's economy. The effect of climate change can lead to a fall of about 1.5% in the country's GDP by 2050 (Department of Environmental Affairs, 2011). South African agriculture has different types of crops, cropping calendars and production levels are very diverse, owing to the influence of the different agro-climatic zones, from the dry North-Western region to the West-Eastern region. The major crops are maize, wheat, sugar cane, sorghum and the minor ones are groundnuts, sunflowers, dry beans, tobacco and potatoes (Department of Environmental Affairs, 2011). Fruit of importance includes apples, grapes, pears, peaches and dried fruits.

Limpopo produces about 60% of all fruit, vegetables, maize, wheat, and cotton. Livestock farming is also a significant contributor to the province's agricultural sector. Limpopo is considered an agricultural household, and the province is home to 16% of South Africa's agricultural households. Despite that, the agricultural sector contributed only three percent to the province's annual average GDP in 2012. The province is the main tomato growing area in South Africa, producing 66% of the total annual tonnage of tomatoes (Department of Agriculture, Forestry and Fisheries, 2010). An increase of tomato production in Limpopo for certain years and there are some decreases of production in a certain period because of the sensitivity of the tomato crop to climate variability and change (Tshiala *et al*., 2012).

2.6. RAINFALL IN NWANEDI

Smallholder agriculture is the driver of rural economic growth and welfare for the poor. Agriculture has a small total of GDP yet remains an important sector in the South African economy. It is an important economic activity in the rural areas. Total agricultural land available for agricultural production is 11 321 million. Limpopo has approximately 88% of the population living in non-urban areas (Statistics South Africa, 2015).

NIS is comprised of the semi-arid with a mean annual rainfall of 350 to 400 mm rainfall, which falls in the summer months. The rainy season is predominantly from November to March when about 83% of the total annual rainfall occurs. The winter season in Nwanedi area is mild. The area

is dry from May to September and it receives less than 7 mm of rain per month. In that case, temperatures may vary from a minimum of 21.30ºC and a maximum of 33.52ºC in summer and between 8.6°C and 25.6ºC in winter (Nell, 2013).

2.7. VEGETATION AND VELD TYPES IN NWANEDI IRRIGATION SCHEME

Nwanedi and surrounding areas consist of Musina, Mopane bush-veld vegetation and are dominated by Colophospermum Mopane and Combretum apiculatum (Nell, 2013). The area is well known for different types of veld namely: mixed bush-veld and sweet low-veld bush-veld. The types of veld are good for livestock such as goats and cattle. The vegetation type in Nwanedi is severely modified and degraded because of agricultural practices. Nwanedi area is covered by Savannah Biome, which is considered to be the largest Biome in Southern Africa and it covers about 46% (Nell, 2013).

The Mopane bush-veld is found on sandy and loamy soils. The altitude ranges from 300 - 700m above sea level. Evaporation rates are very high due to high summer temperatures which can rise up to 44 ℃. With that reason, the grass layer is poorly developed of grasses such as Enneapogon Cenchroides (Nine-awned Grass), Cenchrus Ciliaris (Blue Buffalo Grass), Stipagrostis Uniplumis (Silky Bushman Grass), Aristida Congesta (Tassel Three-awn) and Schmidtia Pappophoroides (Sand Quick), which are good for livestock (Nel and Nel, 2009).

2.8. MAJOR CROPS AND LIVESTOCK IN NWANEDI IRRIGATION SCHEME

Warm temperature and frost-free climate in Nwanedi helps the farmers to produce all year-round. The season of farmers in Nwanedi usually starts in January and overlaps to March. The second season starts between July and September. The major crop produced in the area is jam tomato but they also plant other vegetables such as cabbage, legumes and cucurbits. Vegetables such as sugar beans, green beans, okra, cabbage, butternuts, watermelons and green peppers tomatoes are usually planted between February and June. They are able to produce about 130t of tomatoes per hector (Mashala, 2013).

NIS is composed of both loamy and clay soils which are an advantage, especially in an area that is always dry. Loam soil holds water longer than sandy soil, and normally has enough nutrients. Nonetheless, the problem with loam soil is that when it is too wet, it is difficult to work. If it rains

too much, weeds grow very fast and cannot be controlled and no ploughing could take place. When farmers are unable to get into the field for a long period of time, they may not be able to monitor the status of the crops planted. When preparing the soil, it must be slightly dry and easier to work (Nell, 2013).

They market their products within South Africa and outside of the country and also to those who walk-in to buy directly from the farm. They have a rapport with Tiger Food Brands – which produces tomato paste and Mpac – which undertakes the packaging of mainly oranges in Musina. Nwanedi is also comprised of livestock farmers who rear cattle, sheep and goats. Sheep make up most of the numbers, contributing about 40% to the total livestock whereas goats and cattle contributed 32% and 27% respectively. North of the Soutpansberg mountain range is characterised by Mopani veld suitable for cattle and game (Mashala, 2013).

2.9. CLIMATE VARIABILITY AND CHANGE IN SOUTH AFRICA

The stability of whole food systems may be at risk under climate change because of short-term variability in supply. However, the potential impact is less clear at regional scales, but it is most likely that the climate variability and change will exacerbate food insecurity in areas currently vulnerable to hunger and undernutrition (Wheeler and Von Braun, 2013). Climate change is one of the biggest challenges constraining smallholder agriculture in Sub-Saharan Africa because of extreme weather conditions associated with climate variability. The region's agricultural sector is highly sensitive to future climate shifts and increasing climate variability. Agriculture remains an important livelihood source for most rural Sub-Saharan communities, providing employment for over 60% of its inhabitants and accounting for about 30% of its GDP (Turpie and Visser, 2013).

Limpopo is one of the developing provinces in South Africa and is particularly vulnerable to climate change impact, partly because of its exposure to extreme weather events and sensitive economies. The province also has the high number of rural dwellers dependent on natural resources, though communities in Limpopo region may have a greater ability to adapt to long term changes in climate, such as increased seasonal temperature and altered the patterns of precipitation. The main production areas are: Letaba, which produces the quantity of 3259ha around Mooketsi and Musina, which produces about 859ha. Tomatoes are also planted in the smaller areas of Giyani, Polokwane and Mokopane Districts. The reduction in tomato production in some of the years was

mainly due to droughts experienced in the region. Changes in climatic factors such as temperature, solar radiation and precipitation influence crop production (Tshiala and Olwoch, 2010).

Climate change is one of the most critical long-term global challenges, especially for Africa and, even more, in Southern Africa (Madzwamuse, 2010). Agriculture is more than an economic cornerstone of most rural households in Sub-Saharan Africa and climate change variations pose a threat to the agricultural sector and food security of these households. South Africa is vulnerable to climate change because of its dependence on climate-sensitive economic sectors, high levels of poverty and the inter-related impacts of HIV and AIDS (Madzwamuse, 2010). The poor have few opportunities and are usually affected by the negative impacts of climate change. Both commercial and subsistence farming are affected.

Climate change is also expected to increase food insecurity, worsening poverty in the rural communities in South Africa. The condition affects four dimensions of food security namely: food availability, food accessibility, food utilisation and food systems stability (Ziervogel and Ericksen, 2010). Changes in climate variables could have an impact on science and technology demands, which will eventually affect food security. An increase in temperature might negatively affect the net revenue in the farming industry. The most severe overall revenue losses for the year 2080 are predicted in the North West (of R88,455,490) and in Limpopo (of R106,544,600). In terms of percentage change, the Northern Cape loses the most net revenue (439% decrease), followed by North West (231.1% decrease) and Limpopo (158.6% decrease). It could be suggested that further increases in temperature and decreases in rainfall are likely to make these, already arid areas, less productive (Turpie and Visser, 2013).

In the province, livestock will experience the greatest decline in revenue of R114,352,300 (270% decline. The threat to food security from the commercial agriculture is very real because of climate change in South Africa. By 2050, commercial agricultural net revenue will decline by approximately 18.3% and worsen 2080 (Turpie and Visser, 2013). Therefore, adverse effects of climate variability and extreme weather conditions in South Africa could destabilise the whole region.

2.10. **IMPACTS ON PASTURE CROPS AND LIVESTOCK**

Climate change complicates the existing problems of bush encroachment and invasive alien species. As the atmospheric CO^2 levels rise, it may increase the cover of shrubs and trees in grassland and Savannah with mixed effects on biodiversity and possible positive implications for carbon sequestration (Schulze, 2010). Increased temperatures provide a conducive environment for a wide range of pests and pathogens that are critical to agricultural and livestock activities. When the temperature and evaporation increase, they may sway the incidence of heat stress and water requirements in the livestock production. Kikuyu grass (Pennisetum clandestinum) is one of the important pasture grasses in South Africa because it provides palatable and highly nutritious foods. The yield is projected to decline. According to Nesamvuni *et al*. (2012), it is necessary to use the Temperature-Heat Index (THI) when incorporating climate change projections to show that dairy cattle are likely to experience a more severe heat stress events in the future.

2.11. CLIMATIC CHANGE COPING STRATEGY IN NANEDI IRRIGATION SCHEME

Sub-Saharan Africa is considered to be more vulnerable to climate change in the world. Climate change has an impact on the areas which were suitable for agriculture, the length of growing seasons and crop yields are decreasing and varying from year-to-year and that poses serious challenges on food security (Jiri *et al*., 2015). The smallholder farmers must be able to identify the changes that are taking place in their areas so that they will be able to apply appropriate coping and adaptation strategies. The coping and adaptation strategies of smallholder farmers depend on their perception knowledge level (Jiri *et al*., 2015).

According to Adger *et al*. (2011), the impacts of global climate change are already being experienced in different ways in a wide range of parts of the world. The communities should respond to the coping strategies by adjusting economic activities, changing land use practices, introducing public health initiatives to combat heat hazards and changing the design and implementation of infrastructure. Some of the coping strategies which induce the farmers' adaptation responses are because of the of the following (Jodha *et al*., 2012):

(a) Risk vulnerability and adaptations generating features of their natural resource base which include climatic conditions,
(b) Risk and adaptation to short and long term variability to rainfall and
(c) Adaptation to extreme events such as droughts and floods.

For farmers to be able to a make a decision to adapt, they are guided by their perception to climate change and variability and climate risks related thereof. They must be in position be able to identify the changes already taking place in their areas and adapt to the relevant coping strategies. The ability of farmers to perceive climate change depends on their choice to cope and to adapt. It is also guided by their perception knowledge level. Farmers need to firstly notice that the climate has changed so that they will be able to identify and implement potential useful adaptations (Jiri *et al*., 2015).

Temperature changes have stronger impact on yields than precipitation change (Lee *et al*., 2015). High temperature is one of the most problems experienced in NIS. They could use hybrid planting material instead of using open pollinated planting materials. Climate change poses a serious challenge for farmers into the risk of production which is associated with crop yields, timing of field operation and timing of investments in new technologies (Olesen *et al*., 2011).

Few researches have been conducted in Nwanedi area with relation to how farmers cope with the effect of climate change. However, a study conducted in Kenya has found that; The most common responses from the farmers coping strategies were changing crop variety, changing planting dates (this can be achieved by delaying planting or plant early) as well changing crop type or variety (Bryan *et al*., 2013). For livestock farmers to cope with the effect of climate change, the quantity of livestock, diversifying, changing and supplementing livestock feeds need to be reviewed. Without reservation, crop farmers have to change the fertiliser application and soil and water conservation practices. It has been found that changing planting new crop variety and changing planting dates are the most common and most effective key adaptation measure (Bryan *et al*., 2013).

2.12. CONCLUSION

This chapter has given the outlined effect of climate change in South African and other countries with the same blip. It has given an overview of the study area in terms of its vegetation types. The literature has revealed that the country in general receives less rain, which leads to farmers to apply

artificial irrigation on the crops for growth and development. Causes of the climate change in South Africa were also outlined.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1. INTRODUCTION

Research Methodology consists of a set of specific procedures, tools and techniques that are utilised to gather and analyse data. It should be effective to produces the answers to the research question. Population in the study area has 160 crop farmers. Out of that, the study has used a sample size of 32 respondents, who were randomly selected for interview. Random sampling is one of the most popular methods for choosing a sample among population for a wide range of purposes and has been adopted in the research. Earlier on, data collection was defined as the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. In the study, the data was collected from the primary target. Data analysis involves the drawing of inferences from raw data. It has been processed and analysed using the Statistical Package for the Social Sciences (SPSS). Validity is regarded as an important key to effective research. It is a requirement for both quantitative and qualitative research. Reliability in quantitative research is the same as dependability, consistency and replicability over time and over groups of respondents. Ethical Considerations was defined as a matter of principled sensitivity to the rights of others, telling the truth, respect for human dignity. Consequently, the researcher requested permission to conduct research from the Department of Agriculture in Musina Local Municipality.

3.2. RESEARCH DESIGN

Research design is the overall plan, which connects the conceptual research problems to the pertinent empirical research. It articulates the data required, the methods to be used for collection and how the data will be analysed (Van Wyk, 2012). Research designing is the essential step of a study where the research topic and research problems are identified and presented in a systematic manner. The function of a research design is to ensure that the evidence obtained enables the researcher to effectively address the research problem logically and unambiguously. The design must link the data, which will be collected, and conclusions to be drawn to the initial questions of the study (Yin, 2013). Moreover, it is of paramount importance to be able to connect the

methodology to its appropriate set of research paradigms in order to address research questions and or hypotheses (Wahyuni, 2012).

In this study, the data has been collected from both qualitative and quantitative perspectives. According to Wahyuni (2012), there could be primary and secondary data. The primary data collected using semi-structured interviews whilst the secondary data may the use internal publications provided by participants to the researchers and publicly available data which are relevant to the topic being observed. The qualitative research methodology enables the researchers to obtain relevant information from the sample group through a questionnaire with closed and open-ended questions (Mahama, 2017).

The respondents were given an opportunity to express their experiences and views. The quantitative approach usually involves a large sample, which often uses proxies to measure aspects of the phenomenon of interest which were categorised as being simple and can generalised. The conversion the data into numerical indices and to employ statistical analysis techniques to generalise the findings from a sample of respondents to a population is necessary (Muijs, 2010). This study collected data from the primary with the intention of projecting the results to a wider population.

3.3. RESEARCH METHODOLOGY

Research methodology refers to a model used to conduct a research within the context of a particular paradigm. It comprises the underlying sets of beliefs that guide a researcher to choose one set of research methods over another. According to Van Wyk (2012), research methodology focuses on the research process, tools and procedures to be used. Research methodology should be effective to produces the answers to the research question. A research method consists of a set of specific procedures, tools and techniques to gather and analyse data. In addition, research methodology is also known as a systematic review which is a formalised and repeatable process in order to document relevant knowledge on a specific subject area for assessing and interpreting all available research related to a research question. Breivold *et al*. (2012) attest that research includes the following several stages:

(a) Development of a review protocol,

(b) Identification of inclusion and exclusion criteria,

(c) The search process for relevant publications,

(d) Quality assessment and

(e) Data extraction and synthesis

However, a research method is a theoretical framework that is independent from methodologies and paradigms. A research design is important to connect a methodology and an appropriate set of research methods in order to address research questions or hypotheses that are established to examine social phenomena. A research method that facilitates a deep investigation of a real-life contemporary phenomenon in its natural context is a case study (Woodside, 2010).

The study employed both qualitative and quantitative paradigm. The nature of this study has been determined by the choice of the research methodology. The qualitative approach focuses on understanding the perceptions of individuals. It seeks an insight and is concerned with processes rather than outcomes (Wahyuni, 2012). The style is suitable for the study because it satisfies the research's aim objectives. Conversely, the quantitative approach explains the phenomena by collecting statistical representation, which is analysed using mathematically based methods (Muijs, 2010). There are two main types of quantitative research design which are: experimental designs and non-experimental designs. Experimental designs are known as the scientific method and non-experimental research is done by survey and is very common in the social sciences (Muijs, 2010).

The researcher employed the use of the questionnaire to gather both qualitative and quantitative data pertaining to the effect of climate change in NIS.

3.4. POPULATION

Musina Local Municipality (22° 21' 4.72" S: 30° 02' 22.56" E) is located in the northernmost town in the Limpopo province of South Africa. It is located near the Limpopo river and the border to Zimbabwe (Latitude, 2017). It is the main entry point into the country from countries north of South Africa. Large part of the land in the municipality is used for agricultural purposes ranging from cattle farming, arable farming and game farming. NIS is located in Musina Local Municipality, surrounded by Malale and Madimbo villages. The scheme is situated in the north of the Soutpansberg Mountains and is about 40 km northeast of Tshipise. NIS is located in the Vhembe district North of Limpopo province.

NIS is comprised of 160 farmers. This number does not include livestock farmers as the study was focusing on the crop farmers. The population in this instance is consisted of all farmers in NIS. Population is the entire set of individuals which the findings of the survey are to be taken from (Levy and Lemeshow, 2013).

3.5. SAMPLE

According to Levy and Lemeshow (2013), a sample a set of respondents or people selected from a larger population for the purpose of a survey. Sample design should result in a truly representative sample. It needs result in a minimum error. Again, it has to be practical in the context of money and time available for the research study. It should be in such way so that systematic bias can be controlled.

When selecting a sample size, it is important for a researcher to consider the following principles, which may influence the sample size: the greater the dispersion or variance within the population, the greater the sample will be needed. The greater the desired precision, the larger the sample is needed. The greater the number of sub-groups within the sample, the greater the sample size will be as each sub-group must meet minimum sample size requirements. If the calculated sample size exceeds 5% of its population, then the sample size may be reduced without sacrificing precision (Mootane and Erasmus, 2012).

The primary objective of a sample is to take a section from the population in order to estimate its parameters from the sample (Levy and Lemeshow, 2013). A sample is a finite part of a statistical population whose properties are studied to get information. The study has used a sample size of 32 respondents, who were randomly selected for interview. According to Suresh and Chandrashekara (2012), determining the optimal sample size for a study assures an adequate power to detect statistical significance. It is a critical step in the design of a planned research protocol. Shaping the adequate sample size in qualitative research is ultimately a matter of judgment and experience in evaluating the quality of the information collected. It also depends on how the information is going to be used. The calculation of an appropriate sample size depends on the choice of certain factors and, in some instances, on crude estimates (Suresh and Chandrashekara, 2012).

Study design has a major impact on the sample size. Descriptive studies require a huge number to give acceptable confidence interval for small effects. Moreover, experimental studies require a small sample size. The sample size is required to either reject or accept a study's hypothesis and can only be guided by the a-test. Remarkably, ethical issue should be taken into consideration and the awareness of determination of minimum required sample size. The application of appropriate sampling methods is crucial in order to achieve scientifically and statistically sound results. When a researcher chooses a sample size, it is important to take along with high quality data collection efforts so that it will be able to provide reliable, valid and generalisable results (Suresh and Chandrashekara, 2012).

3.6. SAMPLING METHODS

There is a wide range of sampling methods. However, this study used a random sampling method. The choice of random sampling methods is due to the representativeness of sample group. The application of random sampling methods in practice can be quite difficult due to the need for the complete list of relevant population members and a large sample size. Bryman and Bell (2015) defined random sampling as a method in which each participant in a population has an equal opportunity of being included. Sampling techniques are important because they offer a number of skills that will allow a researcher to reduce the amount of data that is needed for research by considering only from a sub-group (Saunders *et al*., 2012).

Random sampling is one of the most popular methods for choosing a sample among the population for a wide range of purposes. In random sampling, each member of population is equally nominated as part of the sample (Mahama, 2017). The logic behind random sampling is that it removes biasness from the selection procedure and should result in representative samples. The simple random sampling is considered to be the purest and it is a very straightforward probability sampling strategy (Mahama, 2017).

A list of all famers from NIS was prepared. The names were placed in a container. The area of the study consisted of 160 farmers, who each one of the stood a chance to be selected. The list was prepared with the help of extension officers from the Department of Agriculture and 32 names were randomly selected. The selected names were informed about the study. From the farmers who were randomly selected, they were asked for permission to be interviewed.

3.7. DATA COLLECTION

In Wahyuni's (2012) view, data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables subjects to answer stated research questions, test hypotheses, and evaluate outcomes. In this study, there has been a collection of primary and secondary data. The primary data was collected using semi-structured interviews, with the experts in the observed topic from the case organisations. On the other hand, the secondary data constitute internal publications provided by participants to the researcher and publicly available data which were relevant.

A semi-structured interview, which is also known as the qualitative interview, is a hybrid type of interview which lies between structured and in-depth interviews (Wahyuni, 2012). The use of an in-depth qualitative interview is considered as the appropriate format for case study research because its questions cannot be answered briefly. Again, semi-structured interviews consist of several key questions that help to define the areas to be explored, but also allow the interviewer or interviewee to diverge in order to pursue an idea or response in more details (Boeije, 2010). Hence, the approach has been fully conformed in the study.

Positively, the researcher has also adopted the use of questionnaire to collect data. It has been orchestrated in a form of an open-ended design, which also contributed a large amount of data to the study. However, observations were used in situations where people were unwilling or unable to express themselves verbally. The researcher has observed the impact of the environment on the subjects. According to Creswell and Poth (2017), during observations, the researcher must be seen as intrusive and the information observed by him or her is not reportable.

The questions that the researcher has used were organised and all respondents were asked the same set of questions. These questions were both open-ended and close-ended, for the in-depth information from the farmers in NIS about the effect of climate change in the area. Respondents were given a questionnaire to fill and, at some point, they were being assisted to complete where necessary. The aim of using a questionnaire was to survey a representative sample of the population so that generalisation from the respondents could be made.

3.8. DATA ANALYSIS

Wahyuni (2012) buttresses that data analysis involves the drawing of inferences from raw data. It also entails multi-methods, which are applied sequentially. Raw data is generated and managed so that it can be ready for analysis (Boeije, 2010). Quantitative research uses numerical statistics whereas qualitative researches are primarily text-based. In a qualitative research, data management involves three important aspects *videlicet*, data storage, transcribing audio sources, and cleaning the data (Wahyuni, 2013).

For the purpose of the study, a random sample has been used to select farmers in NIS. Data was collected through the use of questionnaires and was processed and analysed using the Statistical Package for the Social Sciences (SPSS), so as to maintain the validity and reliability of the information. Noteworthy is that the analysis involves making sense out of text and image data. However, the responses were summarised and typed using Ms Excel sheets, so as to make it easier to export the data to the SPSS application software. Besides, the mixed method of quantitative and qualitative approaches was used to collect data. That being so, a combination of open-ended and closed-ended questions was used. The open-ended questions allowed respondents to answer in their own words for a more detailed response. That included other questions contained boxes to tick, which did not need an explanation. According to Roberts *et al*. (2014), open-ended responses provide a direct view from the thinking of a respondent yet closed-ended questions do not require respondents to think harder.

However, the strengths of one of the method has been used to overcome the inherent weaknesses of another method (Yin, 2013). That generated new knowledge, insights and has uncovered hidden insights, patterns and relationships that a single methodological approach could not reveal. It also produced a more complete understanding of the research problem that could be used to increase the generalisability of findings applied to the theory and practice (Mertens, 2014).

3.9. VALIDITY

Validity is regarded as an important key to an effective research. It is a pivotal requirement for both quantitative and qualitative research (Cohen *et al*., 2013). In qualitative data, validity might be considered as the honesty, depth, richness and scope of the data achieved. On the contrary, in quantitative data, validity might be improved through careful sampling, appropriate instrumentation and appropriate statistical treatments of the data. Quantitative research possesses a measure of standard error which is inbuilt and must be acknowledged. But in qualitative data, the subjectivity of respondents along with their opinions, attitudes and perspectives contribute to a degree of biasness. Hence, validity should be seen as a matter of degree rather than an absolute state (Cohen *et al*., 2013).

According to Muijs (2010), validity has three distinct aspects which are: content validity, criterion validity and construct validity. In content validity, the content of the manifested variables should rightfully scale the latent concept which has to be measured. Contrarily, criterion validity is closely related to theory. In this case, when developing a measure, it is often foreseen to predict certain outcomes. However, criterion has two main types of validities: predictive and concurrent validity. In predictive validity, the instrument used should predict the outcomes that are theoretically based. But concurrent validity makes a less stringent assumption. The question there is whether the scores on the instrument agree with scores on other factors that are anticipated. Lastly, construct validity is a slightly complex issue relating to the internal structure of an instrument and the concept it is measuring.

3.10. RELIABILITY

Reliability is a way of assessing the quality of the measured procedure used to collect data when conducting a research (Laerd, 2017). For the results to be regarded as valid, the measurement procedure must firstly be reliable. The procedure should be consisting of variables which can either be single or more. Again, the variables measured should be constant. According to Muijs (2010), there is a repeated measurement and internal consistency. Repeated measurement is the ability to measure the same phenomenon different times.

Bryman and Bell (2015) have shown that researchers may use two ways to estimate research reliability such as; test or retest and internal consistency. The test or retest is based on the idea that a researcher should get the same score on both tests (test 1 and 2). Internal consistency refers to

the practise of estimating reliability by grouping requests from the questionnaire, which measure the same concept. The same instrument should come up with similar answers when used on one respondent repeatedly. Hence, researchers are advised to ask the respondents one question at least twice in order to descend whether the same answer will be given or not (Muijs, 2010).

In quantitative research, reliability is the same as dependability, consistency and replicability over time and over groups of respondents (Cohen *et al*., 2013). In this sense, a research must persuade that should it be carried out on another group of respondents, in a similar context it would produce the same results. Reliability, as stability, is a measure of consistency over time and over similar samples (Cohen *et al*., 2013).

The researcher structured questions in way that the respondents were not asked leading questions. The participants were informed so that they could prepare themselves to respond to questions; in order to provide truthful and reliable information. The participants targeted were visited on each individual farm to ensure that the data collected would be not influenced by the other respondents' views. The study concealed information amongst partakers so that they would provide reliable data from their farming practice and gathered experience.

3.11. ETHICAL CONSIDERATIONS

The researcher has requested permission from the Department of Agriculture in Musina Local Municipality. The information obtained has been used only for the purpose of the study. Farmers who participated were informed and their approval was requested prior to conducting interviews. In fact, they were not forced to participate. The researcher has given the participants an assurance that their identity would remain anonymous and their information would be kept confidential.

Fouka and Mantzorou (2011) have identified the major ethical guidelines for research in the following ways:

(a) Respect for anonymity and confidentiality – the researcher must ensure that there is no link between the identity and responses of the participant,
(b) Beneficence – the research must be aimed at benefiting and not to harm,
(c) Informed consent – the researcher must ensure that the participant gives his or her consent and must partake knowing what he or she is doing voluntarily and

(d) Respect of privacy – the researcher must inform the respondents about the aim of the research before collecting data for the research

Noteworthy is that all the above have been conformed during the process of the investigation.

3.12. CONCLUSION

This chapter has managed to explain the description of research design that has been used. The research methodology and population were briefly defined, target population, data collection and sampling method employed were also included. Ethical consideration was highlighted as one of the imperative measures prior to the respondents' participation.

CHAPTER FOUR: RESULTS

4.1. INTRODUCTION

The previous chapter discussed the ways in which the research has been undertaken. This section focuses on the analysis of the data, which is described in tables, figures and a circular diagram. The purpose of this chapter is to present and interpret the empirical findings of the research. In

interpretation, the immediate results are translated into integrated and meaningful statistics and findings. Despite that, the findings have been proved to be related to the objectives of the topic. The success of this study is assured through both the data analysis and interpretation, which are carried out in an orderly manner.

4.2. RESULTS AND DISCUSSIONS

The data that was obtained from the questionnaires was analysed using IBM SPSS statistics (Version 24). Data analysis entailed categorising, ordering, cleaning and summarising the data. The demographic and knowledge questions were analysed through: "descriptive statistics such as mean, standard deviation, minimum and maximum values" (Wegner, 2010). All scaled questions and frequency tables have been used to illustration.

4.3. STATISTICAL ANALYSIS

4.3.1. Statistical software

The data obtained from the questionnaires was analysed using IBM SPSS statistics (Version 24). The analysis entailed categorising, ordering, manipulating and summarising the data to draw meaningful terms.

4.3.2. Descriptive statistical analysis

The data was summarised and presented by making use of descriptive statistics. The demographical information from Section A was analysed descriptively and also described in frequency tables, charts and graphs. Again, percentages were used in the presentation of the findings. The mean, standard deviation, minimum and maximum values for all scaled questions were also computed and used in the explanation of the findings.

4.3.3. Inferential statistical analysis

The inferential statistical analysis, that is, the independent t-test, was used to compare the effect of climate change on the farming business in NIS. Additionally, Cronbach's Alpha was used to test the internal consistency of measurement used for the knowledge variables (Tavakol and Dennick, 2011).

4.4. DEMOGRAPHICAL INFORMATION

The researcher required the personal information of respondents, that included respondents' position, age, gender, Academic or professional qualifications, accompanied by their experience. The demographical information was useful in determining and comparing patterns amongst different categories of the research participants. The table below provides the demographical data of the quantitative survey:

Descriptive statistics		**Frequency**	**Percentage (%)**
Are you the farm owner or the employee?	Owner	31	96.9
	Employee	1	3.1
Gender	Male	24	75
	Female	8	25
Age of the respondent	18 - 35 years	12	37.5
	36 - 50 years	10	31.3
	Above 50 years	10	31.3
Highest level of education	Primary (Grade 1- 7)	3	9.4
	Secondary (Grade 8- 12)	12	37.5
	Tertiary (Diploma and (or) Degree)	17	53.1
	Total	32	100

Table 1: Demographic detail of sample respondents

Based on the demographic data above, the prevalence of respondents who owned a farm constituted 97% higher than respondents who were employed. Most of the respondents were males and constituted 75% while females' counterpart was only 26%. In terms of age, the majority of the respondents were aged between 18 and 35 years whereas those who were between the age of 36 and 50 years and, more than 50 years, constituted 31% each. With attention to academic qualifications, more than half of respondents (53%) indicated that they had tertiary education while a few had primary education (9%).

4.5. RELIABILITY

The internal consistency of the knowledge scale was calculated using Cronbach's Alpha and the average Inter-Item Correlation. These values are presented in the table below:

Scale	Cronbach's Alpha	Average inter-Item Correlation	Number of Item
The effect of climate change on the farming business in NIS	0.134	0.063	19

Table 1: Internal consistency reliability values of scales

The values of Cronbach's Alpha are acceptable for both the scales, if they are greater than the minimum acceptable value of 0.6. Furthermore, the value of the average inter-item correlation is greater than the minimum acceptable value of 0.3. The Cronbach 's Alpha of this study is 0.134 and the average inter-item correlation is 0.063, less than the acceptance value of Cronbach's Alpha and average inter item correlation.

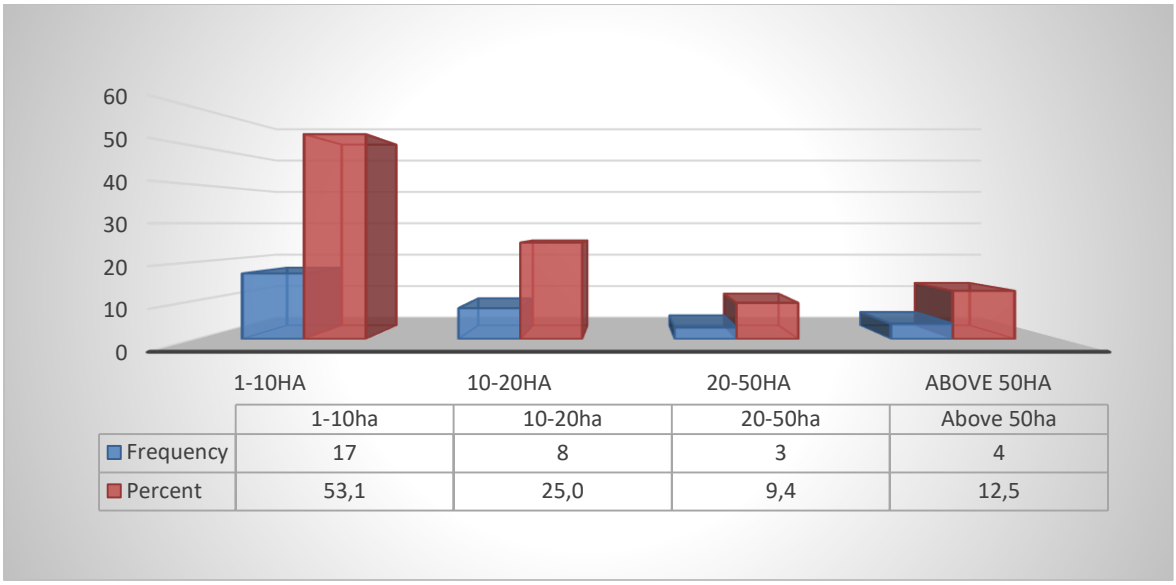
4.6. RESULTS

This subdivision presents the results of the research. The structure has been used to present the item level responses, followed by the scale level responses and lastly, the tests of the hypotheses. The following assembly has been followed for each sub-research questions:

(a) Does high temperatures in Nwanedi Irrigation Scheme cause stress on livestock?
(b) Does high temperature in Nwanedi Irrigation Scheme play role in soil water deficit soon after irrigation?
(c) Does water deficit affect fruits and vegetable at Nwanedi Irrigation Scheme?
(d) How will climate change affect the productivity?

- **Responses to details of the farm**

There was a need to determine the size of the farm in order to enable the researcher to make demographic inferences concerning the respondents. The figure below depicts size of the farm:



	1-10ha	10-20ha	20-50ha	Above 50ha
Frequency	17	8	3	4
Percent	53,1	25,0	9,4	12,5

Figure 1:Size of the farm

The above has respectively shown that amongst the respondents, 17(53%) of them indicated that their farm had 1 to 10ha. Again, 8(25%) specified that the farm had 10 to 20ha whereas 3(9%) shown that their farm had 20 to 50ha and only 4(13%) of the respondents affirmed that their farm was above 50ha.

- **The following is a table representing how many people were farming and the size of land they occupied:**

	Frequency	Percentage (%)
1	1	3.1
2	2	6.3
3	1	3.1
3	2	6.3

4	5	15.6
5	2	6.3
5	2	6.3
6	3	9.4
7	1	3.1
8	1	3.1
10	2	6.3
12	1	3.1
15	1	3.1
15	1	3.1
20	1	3.1
25	2	6.3
32	1	3.1
35	1	3.1
40	1	3.1
65	1	3.1
Total	32	100.0

Table 3: Hectares that are currently under the production

The table above has shown that 5 (15.6%) people were currently farming on 4ha of their land. On the other hand, about 3 (9.4%) persons occupied 6ha, with 2 of them using 2ha and 3ha, which constituted 6.3% of their capacity. But majority of the farmers used on 3.1% of their full capacity.

- **The chart below visualises the quantity of the crops and livestock was available amongst the farmers:**

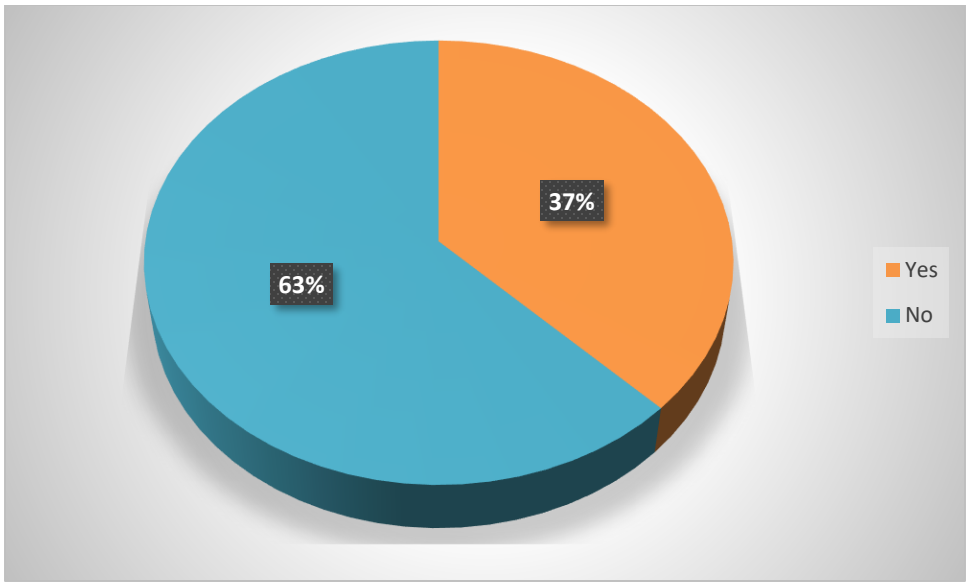


Figure 2: Has your farm been your farm used to the full capacity?

The above chart illustrated that 12 farmers (37%) used their farm to the fullest capacity and 20 farmers (63%) did their farm to the full capacity. Hence, the majority of farmers in this study revealed that they were using their farm to the full capacity.

- **Below are the reasons for using or not using the farm to its capacity:**

	Frequency	Percent
Not indicated	10	31.3
de bushing	1	3.1
financial problem	1	3.1
he left an area which needed debushing	1	3.1
lack of capacity	1	3.1
lack of finance and shortage of water	1	3.1
lack of funds	6	18.8
lack of resources	1	3.1
low water supply to other portions	1	3.1
money to acquire input	1	3.1
n/a	2	6.3
no money to develop	1	3.1
no more to buy seeding	1	3.1
other portion is rocky	1	3.1
to give the land rest	1	3.1
to give timbale	1	3.1
water, the former hire water from the neighboring farm	1	3.1

Total	32	100.0

Table 4: If no, what are the reasons for not using the farm to the full capacity?

In the above table, 10 (31.3%) persons did not indicate the reason why they were not using their farm to its fullest capacity. However, 6 (18.8%) of them lacked funds in order to use all the land. The results show that 3.1% of the farmers had been facing financial challenges, which lead them not to be able to buy farming inputs such as seeds or seedlings, water supply mechanisms and debushing material.

- **The following are the number of years that the farmers had been in production:**

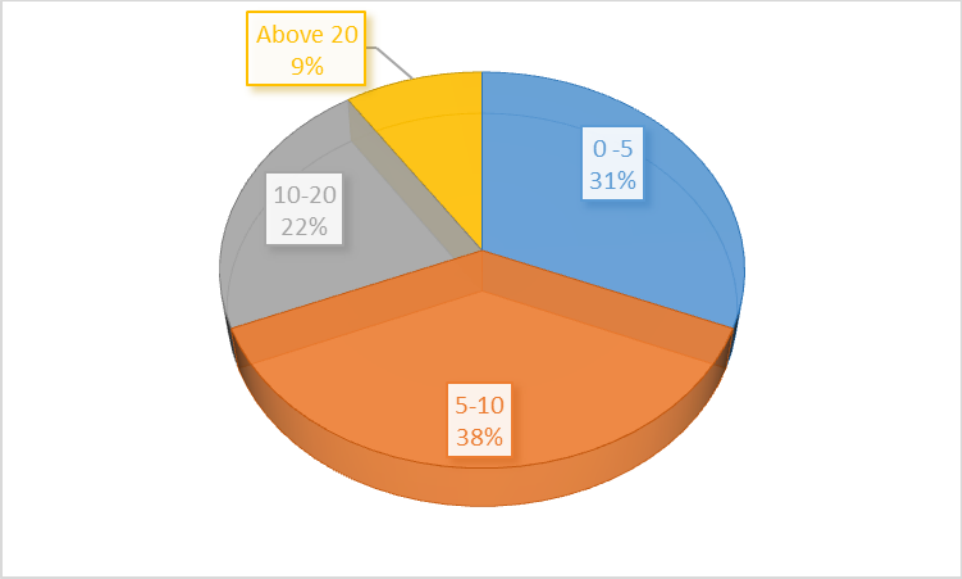


Figure 3: How many years were you farming in Nwanedi Irrigation Scheme?

The pie chart above portrayed the highest percentage of 38%, out of 12 farmers who had been farming in Nwanedi irrigation range from 5 to 10 years. About 10 farmers had 0 to 5 years of experience in farming around the area, which constituted (31%). Farmers who had been farming for more than 10 years were 7, which constituted 22%. The results shown that the lowest numbers of farmers who constituted 9% were only 3 – who had more than 20 years of farming knowledge in Nwanedi Irrigation Scheme. That was also illustrated in the Figure 3 below:

- **Respectively, the table shows the major crops:**

Tomatoes
Butternut
Maize
Okra
Watermelon
Chilies
Moringa
Samberg
Beans
Pumpkins
Cabbage
Gem squash
Egg plant
Onion
Indian spice
Spinach
Baby veg

Table 5: What are the major crops that you grow?

The table above exemplified the major crops grown in NIS. The crop arrangement is verically in ascending order. The most produced crop by almost every farmer was Tomato, Butternut, Maize, Okra, and Watermelon.

- **Depicted below are the main sources of water:**

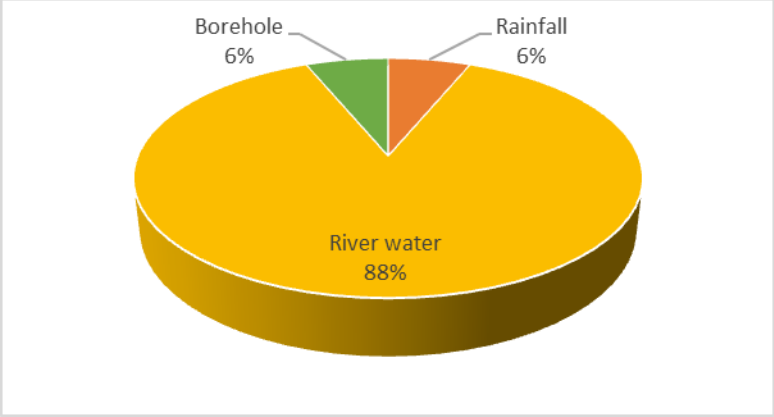


Figure 4: What are the sources of water you use for irrigation?

The results, as shown by the figure above, depicted that 28 farmers in the area of study relied on river water as their source of water, which constituted 88%. Only 2 farmers (6%) used rainfall water and 2 (6%) had boreholes as their source of water for watering their crops.

- **The bar shows the responses to climate change question, accompanied by a table:**

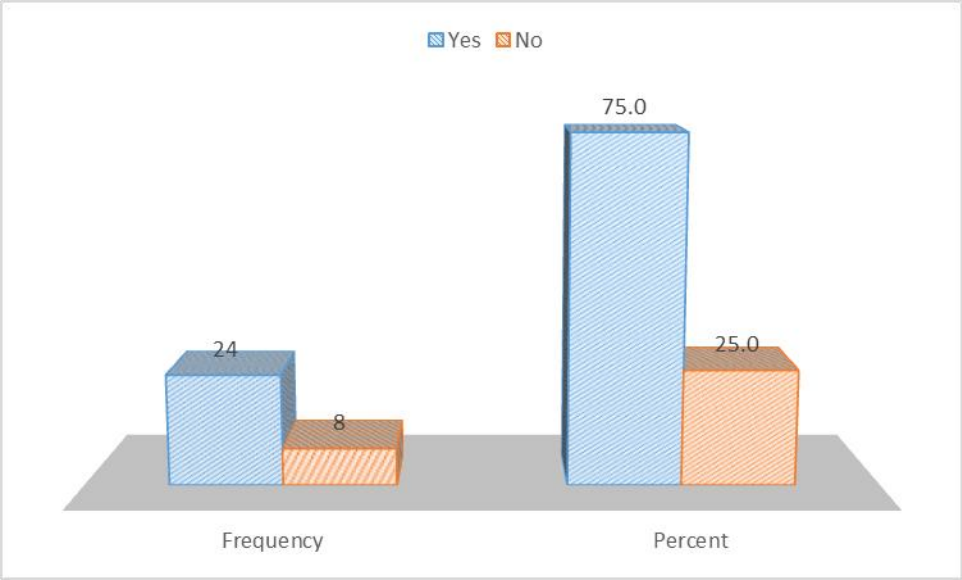


Figure 5: Have you ever heard about a climate change?

The results have shown that, 24, out of 32 respondents had heard about climate change and that constituted 75% of the population. Only 8 (25%) farmers had never heard about the climate change. The results are also illustrated in the figure below:

	Frequency	Percent
Yes	7	21.9
No	25	78.1
Total	32	100.0

Table 6: Have you ever attended any programme on climate change?

Equally important, the table above echoed that 25 (78.1%) farmers had not attended any programme on climate change. Only a few farmers, 7 (21.9%) had attended workshops about the calamity.

- **The table illustrating an understanding of climate change:**

	Frequency	Percent
	1	3.1
change of climate	2	6.3
change of seasons	2	6.3
change of weather	2	6.3
changing of climate	2	6.3
climate change	1	3.1
disease in crops	1	3.1
drought related	1	3.1
extreme weather conditions	1	3.1
increase in temperature	1	3.1
is the change of weather seasons	1	3.1
it is the change of weather	1	3.1
n/a	2	6.3
never ending dry spell	1	3.1
no idea	3	9.4
Nothing	2	6.3
rain is not raining like before summer is too hot	1	3.1
temperatures increasing	1	3.1
things are changing from good to bad	1	3.1
to extreme hot temperatures	1	3.1
weather changing	2	6.3
weather patterns are changing	1	3.1
winter is not cold like previous years	1	3.1
Total	32	100.0

Table 7: What do you understand about the concept "climate change"?

The results, as shown in the above table, projected that farmers had different understanding about the concept of "climate change". About 9.4% (3) and 6.3% (2) had no idea what was climate change. On the majority of people who said they understood the concept, did not fathom it as anything that would have an impact on the weather change in terms of lack of rain and extremely hot temperatures, which constituted (6.3%).

- **A representation of how climate change affected production:**

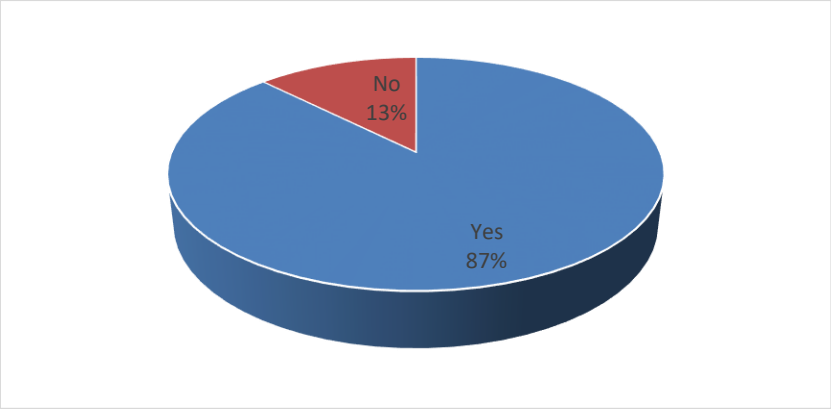


Figure 6: Have you ever noticed the difference in climate change in terms of production if it is declining?

The results shown that the majority, 28 (87%), of the respondents had noticed the difference of their production, declining as a results of climate change. Nevertheless, only 13% had never noticed or observed the low production due to climate change.

- **Signs of the impact of climate change:**

	Frequency	Percent
Not indicated	4	12.5
affected production	1	3.1
crops that adapt well in winter are affected due to warm winter season	1	3.1
crops which prefer cold weather grow excessively and during the day	1	3.1
Drought	1	3.1
dry season is long and affects tomatoes	1	3.1
high temperature	1	3.1
indirection of new disease they did not know	1	3.1
it is hotter	1	3.1
less rain than the past years	1	3.1
low production	1	3.1
more disease came using the river water which was not flowing	1	3.1
much colder and less rain	1	3.1
no rain	2	6.3
plants shrinking	1	3.1
production decline and it cast me as a farmer to use more money to get good products	1	3.1
production went down	1	3.1
sunburn on tomatoes, irrigation period as how longer	1	3.1
temperatures get very high and it doesn't	1	3.1
the disease on crops is too much	1	3.1
the insects are increasing	1	3.1
this farm used to receive a huge amount of rain and fill the river	1	3.1
time duration of rainfall affects production	1	3.1
time of winter ending and starting has changed	1	3.1
water shortages liming production	1	3.1
we use to harvest for longer periods	1	3.1
weak crops due to heat	1	3.1
winter is short and summer rain is late	1	3.1
Total	32	100.0

Table 8: If yes, explain what you have observed

The table above embodied that 4 (12.5%) people had not observed if the production was declining, however, 2 (6.3%) had observed that the area ran short of rainfall as a result of climate change. But within the majority of the respondents, each had his or her own observation from drought, high temperature and an outbreak of various diseases.

- **The influence on profit generation:**

	Frequency	Percent
Not indicated	1	3.1
affects us a lot and loss profit	1	3.1
change of rain patterns affect production and profit	1	3.1
if no rain the will low quality	1	3.1
if the is too much dew the farmer must use lot of money to buy chemicals	1	3.1
in previous years when we plant tomato in summer we could still get some harvest in winter	1	3.1
increases cost because irrigate more	2	6.3
it decrease production	1	3.1
it decrease the income	1	3.1
it decreases from 100 to 80 percent	1	3.1
it limit production profit per hector. Without water no farming	1	3.1
less profit as production is decreased	1	3.1
loss profit	1	3.1
low production	2	6.3
low yield cause low profit	1	3.1
more disease will need more money	1	3.1
most of the time we face drought and during summer is too hot	1	3.1
no idea	2	6.3
no it doesn't	1	3.1
planted what does not consume	1	3.1
poor quality of tomatoes	1	3.1
production cost is too much which make a loss	1	3.1
production decrease when planting winter crops which do not grow efficiently due to hot temperatures	1	3.1
profit is affected negatively	1	3.1
quality of products decline and producing less tons	2	6.3
there was no production which means no cash flow	1	3.1
unstable markets	1	3.1
we irrigate less as there water restrictions	1	3.1
Total	32	100.0

Table 9: How does the climate change affect the profit generation of your farm?

In the table above, the results of the respondents who saw the impact of climate change on the profit generation of their farm was portrayed. About 6.3 % (2) of them had observed the decline in quality, which affected the total tonnage they had used to produce prior the impact of climate change, whilst others observed low production from their production. Others observed the increase

in cost of production because they had to irrigate more than usual, due to high temperature, which made evaporation rate to become too much. The results also shown that 2 (6.3%) had no idea if their profits were affected. Some individuals 1 (3.1%) had observed a loss as their production decreased when planting winter crops that did not grow efficiently due to hot temperatures, change of rain patterns affect production and profit.

- **Growth involvement and climate change:**

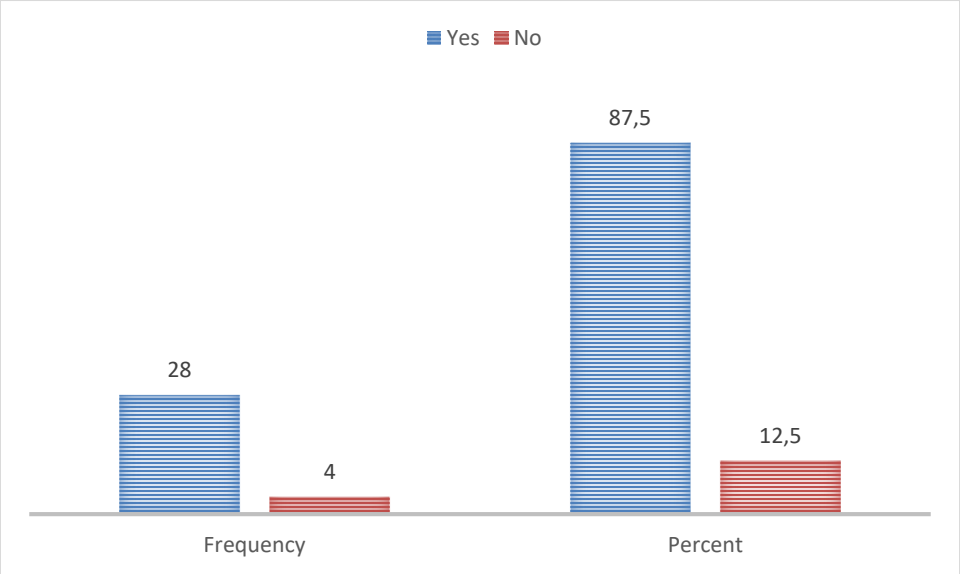


Figure 7: Does climate change affect the growth and yield of the crop production?

Above represented was that 28 (87.5%) agreed that climate change affected the growth and the yield of the crop production. The majority had observed it from their farming activity that due to climate change, their crops had a challenge in terms of growth, which had negatively affected the total yield that was expected per hector. Moreover, only 4 (12.5%) had not observed the impact of climate change on the growth of their crops and the total harvest (yield).

- **Motives resulting from growth and climate change:**

	Frequency	Percent
Not indicated	4	12.5
adaptability of a crop to new climate	1	3.1
as pest increase due to high temperature the yield decrease	1	3.1
crop runs dry for longer period due to high evaporation rate and impact crop development	1	3.1
growth affect quality	1	3.1
hot conditions affects crops	1	3.1
in okra in cold weather the harvesting period takes time	1	3.1
it affects the yield as there are no easy irrigation schedules	1	3.1
it decreases, and affect profit	1	3.1
it stop the who production	1	3.1
low production as a results	2	6.3
moisture in the soil affect growth and crop take longer	1	3.1
harder to produce	1	3.1
new pests and low rainfall	1	3.1
no production on the farm	1	3.1
pest increase due to high temperature yield decrease	1	3.1
pests come when weather is favourable	1	3.1
poor crop stand , low yield	1	3.1
products are of poor quality	1	3.1
reduce the yield per ha	1	3.1
slow growth of crops cause low yield	2	6.3
sometimes it is slow and ripen very fast	1	3.1
the chemicals used as insecticides are sometimes not effective	1	3.1
tomatoes get burn	1	3.1
when it is too hot quality of tomatoes is affected	1	3.1
when it's cold growth is slow	1	3.1
yield is reduced	1	3.1
Total	32	100.0

Table 10: If yes, explain

The table above has shown the results of the respondents who agreed that they had observed an impact of climate change on the growth and yield of their products or crops. About 2 (6.3%) of them had observed a low production whilst the other 2 (6.3%) had observed a slow growth of crops. Their crop took longer period to grow, which resulted in low yield and it needed more production inputs that also impacted the production costs. The majority of the respondents had

their own experience, differed from each and that constituted (3.1%), which ranged from pest increase due to high temperature the yield decrease, crop runs dry for longer period due to high evaporation rate and influence on crop development.

- **Responses pertaining to drought:**

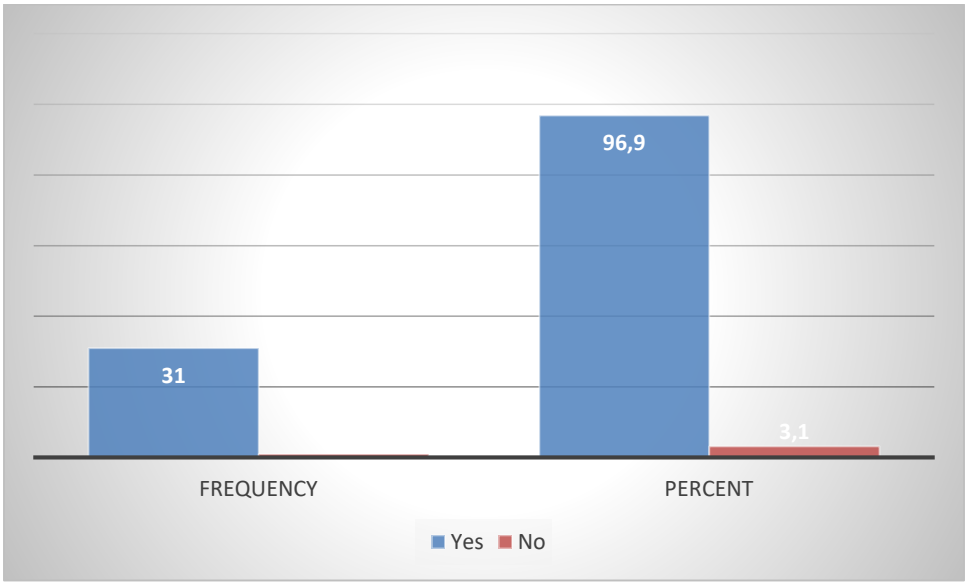


Figure 8: Have you ever experienced drought over recent years?

The results have shown that 31 (96.9%) had experienced dryness, in the recent years as, illustrated by table 14 and figure 10. Fortunately, only 1 (3.1%) had not encountered drought in recent years of farming experience.

- **How drought affected profit making:**

	Frequency	Percent
Not indicated	1	3.1
I used 2 hectors instead of 7 due to lack of water	1	3.1
it decreased	1	3.1
last year we face drought	1	3.1
less production	1	3.1
low production in farm	1	3.1
low rainfall affect production	1	3.1
no farming activities	1	3.1
no production	2	6.3
no production and no profit	2	6.3
no production due drought	1	3.1
no production farm closed down	1	3.1
no production for more than 8 months	1	3.1
no production for the whole year	1	3.1
no production took place due to water shortage	1	3.1
no production/farming activities were done	1	3.1
Have planted but production had to stop	2	6.3
production stopped	1	3.1
production was decreased	1	3.1
production was low	1	3.1
stop the whole production because the was no water in the rivers	1	3.1
the was no production	1	3.1
the was no production with profit	1	3.1
there was no production	1	3.1

Table 11: If yes, what was the impact on the production and your profit generation?

The table above depicted the results of how the farmers were affected by drought weather condition of the farming business in Nwanedi Irrigation Scheme. About 2 (6.3%) did not plant anything on their farms which meant that no profit was generated during the drought period. They did not have alternative water solution to water their crops. On the other hand, other respondents had planted 2 (6.3%) but had to stop with the production along the way as there was no water to water their crop. There was enough water to plant but later they could not access water as a result of scarcity by drought. The results also shown that each farmer had experienced the effect of drought differently.

- **Impact on jobs:**

	Frequency	Percent
Not indicated	1	3.1
as there was no production and profit I had to retrench them	1	3.1
drought affected our production	1	3.1
during drought no jobs	1	3.1
employees lost jobs	4	12.5
employment was affect negatively	1	3.1
famers were not working and staying at their homes	1	3.1
farm employee were jobless	1	3.1
had to let employees go	1	3.1
lost job cause the was no activity happening in the farm	1	3.1
many employees had to be cut because the production was less	1	3.1
most of them were stop to work and production	1	3.1
n/a	1	3.1
no employment	1	3.1
no employment at all	1	3.1
no employment was done during drought conditions	2	6.3
no jobs	2	6.3
no jobs on farm	1	3.1
no jobs on the farm	1	3.1
no of employees reduced	1	3.1
no production no work	1	3.1
no temporal workers were hired	1	3.1
there was no work at all	1	3.1
we had to retrench all workers	1	3.1
with no production no income and employment	2	6.3
workers were let go	1	3.1
Total	32	100.0

Table 12: How did the drought affect employment or your employees?

The results shown that 4 respondents (12.5%) had to stop employees from coming to work, in other words, employees had lost jobs. The other 2 (6.3%) could not create jobs for the employees as there was no activity taking place in the farming field. Therefore, employees had to be stopped until further notice. In a situation where the farmers had a huge number of employees, some had to be reduced because there was a meagre production, which did not need more workers. On the other hand, some had to cut all employees because there was absolutely no farming activities taking due to lack of water. Because crops rely on water for development, with no water supply, everything had to stop.

- **Responses to low rainfall:**

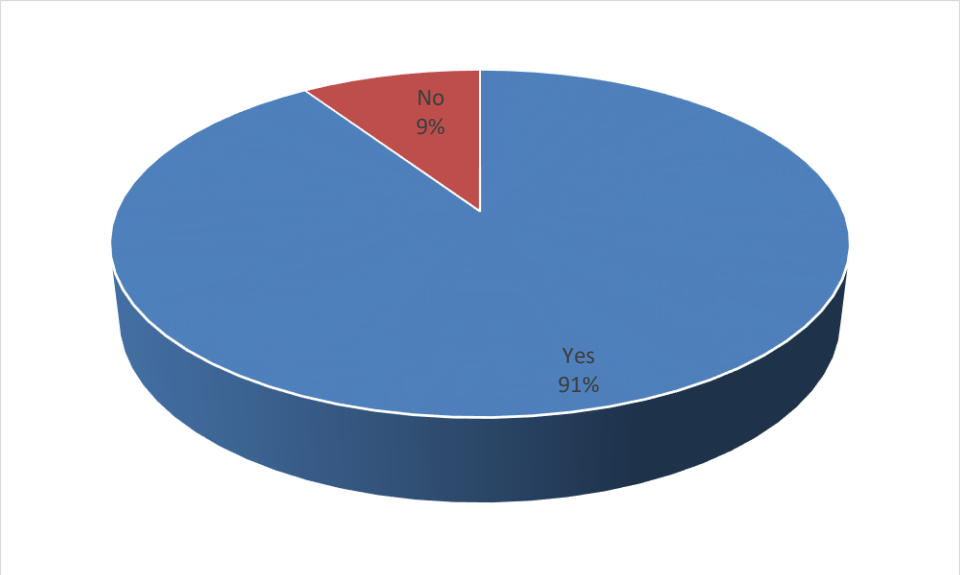


Figure 9: Have you ever experienced low rainfall?

The results above shown that the majority of farmers experienced a low rainfall in Nwanedi Irrigation Scheme. Yet only 3 (9%) did not experience low rainfall.

- **The impact of low rainfall:**

	Frequency	Percent
Not indicated	3	9.4
affect yield and profit	1	3.1
dams and rivers	1	3.1
River was empty before production cycle complete	1	3.1
dams were only left with water for animals and farming stopped	1	3.1
expected yield will be low the target	1	3.1
had to irrigate more	1	3.1
had to struggle to get water	1	3.1
lack of water for irrigation	2	6.3
less production	1	3.1
little rainfall affect production	1	3.1
low production with low quality which affect price of crop	3	9.4
low water being pump from the river which resulted to irrigation scheduling by farmer	1	3.1
low yield and of low quality	1	3.1
low yields as the river water was cut off	1	3.1
lower production	1	3.1
no much impact because Nwanedi is low rainfall	1	3.1
planted few tomato	1	3.1
reduce production	1	3.1
river runs dry	1	3.1
shortage of water	1	3.1
the impact was not that much	1	3.1
the level of water	1	3.1
the was low production yield	2	6.3
water restriction	1	3.1
we had to plant for small space of time	1	3.1
Total	32	100.0

Table 13: If yes, what was the impact?

The results on the above table revealed that 3 (9.4%) people had experienced low rainfall, which resulted in low production at the expense the price of crops. Due to low rainfall, there had been a meagre water supply before the production cycle could be completed, which affected the growth and development of crops. Due to that, the crop yield and quality were low and had negatively affected the profit. However, some respondents did not observe the impact of low rainfall. When the area was experiencing a low rainfall, the river had a challenge of supplying water to all farmers

at once; some areas were affected to a point that they had to cut supply of water from the river to other farmers as the river was having few or little to support all the farmers.

- **Floods in Nwanedi area:**

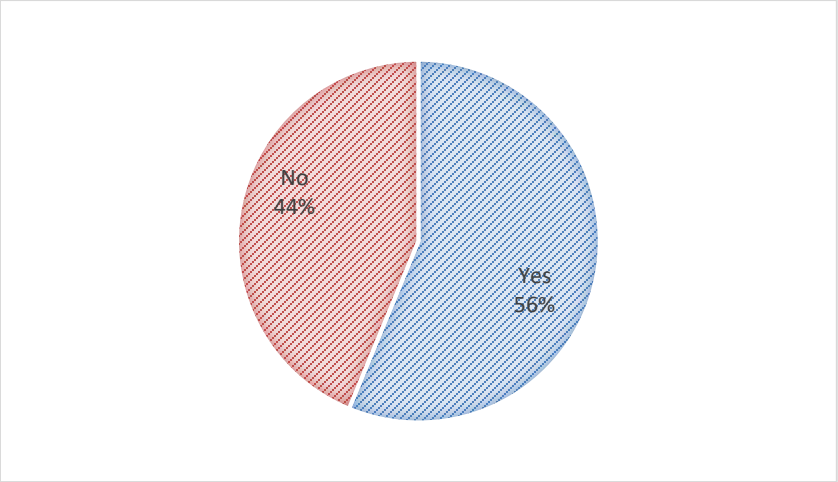


Figure 10: Has this farm or Nwanedi Irrigation Scheme in particular, ever experienced flooding in the recent years?

The results show that 18 (56%) experienced flooding in the recent years of their farming experience in NIS. While 14 (44%) had not experienced flooding in their farming experience in the recent years in the area of the study. See figure 12 and table 20, which illustrated the results.

- **The impact of floods:**

	Frequency	Percent
Not indicated	11	34.4
affected pumps	1	3.1
drips were washes away by floods	1	3.1
erosion was experienced and irrigation pipes were washed away	1	3.1
farms down the river damages on their irrigation systems	1	3.1
flood caused farmers to lose their pipes and remain without irrigation infrastructure to irrigate	1	3.1
in 2012, motors and pumps were washed away	1	3.1
irrigation system by the river were washed away	1	3.1
it eroded the soil and infrastructure was all taken away by floods	1	3.1
loss of property and crops	2	6.3
most crops were eroded	1	3.1
n/a	3	9.4
people lost pumps	1	3.1
pump engines where washed away	1	3.1
lost pumps	1	3.1
the was no production at all	1	3.1
the was soil erosion and floods	1	3.1
irrigation system damaged	1	3.1
washed away some pumps	1	3.1
Total	32	100.0

Table 14: If yes, what was the impact?

The table above depicted the experience that was observed during floods in NIS. Many people from their individual farms had lost property (been damaged) and had lost their crops (6.3%). The top soil, which was important to the crop, was washed away by floods and that affected the crop development. Most farmers had lost irrigation pipes because they were washed away by the floods. The engine and motor pump that had been used to pump water from the river were also washed away. Again, others could not do any farming activity because when there were floods, there was no time to prepare the land and those who had already planted could not save their crops.

- **Responses to inorganic fertilisers:**

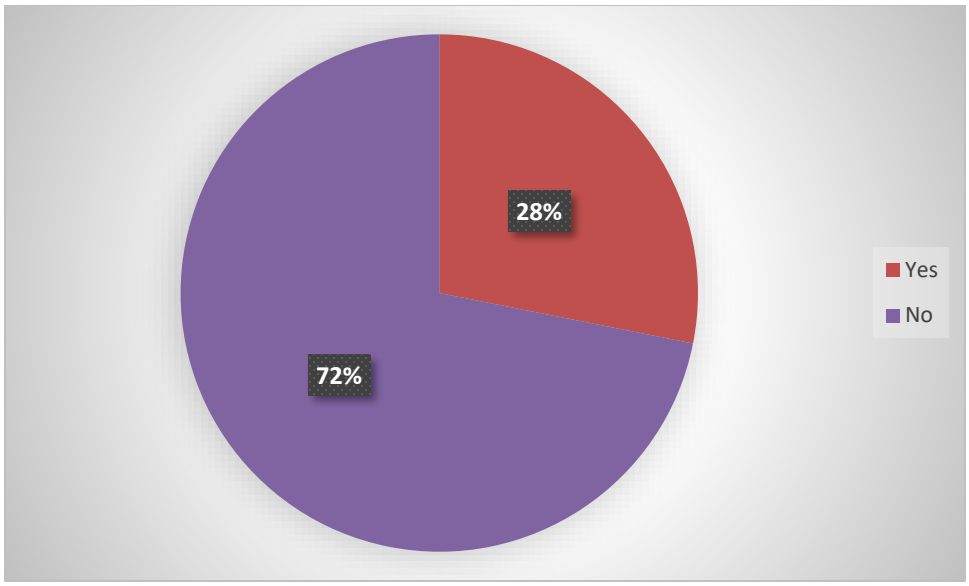


Figure 11: Do you know that the application of inorganic fertilisers and the use of tractors (CO2 emission) in the farm contribute to greenhouse effect?

The figure above (and Table 22) shown that majority of farmers (23 (72%)) in NIS did not know that application of inorganic fertilisers and the use of tractors (CO2 emission) in the farm contributed to greenhouse effect. Conversely, they did not even know what greenhouse effect was. However, nine (28%) of them knew the impact of the emission from the tractors that they used as well as the application of inorganic fertilisers.

- **Planting and harvesting the same crop:**

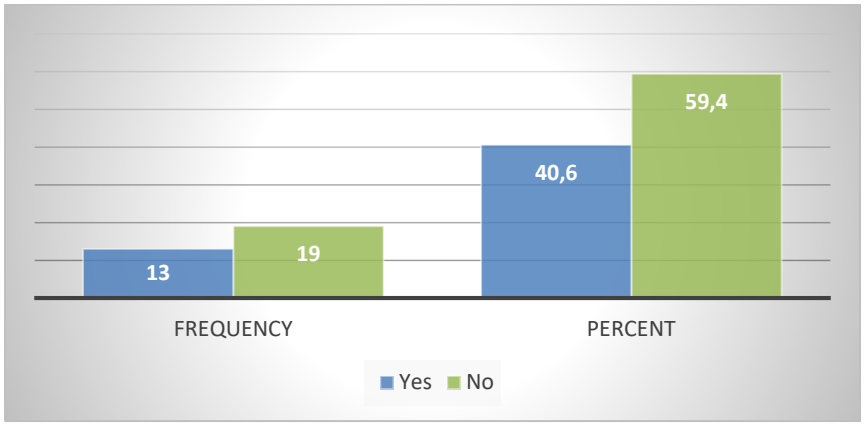


Figure 12: Are you still able to produce the same crop and able to harvest same yield that you have been planting over the past years?

In the above results, 19 (59.4%) persons were not able to produce and harvest the same crop within the same yield that they had been planting in over the past years (see above table 23 and figure 13). But only 13 (40.6%) people had the ability to produce.

- **Changes in production:**

	Frequency	Percent
Not indicated	12	37.5
after flood the bome of plant was less than before	1	3.1
as temperature increased pest were introduced which results in low yield	2	6.3
disease and lack of water	1	3.1
drought and shortage of workers	1	3.1
harvest low	1	3.1
harvest less time more especially on tomato, we used to harvest more than one months but now things have changed	1	3.1
high production cost	1	3.1
knowing your soil status is important	1	3.1
lack of rainfall caused yield to go down	1	3.1
last year's drought had an impact on her finance	1	3.1
less production	1	3.1
low yield due to high temperatures	1	3.1
many disease and pests due to high temperature	1	3.1
moisture is evaporated to quickly due high temperature	1	3.1
n/a	1	3.1
soil has lost its nutrients	1	3.1
the timing of planting has changed and marketing for produce is difficult	1	3.1
there is a decline size	1	3.1
tons have gone down	1	3.1
Total	32	100.0

Table 15: If no, what has changed?

The table above exhibited the different answers of the respondents who had experienced the difference of the yield. Moreover, they were experiencing low yield due to high temperature, which, created a conducive environment for pests that constituted to 6.3% (2). But one of the respondents had shown that there was a real change which he or she could observe, more especially, with tomato production. Again, harvesting time was reduced contradicting with that he or she used to harvest more for than one month. Furthermore, others were experiencing various

diseases and pests due to high temperature and moisture that evaporated to quickly due high temperature. Hence, the tonnage that they used to harvest per hectors had gone down.

- **Pests and diseases in the farm:**

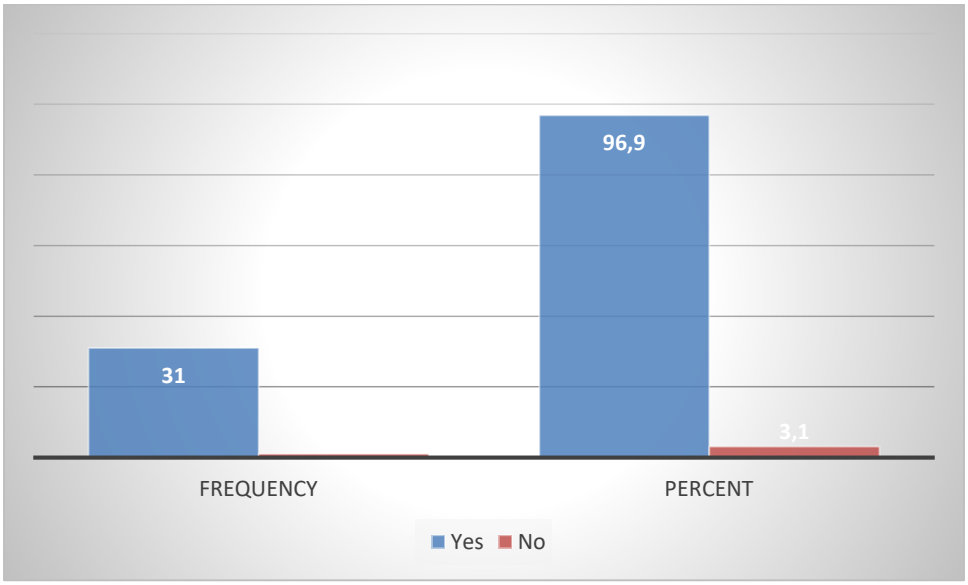


Figure 13: Do you encounter increase in pests and diseases when farming in this area as opposed to previous years of farming?

The overhead outcomes shown that 31 (96.9%) farmers had agreed that they had observed an increase in pests and diseases when farming. That had opposed the previous years of farming as indicated above by figure 14 and table 25. It was only 3.1% of toilers who did not experience an increase in pests and diseases when farming in NIS.

- **How pests and diseases affect the business:**

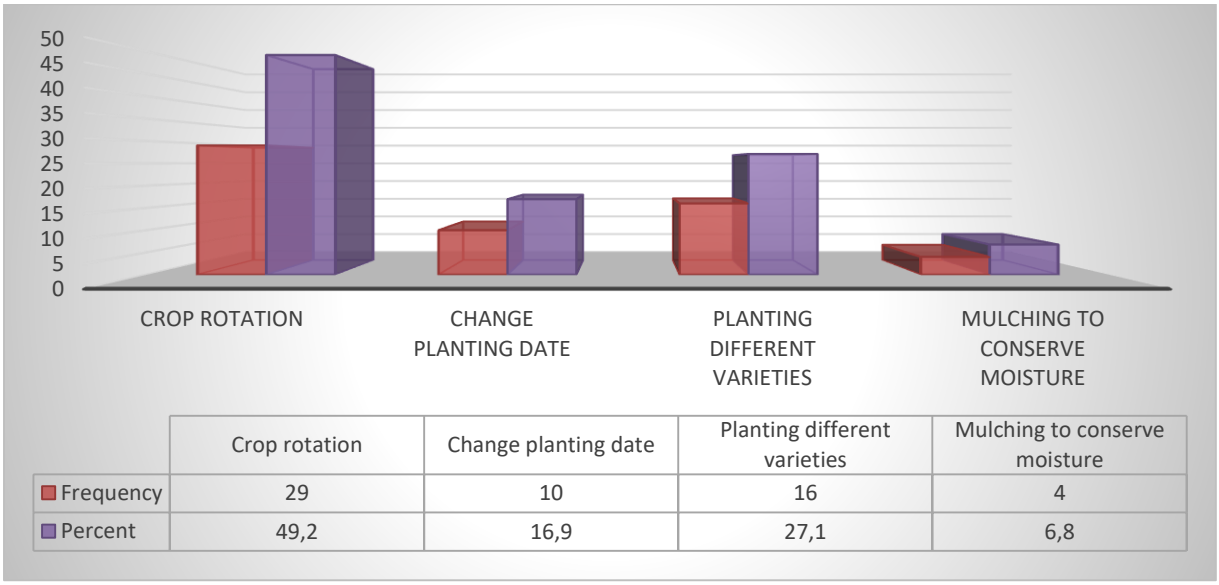
	Frequency	Percent
affects production and profit	2	6.3
had to buy more insecticides/fungicide to control pest	1	3.1
high temperatures	1	3.1
increase in temperature	1	3.1
increase the cost by needing labour and expensive chemicals	1	3.1
increase in temperature resulted in low yield	1	3.1
it decreases the yield and profit	1	3.1
it didn't affect the profit	1	3.1
it reduce profit because we buy chemicals which are expensive	1	3.1
loss of profit	1	3.1
low production	1	3.1
low quality which decrease profit	1	3.1
low yields and low profit	1	3.1
more labour and costing more to produce and reduce profit	1	3.1
n/a	1	3.1
need to buy expensive chemicals	1	3.1
pest affects yield ,production and profit	1	3.1
pests and disease is increasing it affect yield production	1	3.1
produce low quality crop	2	6.3
profit is lost because of expensive chemicals	1	3.1
reduce yield , appearance and quality	1	3.1
the damage the crops	1	3.1
there are new pests	1	3.1
they demand tomatoes	1	3.1
they demage crop	1	3.1
tuta absoluta damages tomatoes	1	3.1
tuta is eating crops	1	3.1
we are experiencing new pests like tuta absoluta with not insecticides to control it	1	3.1
when new pest invade this results in more chemicals being bought which costs	1	3.1
yield decline and profit will be less	1	3.1
Total	32	100.0

Table 16: If yes, how do they affect the business in terms of yield, production and profit?

The upshots, as shown above, revealed that 2 (6.3%) farmhands had experienced that the increase of pests and diseases affected the production, and eventually, the profit. Noteworthy is that others

(2 (6.3%)) had observed that the crops that they produced were of low quality, and that had a low standard, as required by the market, which affected profit generation. The results also shown that they had to spend a lot of money to buy more insecticides and fungicide to control pests and diseases. It was also illustrated that the farmers were experiencing new pests such as Tuta Absoluta, which were not there before and they had not yet found the insecticides to control them. When there was an increase in pests and diseases, more chemicals had to be purchased and that led to a high cost of production and had affected the profit generation.

- **Strategies of coping with climate change:**



	Crop rotation	Change planting date	Planting different varieties	Mulching to conserve moisture
Frequency	29	10	16	4
Percent	49,2	16,9	27,1	6,8

Figure 14: What are your coping strategies to minimise the impact of climate change?

The above depiction manifested that 29 (49.2%) farmers applied crop rotation as a strategy to minimise the impact of climate change. However, about 10 (16.9%) of them changed planting date to minimise the impact of climate change. The results also shown that 16 (27.1%) persons planted different crops to stand chances of gain. But few respondents used mulching to conserve moisture as one of the coping strategy to inhibit the impact of climate change.

4.7. CONCLUSION

This chapter has presented a summary of the results that were gathered from NIS. The outcomes were transcribed without biasness and they were accurately organised of the purpose of the study's integrity and reliability.

CHAPTER FIVE: DISCUSSION

5.1. INTRODUCTION

This chapter outlines the overview of the study, where the study was investigating the impact of climate change on the farming business in Nwanedi Irrigation Scheme and findings from literature review. It was found that South African economy relies on agriculture and, therefore, it is crucial to understand the changes in climate that could affect agriculture. The findings from an empirical study were outlined in the previous chapter. Again, verdicts from the interviews have also been outlined and it was found that majority of the respondents were the owners of the farms, who had different understanding about the concept of "climate change". Recommendations have been offered and one of the key to aspect is to plant hybrid planting materials, which will be able to resist high temperature and to utilise little moisture to survive. Recommendation for further research is to conduct the same study in other parts of Limpopo province and other provinces within the borders of South Africa. Limitation of the study was also outlined.

5.2. OVERVIEW OF THE STUDY

The study investigated the impact of climate change on the farming business. Agriculture is an important economic sector in Limpopo province and it contributes to its economy and the employment opportunities. In South Africa, smallholder irrigation schemes are of paramount importance. The study has offered literature review related to the topic, which indicated that climate changes posed a serious challenge in farming business in NIS. Farmers will have to change their current practices in response to climate change, for instance, sowing a variety of crops, changing the timing of field operations and or expanding irrigation systems (Lobell and Gourdji, 2012). The materials and methods used for this study were also represented in Chapter 3, where it was defined that the research design showed the overall plan, which connected the conceptual research problems. It also articulated the data required and the methods to be used to collect and how the data will be analysed (Van Wyk, 2012).

The results shown that farmers had experienced drought in a different ways, that is, some farmers used a small piece of land instead of total due to lack of water. Those who managed to produce have harvested too little, and eventually, less profit was made. It was also shown that some farmers

had to stop employees from going to work, in other words, employees had lost jobs. Hence, low yield was experienced due to the high temperature that created conducive environment for pests.

The study aimed to find out if Nwanedi irrigation farmers were affected by the effect of climate change. However, it has been found that there was an impact of climate change on their operation. The researcher needed to found out how the farmers coped when such impacts were experienced. That being so, some farmers do not know and understand that there was climate change. That obscured them to rapidly descend some of the coping methods. The majority of people who believed that climate change was real adapted to the strategies to minimise the impacts.

5.3. FINDINGS FROM LITERATURE REVIEW

South Africa and most of the African countries rely on agriculture for economic maintenance. Therefore, it is crucial to understand the changes that have already taken place and that are likely to take place in the near future in agriculture (Maponya and Mpandeli, 2012). The effects of climate change, in the last two centuries, have been increasing the temperature and a reduction in water resources as well as negative affects the health of the crops. The change will have many effects on the global food supply and demand. It will also affect food systems, more especially, to the communities which solely depend on their own production (Wheeler and Von Braun, 2013).

The climate change studied, is being experienced as an increasing temporal and spatial variability in temperature, precipitation, winds and magnitude of extreme events such as frequency and intensity of heat waves, heavy rainfall which lead to floods (Vermeulen *et al*., 2012). Some areas experienced longer dry spells and drought chances are likely to increase. Many food production activities had an impact towards the rise of the production of greenhouse gases and other climate change factors. Conversely, other gases formed through the emissions that are associated with fertiliser application. The other contributing factor towards the GHG emissions is the production of feed for livestock and aquaculture because of fossil fuel (Vermeulen *et al*., 2012).

The impacts of climate change were not only observed on the crop yields, but also on food quality, which may be critical for food security in future. Moreover, other effects of climate change on food quality during crop production are the risks of experiencing contamination of agricultural land, groundwater and surface water, heavy metals, agricultural residues, and hazardous wastes (Vermeulen *et al*., 2012).

The impacts of climate change were associated with higher temperatures, low rainfall and increased rainfall variability. In addition, they led to crop yield reduction and that threatens food security in low income and economies, more especially, on communities that rely on agriculture (Deressa *et al*., 2011). If average temperatures are high, they raise serious temperature trends, which increase poor rainfall patterns and accelerate the frequency of droughts (Maponya and Mpandeli, 2012). In countries such Ethiopia, agriculture is the main sector of the economy. It contributes about 0.52% of the GDP and employs about 0.80% of the population whilst generating more than 0.85% of the foreign exchange earnings (Deressa *et al*., 2011). For that motive, farmers should be able to adapt in order to reduce the negative impact of climate change. Different socio-economic and environmental factors affect the abilities to perceive and adapt to climate change (Deressa *et al*., 2011). Shortage of water has a negative impact on agricultural production and that will lead to food scarcity (Maponya and Mpandeli, 2012).

5.4. FINDINGS FROM EMPIRICAL STUDY

Nwanedi irrigation was comprised of 160 commercial crop farmers, who sold their products to big markets of South Africa and neighbouring countries such as Mozambique and Botswana. Therefore, using a manual tillage, hand hoe was impossible because they were farming in many hectors. The implication is that the emission of gas was very high as they used tractors to prepare the land for farming activities such as tillage, harrowing and ridging. They also used fertilisers to enhance fast growth and to prevent stunting growth of their crops. The act, over a period of time, caused climate change. Therefore, there must be information sharing sessions, which would help farmers in and around Nwanedi to understand that climate change is real.

The source of water to irrigate their crops was mainly river water. The scheme was named after Nwanedi River, which supplied irrigation water to all farmers in NIS. The river was badly affected by drought conditions, which took place between 2015 and 2016 cropping season. Thus, they did not receive rain to sustain the river. That affected most of the events – from farming activities and human life. Many farmers had to stop farming during that period. The river ran dry, however, it managed to source farms that were situated towards its flowing direction.

The study has found that drought was regarded as the worst experience that farmers faced. Without water, farmers did not to plant anything on their farms, which meant that no profit was generated

during the drought period. They did not have any alternative water solution to water problems. However, others who planted had used a very small scale than usual. Notably, drought affected job loss in the farming business where many employees had to be stopped from coming to work.

The study has found that NIS experienced high temperatures, which they had never experienced before. That exacerbated the situation because if it was too hot, little moisture in the soil had quickly evaporated. That meant that the artificial irrigation process had to be conducted regularly. Remarkably, extreme temperatures created conducive environment for pests and diseases. Consequently, new pests such as Tuta Tundra, which were not found in the area before, had been observed. The pest damaged the leaves of the tomato crop, which made a great loss in profit.

The study has also found that crops had experienced a challenge in terms of growth, which had an adversely effect on the yield expected per hectare. In terms of tomato production as the main crop produced in Nwanedi, they used to harvest tomato fruit for at least 3 months after first harvest but with the effect of climate change through high temperatures, they could no longer harvest for a longer period as the crop died soon after the first harvest. Increases in the temperature had major impacts on both the crop and livestock commodities. Hence, crop farmers were affected badly by the climate change, rate of evaporation increases. For that motive, the decrease of rainfall and increase of temperature impacted in the reduction of crop yields for up to 74% (Musetha, 2016).

5.5. FINDINGS FROM THE INTERVIEW

Majority of the respondents were owners of the farms, who had a different understanding about the concept of “climate change”. Most of the people who said they understood the concept, had shown that they did not think it was anything which had an impact on the weather change in terms of lack of rain and extreme hot temperatures. Climate change was difficult for them to fathom because the causes such as greenhouse gases (GHGs) were invisible and difficult to predict or interpret correctly, more especially, at local levels and human time scales.

Drought conditions were so real to such an extent that farmers in NIS had experienced it in October 2015 until the late 2016 cropping season. The situation was worse to those who depended solely on rainfall water because there was nothing to be done as they had indicated that the reason to rely on rainfall was because they do not have funds to buy irrigation pipes to pump water from the river nearby. The condition had brought more diseases and toxic insects. Hence, a decline in the total tonnage they used to produce prior the impact of climate change was experienced. Again, a loss of production decreased when planting winter crops, which did not grow efficiently due to hot temperatures. When there was a change in the amount and seasonality of river flows caused by changes in monthly precipitation and temperature, it had an impact on the ecosystems and the availability of water for irrigation, industrial and domestic use. Consequently, climate change had limited crop productivity and increased the risk of rain fed farming systems.

Moreover, drought as a result of climate change, had led farmers in Nwanedi not to plant anything, which meant that no profit was generated within the entire period. The implication was that during drought period, many jobs were lost in the farming business. Again, it affected the growth and development of crops. If the growth and development was affected, the crop yield and quality had been low and impacted negatively on the profit. The majority of the farmers in NIS did not know that application of inorganic fertilisers and the use of tractors (CO2 emission) in the farm contributed to greenhouse effect.

Farmers in NIS had observed a low yield, especially with tomato production, the harvesting time was reduced. Many diseases and pests were experienced due to high temperature and moisture had evaporated to quickly due high temperature. The farmers had observed an increase in pests and diseases excessively, as opposed to previous years of farming.

5.6. RECOMMENDATIONS

The study has shown that the effect of climate change is real and it threatens farming business in NIS. There were so many farmers who did not understand or have a knowledge that climate change an existing factor. Therefore, it is recommended that the Department of Agriculture and Rural Development, through its extension officers, receive training pertaining to the condition. In that way, they will have information sharing sessions with the farmers to inform them about the climate change and its impact on the farming activities. If they receive information from the officer that

they work with on daily basis, they would be able to understand and follow the appropriate measures.

Climate change results in a long-term water shortage, worsening soil conditions, drought, desertification, disease and pest outbreaks on crops and livestock. In this case, it is recommended that farmers must harvest rain by building dams and use river water as additional source of water for irrigation. That will help in securing food and employment during drought conditions in the agricultural sector. In Africa, about 60%-70% of the population depend on agricultural sector for employment, which contributes about 34% on GDP. Hence, it is important ensure possibilities that will keep them farming no matter the weather conditions.

An increase of potential evapotranspiration intensifies drought stress in the semiarid and tropics. Temperature changes have a stronger impact on yields than precipitation. High temperature is one of the most problems experienced in NIS. It is associated with the introduction of new pests as the environment is favourable for their survival and multiplication. For that motive, it is recommended that they must use planting materials which are resistant to a wide range of pests and diseases. They could also use hybrid planting material instead of using open pollinated planting materials. However, hybrids seeds are expensive, but they are effective and beneficial to farming business. If they use resistant varieties, they could also save the cost to buy chemicals to control pests and diseases.

Agricultural extension officers serve as a link between the farmers and plant breeders. It is recommended that farmers must be able to identify what they want in terms of seeds specification that will fit into their cropping system. Extension officers will, therefore, link farmers with the plant breeders so that they will be able to breed seeds that will be able to tolerate high temperatures and resist a wide range of pests and diseases.

Climate change poses a serious challenge for farmers into the risk of production, which is associated with crop yields, timing of field operation and timing of investments in new technologies. Hence, it is recommended that the farmers in NIS must change their planting date. They must plant either too early for summer crops before it becomes too hot, where the build-up of huge number of pests take place or they must plant later when winter is approaching because

many pests do not thrive well. In cold temperatures, most animals are hide, and as such, they pause the mating season, which stops them from multiplying.

It is also recommended that farmers must apply zero tillage. This can be achieved by planting cover crops or legumes crops. Legumes crops are also beneficial to other that will be planted after because they produce nitrogen, which means that less of inorganic fertilisers will be applied. On the other hand, zero tillage will be a way of reducing emission from the tractors which causes greenhouse effect. These cover crops help to conserve soil moisture for a period of time because the soils are not exposed directly to the sun. But maize and soya beans can be added as cover crop during winter cropping season. Hence, leaving soil fallow ready for the next crops.

It is important to employ management practices in order to cope with the risks from both excessive rainfall and drought events by improving water infiltration that can store soil water, reduce runoff and erosion. Emissions can be reduced by focusing on collective responses by civil society and private sectors.

5.7. RECOMMENDATION FOR FURTHER RESEARCH

Most of the farming activities are in the rural areas and they play a major role in improving the livelihood. That is crucial for the rural economy and food security. Further research should dwell much on how the effect of climate change influences rural communities in terms of their livelihood and the economic growth. The same study can also be done in the rest of Limpopo province and South Africa as whole.

5.8. LIMITATION OF THE STUDY

Time was the limiting factor in the study. The researcher is based in Polokwane City and has conducted the research in Nwanedi, which is about 240km away. The researcher had focused on the crop farmers, if there was more time, another glimpse could have been given to the livestock farmers. Unfortunately, the researcher only focused on crop farmers in NIS.

5.9. CONCLUSION

The effect of climate change is a real situation which threatens both humans and agriculture. Drought and high temperature are the two most enemies through which farmers experience sway

effects of climate change. Most of the problems encountered when there is high temperature – that leads to a quick evaporation of the soil moisture. High infestation of pests is because high temperature creates conducive environment for them to multiply and exist in a huge quantity. That has an adverse effect on the profit generation because farmers will have to spend more money on buying chemicals to control pests and diseases, which damages the quality and, in some instances, destroys everything and leaves nothing to harvest.

Drought is a biggest threat because when rivers dry out, farmers do not have an alternative means of accessing irrigation water. Water is life in all living organisms. Hence, without water, there would be no farming activities. It is important to find a means of reserving water so that should drought occur, alternative water to irrigate the crops. The study has found that the condition is largely familiar in rural farmers who do not have money to bring about substitute solutions to cope with the effect of climate change. Hence, high job loss was encountered.

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Appendix A

Questionnaire:

Instruction: Please spare a few minutes of your valuable time to answer this questionnaire, please mark with "X" in the box next to the answer of your choice or write in the space provided below the question.

1. **Demographic profile.**

1.1.Details of the farm owner:

1.1.1. Are you the farm owner or the employee?

Owner	Employee

1.1.2. If you are the farm owner provide your name below

_____

1.1.3. If not the farm owner provide your name below

_____

1.1.4. Gender

Male	Female

1.1.5. Age of the respondent

18	35	
36	50	
Above 50		

1.1.6. Highest level of education

Primary	Grade 1-7	
Secondary	Grade 8-12	
Tertiary	Diploma/Degree	

2. Details of the farm:

2.1. Name of the farm

_____

2.2. How big is your farm?

1-10ha	
10-20ha	
20-50ha	
Above 50ha	

2.3. How many hectares are currently under the production?

_____

2.4. Is your farm used to the full capacity?

Yes	No

2.5. If no, what are the reasons for not using the farm to the full capacity?

_____

_____

_____

2.6. How many years were you farming in Nwanedi irrigation scheme?

0-5	
5-10	
10-20	
Above 20	

2.7. What are the major crops that you grow? Please list them

1._____

2. _____

3. _____

4. _____

5. _____

2.8. What are the sources of water you use for irrigation?

Rainfall	
River water	
Borehole	

2.9. Have you ever heard about a climate change?

Yes	No

2.10. Have you ever attended any programme on climate change?

Yes	No

2.11. What do you understand about the concept "climate change"?

_____

_____

_____

2.12. Have you ever notice the difference in climate change in terms of production if it is declining?

Yes	No

2.13. If yes, explain what you have observed

_____

_____

_____

2.14. How does the climate change affect the profit generation of your farm?

Explain:_____

_____

_____

_____

2.15. Does climate change affect the growth and yield of the crop production?

Yes	No

2.16. If yes, explain

_____

_____

2.17. Have you ever experience drought over recent years?

Yes	No

2.18. If yes, what was the impact on the production and your profit generation?

_____

_____

_____

2.19. How did the drought affect employment/ your employees?

_____

_____

_____

2.20. Have you ever experienced low rainfall?

Yes	No

2.21. If yes, what was the impact?

_____

_____

_____

2.22. Have this farm or Nwanedi irrigation scheme in particular ever experienced flooding in the recent years?

Yes	No

2.23. If yes, what was the impact?

_____

_____

_____

2.24. Do you know that the application of inorganic fertilizers and use of tractors (CO2 emission) in the farm contribute to greenhouse effect?

Yes	No

2.25. Are you still able to produce the same crop and able to harvest same yield that you have been planting over the past years?

Yes	No

2.26. If no, what has changed?

_____

_____

_____

2.27. Do you encounter increase in pests and diseases when farming in this area as opposed to previous years of farming?

Yes	No

2.28. If yes, how do they affect the business in terms of yield, production and profit?

_____

_____

_____

2.29. What are other things which you think contribute negatively on the farming businesses which are associated with climate change?

_____

_____

_____

2.30. How can we prevent them in future?

_____

_____

_____

2.31. What are your coping strategies to minimise the impact of climate change?

Select one or more of these strategies below

Crop rotation	
Change planting date	
Planting different varieties	

Mulching to conserve moisture	

2.32. If you do not apply none of the above what are your coping strategies?

_____

_____

_____