ADAPTATION TO CLIMATE VARIABILITY BY SMALL-SCALE FARMERS IN JUBEK STATE, SOUTH SUDAN

By

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DECLARATION

I declare that this is my original work and has not been presented for a degree or any other award in any other university.

Signature…… Date: ……

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DEDICATION

This work is dedicated to my late father who encouraged me a lot before his death, and to my husband Mr. Dominic Wani who also encouraged and supported me financially throughout my course study.

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LIST OF ABBREVIATIONS AND ACRONYMS

CSA Climate Smart Agriculture

FAO Food and Agriculture Organization

FGD Focus Group Discussion

GDP Gross Domestic Product

GHG Green House Gas

IFSPC Integrated Food Security Phase Classification

IPCC Intergovernmental Panel on Climate Change

KII Key Informant Interviews

SPSS Statistical Package for Social Sciences

VDMC Village Disaster Management Committee

OPERATIONAL DEFINITION OF TERMS

Climate Variability: This referred to the mean variation of weather condition deviating from time to time on either temporal or spatial scales beyond the normal weather events that caused effects to yields of farmers in Jubek State.

Climate Change: This is a change in weather pattern related to changes in oceans, land surfaces and ice sheets, occurring over time and has a negative impact on farmers yields in Jubek State.

Climate Adaptation: This referred to various adjustments by Jubek State farmers to damages and losses caused by effects of climate change and variability.

Adaptation Strategies: These are different approaches or methods of coping up with the effects of climate change and variability adopted by farmers in Jubek State.

Small-Scale Farmers: These are farmers in Jubek State who practice cropping or livestock keeping in a mixed set-up of small farm for commercial purposes and subsistence productivity.

Farmers Perceptions: This referred to the general knowledge, attitudes, values and understanding among the small-scale farmers in Jubek State in regards to climate change and variability.

Agricultural Crop Yields: This referred to total quantity of yields of crops such as maize and sorghum produced by farmers in Jubek State.

ABSTRACT

Agriculture provides nearly 80% of the world's population livelihoods. This is heavily affected by climate variability. Climate variability affects agricultural production due to association with drought and floods. This effect had significant influence in South Sudan where nearly 83% of population relies on rain-fed agriculture. Hence, this has led to decline in about of 30-50% on staple crop production. Jubek State was selected for the study due to majority of the farmers' dependency on rain-fed agriculture and over stayed there for more than eight years. Therefore, the current research aimed to examine farmers' perception and level of awareness on the crop yield, analyze how socio-economic factors influence adaptation strategies to climate variability and evaluate suitable adaptation strategies against climate variability in Jubek State of South Sudan. The sample size was determined by Yamane formula to be 399. The study used simple random and stratified sampling, purposive sampling and multi-stage sampling procedures. Closed and open-ended questionnaires, interviews, field observations and taking notes. Secondary data and related information were obtained and reviewed from electronic depositories, libraries and institutional offices. The study adopted qualitative and quantitative analyses and the results were presented in tables and graphs. Test for significance was set at $p \leq 0.05$ for all hypotheses. The results on farmers perception and awareness showed that there was a reliable consistency of Cronbach's Alpha (α)=0.63 with the six issues that were scrutinized and most of the farmers were aware with a weighing means scale ranging from 3.00-4.00. The descriptive statistics of socio-economic factors showed that 79% of male households head were using climate adaptation methods and females 21% only. Crop farming was the main farming practiced by the community with 47.6% total compared to pastoral farming 30.4% and mixed farming 22.0%. The majority of married households with 87.7% were using climate adaptation method compared to singles/widows with 68.8%. The majority of farmers with 57.5% work on their own farms while 42.5% had some alternatives. In the descriptive statistics of adoption to climate adaptation strategy, majority of respondents 68.8% used improved seeds as an adaptation method while 31.2% not. The study further established that, choice of farmers' adaptive capacity to climatic variability and farmers' socio-economic factors such gender, marital status, code of employment, size of the household and size of the farm were significantly affecting choice of adaptation to adopt $p < 0.05$. The study analysis deduced that climate was changing and would require adaptive methods to combat. The study recommended that; South Sudan Government should deploy more agricultural extension officers to create more awareness on climate information and to focus on awareness creation of farmers on better production techniques and climate change adaptation strategies. Also, the National Government and NGOs to promote crop insurance to farmers who are affected with floods to adapt to prone areas and establish more extension service centers for practicing good agricultural activities to increase productivity.

CHAPTER ONE: INTRODUCTION

1.1: Background Information

According to IPCC, (2020) climate change refers to atmospheric weather patterns that varied persistently in reduction of food production , rising of sea level over time scale of many years ago, at geo-spatial range. It is caused by natural or human intervention on the environment. This is mainly described by variability of parameters such as temperature, precipitation, humidity and sunshine intensity on daily weather inconsistencies. They impacted the environment in terms of droughts and floods due to erratically precipitation. Further, these changes of weather patterns have negative impact on agricultural yields such as Sorghum and Maize. For a long period, these effects have been occurring due to greenhouse gases (GHG) accumulated in the atmosphere leading to increased records of atmospheric air temperature and changes in rainfall patterns. According to WMO, (2021), in some parts of America the global sea level projection was causing the ocean to be warm and acidic. Its impact is seen in food security and displacement of population.

This scenario confirms to the changes in planet right from the depth of the ocean up to the top of mountains. Glaciers are melting rapidly, frequent rain on the Greenland ice sheet, heat waves in Canada and some parts of USA, dragging temperatures to about 50ºC in one of the villages in British Colombia. Temperature in California reached 54ºC during the large heat waves in southern western USA. The heat waves were mostly followed by devastating fires. As a result, these effects of climate change and climate variability are mostly experienced in agriculture which provides 80% of the world's population livelihood dependency (FAO, 2013). Further, it shows negative impacts on world's food security. The changing climate effects raises food affordability price, reduces accessibility and significantly degrades environmental resources for livelihoods of human. Moreover, climate variability is projected to impact greatly on cereal crop produce, by making crops vulnerable to water stress and prevalence to invasive weed, pests and diseases during the growing period (Schulte *et al.,* 2016). Bhuyan *et al.* (2018) alludes that due to these vulnerabilities crop production would decrease in the magnitude of 90% by 2100, if the trend persists. Some parts of Africa, like the semi-arid and southern parts of south Africa were mostly affected by drought, and soil degradation as a result of high extreme weather events (Narendra *et al.,* 2020). Somewhere in Ethiopian drylands, food

insecurity is a recurring feature. The risk of food insecurity has been heightened by climate variability and climate change. In Ethiopia, common beans is the main source of protein for people who do not get access to animal protein. Though, the national average yield in Ethiopia is 1600 kg ha^{-1} which is far below yield (3000 kg ha^{-1}). This is majorly attributed to climate variability which resulted to drought, low soil fertility as well as lack of improved agronomic practice (Mohammed & Feleke, 2022). In West Africa, especially semi-arid and sub humid regions, climate variability was seen in onset rainfall variation within the growing season causing eruption of drought occurrence in that region (Nicholson, 2018).

In East Africa region, severe drought and floods occurred frequently causing food insecurity and displacement on human settlement and their livelihood. The main drivers of this large-scale variability were found to be correlated with Indian Ocean Dipole and the Intertropical Convergence Zone of the Great Horn of Africa (Gebrechorkos *et. al.,* 2020). Furthermore, the East African temperature are simultaneously increasing by an average of 1.2ºC and expected to rise marginally from 0.05ºC-2.5ºC from the year 2000-2050. In Kenya, temperature was expected to rise on an average of 1.3ºC to 3.9ºC as by 2100. The months of March, April and May was expected to rise by a small margin compared to October, November and December in the Plateau Mountains and the coastal region (Maina &Messo, 2017).

In South Sudan, the effects of climate variability is seen in reduction of crop production for the past years as a results of drought and floods (Araya *et al.*, 2018). South Sudan is a land locked country in North Eastern Africa, covering a population of about 13, 096,000 with a low population growth rate of about 2.5% per year. The population is mostly affected with floods and drought with an estimated effect from 7,900,000 to 1,140,000 people during the year from 1996-2016 (Worldometer, 2017). Furthermore, the rainfall seasons is bimodal as from March-May (short rain) while from July-November (long rain). They mostly experienced rainfall variability in the upper region compared to semi-arid region with moderte variability.

For the past several years, South Sudan has experienced climatic changes in weather pattern such as rainfall and temperature. Average temperature has slightly projected from 1º-1.5ºC during the 1970s.This rate of temperature has significant increased for

the past 3-4years. The maximum temperature slightly projected higher than the average temperature causing extreme heat in the environment (UNEP, 2018).

For a long period of time, the South Sudanese were suffering from increased temperature rise. Rainfall variablity was expected to project to 600mm/year by the year 2100 as predicted by the GCM projections. South Sudan is more vulnerable to climate variability events, as such agricultural sector in which the total majority of the population rely on was heavily impacted. Conflict (civil Wars) and climate variability are the major drivers of food insecurity, displacement, migration, diseases and poverty to the large Community of Rain-Fed agriculture in the country. Climate variability has affected grain (sorghum) and cereal (maize) with about 70% of rainfall variation (Abera *et al*., 2018).

A report by the global forest report, (2017) showed that, the total GHG emission from the agricultural practices was 43.1% of the total annual emission from agriculture. Furthermore, the Intended Nationally Determined Contribution (NDC) document have been submitted to UNFCCC for priorities in regulations and policies to invest in low carbon emission as an adaptation and mitigation strategies.

Climate change is a long- term event causing multiple stressors without any responses to the whole world. The best policy for combating it is through adaptation strategies (Huang & Sim, 2021). One way of success to balance the climate variability and farmers crop production is adaptation to the effects of climatic vulnerability, which is mostly applied at farm levels. Many studies have been done with direct interaction to determine the behavior of farmers towards adaptation and effect of climate change (Huang & Sim, 2021). Adaptation at its best level can be achieve by polices such as information, credit, extension and farm advisory services.

These adaptation strategies are diversified according to the crop type and the area of application including change in time management and work, market responses, government aid and policies; technological advancement and innovations (Bozzola *et al.,* 2018). In developing countries, there are many challenges related to coping the adverse effect of climate variability such as political boundaries, crop growing region and geographical information (Khan *et al.,* 2020). These adaptations are still at infancy stage in the developing nations; therefore, farm produce is at high risk of droughts and floods. Generally, this is certain that, Africa food production by 2050

will decline by 12–21% due to effects of climate variability (FAO & WFP, 2020). Therefore, the need of suitable adaptation to encourage resiliency of climatic (rainfall &temperature) variables is required to improve farm produce in Jubek State and South Sudan as whole, which will result to enhancing food security (Belay *et al.*, 2017). Therefore, this study aimed to improve adaptive capacity on climate variability in South Sudan to leverage poverty and food insecurity.

Small-scale farmers are the most vulnerable resilience who face a lot of challenges concerning climate variability in their farms and livelihoods. In terms of rain-fed agriculture, they are subjected to floods and drought which caused food shortages and hunger to the community at large. Historically, their areas are less productive due to their dependency on rain-fed agriculture and traditional farming methods. They have capacity to adapt and adjust to the use of new innovations and cultural practices to climate variability. They produce limited food only for their families. Others work in the town during dry seasons and come back during rainy season to cultivate for home food and cash crop. Others are working in other people's farm due to access of land and ownership (FAO, 2015).

Farmers of South Sudan are more vulnerable to the effects of climate variability. Floods reduced small-scale production and access to markets. Irrigation and water harvesting are less practice by the small-scale farmers due to the dependency on rain-fed agriculture. Some of the Organization empowered the farmers to focus and manage rural business in crop production and post-harvest management by giving them important resource to adapt to climatic challenges. As such they continued managing through project implementation organized by the NGOs to address climate variability challenges, access to early maturity and drought resistance seeds, training on water and conservation management, afforestation and construction of water infrastructure such as boreholes (Omondi *et al.*, 2014).

Furthermore, in Warap State, flooding was the main challenged among the small-scale farmers. By the help of WFP programs, farmers were trained on how to adapt to climate risk by changing the flood land into rice field, building dykes for land protection from floods, digging pits for harvesting rain water for dry season. Also, in Unity State, for over three years' lands were flooded. Resilience such as the displaced

women started making fire woods from water hyacinth weeds. So, this becomes a local solution to their variability.

1.2: Statement of the Problem

In spite of measures which have been put by the Non-governmental organizations to encourage food security in South Sudan through climate adaptation methods as a way of coping up with effects of changing climate such as droughts and floods (d'Errico *et al.,* 2019), there are still many cases of famine and hunger following the agricultural deterioration by floods and droughts in the country (Maxwell *et al.,* 2020). There are many policies, interventions and innovations that encourage water conservation and harvesting to improve crop production in the midst of erratic rainfall (Moshi & Isinika, 2016), however, these techniques have not been implemented and used adequately to increase productivity in most parts of African countries (Hamza & Iyela, 2012). Therefore, climate variability has remained a constant threat in developing nations, lowering food security index and imposing poverty to African economies (Mozzato *et al.*, 2018).

Scientific evidenced information has confirmed that climate variability and its associated risks like floods; prolonged dry spell due to erratic seasons of weather has an effect on farm productivity (Vamvakeridou-lyroudia *et al.,* 2020). The increased climatic uncertainty results to low farm yields hence implied to food insecurity (FAO, 2018). Moreover, Chung & Promburom, (2015) and Karpouzoglou & Barron, (2014) posited that extreme temperatures and sporadic rainfall were significantly affecting food production in agriculture and further stress to marginal zone practicing agriculture. And mostly ASALs are devastated affected by such weather forecast that regionally occurs.

South Sudan has no exception to unprecedented crop yields due to climatic variability, and 60% of the country's population are severely food insecure (IPCC, 2017) as result of low agricultural produce. The country has been declared a famine state in February 2017, this deepens economic status. Consistent flooding, prolonged dry spells and pest invasion from effects of climate change has led to decline of crop yield to 60% loss in 2018 (FAO, 2018). This loss is associated with the conflict of 2013 to 2017 whereby 2.4 million people were displaced externally in neighboring countries and internally as IDPs. This conflict deteriorated the economy while climate

shocks such as floods and droughts affect livelihoods by causing food insecurity, IPC, (2016). Over 80% of South Sudan rural population depends on rainfed agriculture. Most of the areas that are affected with crisis emerged into levels of food insecurity and they are in agro-ecological zone that are perennially affected by cycles of dry spells, prone to drought and floods. Heavy seasonal rains always cause flooding in many parts of the country leading to difficulties in movement, access to markets and basic services. this affects settlements and prevalence of water borne diseases such as cholera, diarrhea and malaria. the country also experienced dry spells that can lead to drought with below average and sporadic rainfall causing water shortage, poor harvest and livestock loss. All this interfered with farmers' adaptive capacity to effects of climate change. Therefore, there is a limited access to finance, insufficient policies and strategy, weak institutional performance and willingness to curb climate change effects.

Adaptation strategy on farms is expected to increase the productivity slightly thus making it a constraint subject of discussion. Moreover, without adaptation yields in the dry season would decrease by (-45%) and with adaptation they would decrease by (15%) less (FAO, 2020). Therefore, there is a need to carry out the research on the best adaptive measure that would improve yields. However, the contribution of adaptive capacity to climate variability on farm produce has not yet fully been understood in Jubek State and the entire South Sudan. Previously, the assessments of impacts of climate variability in South Sudan mainly concentrated on agriculture and pastoralism without consideration of the adaptive solution to such losses. For example, Gram *et al.*, (2019) in rural areas of Northern Hinterland of Pakistan and studies by Dallimer *et al,* (2018) insight of Kenya have mainly analyzed and documented climate variability on farming activities in the households and community level and household economics are one of the main characters that are geared to check the importance of agriculture in society in the midst of climate variability.

There is relatively little information on the literature available on climate variability impacts on agricultural livelihood, thus securitizing the suitable adaptive measures for the farm yield. Thus, this study identified the socio-economic factors that gap the adaptive solutions to cope with erratic climatic variables (rainfall and temperature) and finally synthesize the best adaptation for the Jubek State and specifically to farm

inputs that would improve the yields of small-scale farmers thus resulting to poverty reduction within the households of Jubek State South Sudan.

1.3: Research Questions

The study was guided by the following research questions

i. What is the farmers perception on climate variability on agricultural yields in Jubek State, South Sudan?
ii. How do socio-economic factors influence adaptation strategies on agricultural yields in Jubek State, South Sudan?
iii. How do adaptation strategies affect agricultural yields in Jubek State, South Sudan?

1.4: Research Objectives

1.4.1: Broad Objectives

The aim of this study was to establish a viable mechanism for climate variability adaptation for different agricultural yield by the farmers in Jubek State, South Sudan.

1.4.2: Specific Objectives

The study adopted the following specific objectives:

i. To examine farmers perceptions on effects of climatic variability on agricultural yields in Jubek State, South Sudan;
ii. To analyze how socio-economic factors, influence adaptation strategies on agricultural yields in Jubek State, South Sudan; and
iii. To evaluate suitable adaptation measures on climate variability to agricultural produce in Jubek State, South Sudan.

1.5: Research Hypotheses

The study set to test the following null hypotheses ($p \leq 0.05$) in relation to the questions and objectives stated.

i. Farmers' socio-economic factors do not significantly influence adaptation to minimize effects of climate variability on agricultural produce.
ii. Choice of farmers' adaptive capacity to climatic variability do not significantly influence crop yields.

1.6: Justification

Agricultural sector is the most devastated sector by impacts of climate change and its variability. IPCC, (2020) stated that economic growth and human wellbeing are connected to climate change patterns which affect agriculture. Gebrechorkos *et. al.,* (2020) stated that, in East Africa region, floods and drought were the main drivers of food insecurity and human settlement and temperature was expected to rise marginally with an average from 0.05°- 2.5° by the year 2020 to 2050. Araya *et al., (*2018) also alludes that, in South Sudan, floods and droughts reduced crop production. Therefore, this climate uncertainty needs response that would mitigate the effects of climate change by sustaining natural resource for present and future generation. Thus, research was needed to find better adaptation measures to the effects of climate change in international and local scale to understand the nexus between agriculture, climate change and livelihood. So, adaptation methods is used by modern science as an inter-disciplinary approach to curb the effects of climate change on agriculture by maintaining livelihood support (Mutenje *et al.,* 2019). This effort contributes to the improvement of food security by achieving sustainable development goals (Phinzi *et al.*, 2019).

1.7: Conceptual Framework

Considering the above theory, climate change and variability is the independent variables and poses great impact on crop production in Jubek State through increase and decrease in temperatures, erratic rainfall, floods, prolong rainfall and prolonged drought. This varying and changing of climatic events affect crop yields through high or low temperature and rainfall patterns, people's livelihood, adaptation strategies and also causing food insecurity. Therefore, adaptation strategies are required to build resilience where, food insecurity, poverty, conflict, displacement are important to consider as (intervening variables) which intensifies the effect of climate change and variability in either direction. In building resilience, there is need for climate awareness and adaptation in adjusting to counteract the effects of different characteristics of resilience building like experience, being prepared, adaptability, collecting and coordinated response to enhance household adaptive capacity. Most definitely will have a great help on what to happen environmentally, economically and socially both at present and in the future. The general well-being of farmers will

depend on how effective the adaptation strategies are executed. If done sustainably then chances are that the needs of Jubek state community will be catered for at the moment and not jeopardy that of future generations.

The conceptual frame work highlights the relationship between independent variables (Temperature & Rainfall) linking to dependent variables Crop yields and Farmers Perceptions towards climate change and variability which in turn can be controlled by (intervening variables) applying adaptation mechanism hence in turn strike a balance of climate variability and farmers yields. It shows how climate change and variability influenced agriculture and specifically crop yields, a sector that mostly relied on rainfall and temperature, which in turn affects food security, livelihood and economic factors.

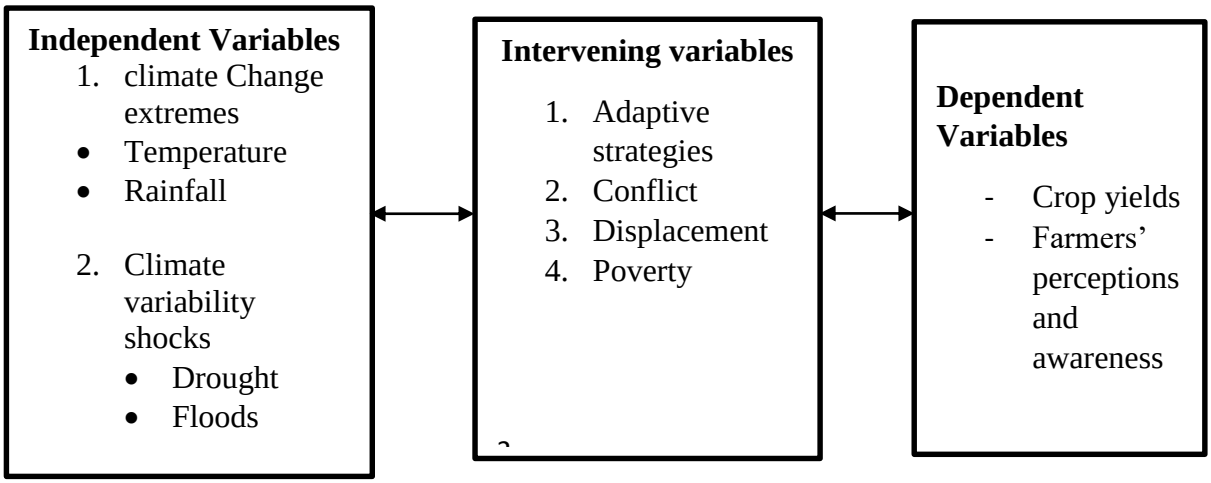

Figure 1.1: Conceptual Framework.

CHAPTER TWO: LITERATURE REVIEW

2.1: Climate Variability Trends

Climate variability is one of the most devastating threats affecting many livelihoods through their dependency on agriculture (IPCC, 2020). Many studies concerning climate variability have been done in developing countries but still ignoring its effects on small-scale farmers. Rainfall and temperature are the basic climatic variables that influence agricultural production, therefore any change in climatic variables would affect agriculture positively or negatively (Chung & Promburom, 2015) . A study carried out by FAO, (2016) revealed that the effects of climate variability will affect agriculture by causing food reduction and availability. There will be changes in weather which will cause irregularities in soil moisture content and fertility, length of growing season and increase of extreme climate risks. Bhuyan *et al,* (2018) posited that seasonal rainfall has been reducing by 8.8 mm to 40.1 mm over century in Bangladesh. This study also found that rainfall days have reduced from 60 to 30 days in both wet and dry season.

The existent of climate change in Africa is real. As a fact of multiple stresses leaving the region more vulnerable with no access to adaptive capacities (IPCC, 2020). The predicted increased in temperature by 2100 will range from 1.5º-6ºC in semi-arid and Sahara regions of southern Africa. As a result of this catastrophes, there will be continuous increase in drought, soil degradation, and rainfall shortages within the growing seasons. Therefore, there is need for adaptation for this changing environment. Also, there is need for strategic ways by the government institutions to respond to these effects. There is need for more innovation's approaches (Narendra *et., al* 2020).

In west Africa, especially semi-arid and sub-humid regions were characterized by variation in onset rainfall within the growing season, eruption of drought was seen occurring in the regions (Haussmann, 2012). A study done by S. Ogunja *et al,* (2020) in West Africa showed that simulation on modelling the impact of climate change on crop yields have a great significant correlation between the temperature, rainfall and the yields.

In East Africa region, severe drought occurred frequently affecting the population who depends on rainfall agriculture (Nicholson, 2016a). Further said, among the

seven flood prone countries of Africa, five in East Africa is heavily affected with floods. (Nicholson, 2014a) posited that the effect of this extreme events has caused a great destruction on population livelihood when it happens in the same year. In the Greater Horn of Africa, the region experienced bimodal seasonal rainfall, where long rains occurred between March-May and short rains occurred between October-December. Since 1999, the long rains reduced precipitation along the region causing regular drought (Yang *et al*., 2015).

A study done by Abhirup Dikshit, (2020) had identified two distinct trajectories affecting the Great Horn of Africa by increasing and decreasing drought in the region during the long rain season of 2014, rainfall pattern was changing across the region. As a result, there was induced climate change probability resulting in the region from Lake Victoria to the Northern Kenya which receive less rainfall and increasing drought. These dominant factors of the large-scale climate variability affecting the region were the Intertropical Convergence Zone of the Great Horn of Africa and the Indian Ocean Dipole. In general, the impact of climate variability is regionally and locally in terms of its impact. As such human contribution in terms of quantity is not yet known. There is need to find which factors are caused by human activities. In fact, drought resulted from a combination of factors (Trenberth *et al*., 2015).

According to Gebrechorkos *et al.,* (2020) rainfall variability in East Africa was found to be correlated with Indian Ocean Dipole and the Intertropical Convergence Zone. In addition, this study reported that Eastern and Western parts of East Africa are becoming drier and drier due to severe droughts during the study (1981 to 2016).

Gebrechorkos *et al*, (2020) reported that in East Africa, temperatures are simultaneously increasing by an average of 1.2°C and is expected to marginally rise between 0.05º - 2.5ºC from the year 2000 and 2050. Moreover, in Kenya the temperature was expected to range on an average of 1.3ºC to 3.9ºC as by 2100. The month of March, April and May were expected to rise by a small margin compared to October, November and December in the Plateau Mountains and the coastal areas. while January, February and March were also expected to rise as shown by (Maina & Messo, 2017) and (Amadi, 2018) studies in Thika and Baringo respectively.

The variability of climate has been occurring over the years in this century. This has led to realization of extreme weather conditions which cannot be upheld by the

environment. Therefore, increasing distress about the possibility of eradicating this problem has been a challenge due to increased anthropogenic-induced climate change effects. There is no doubt that the global surface temperatures increase day by day as from 0.78°C estimates 19th century with an interval change of 0.72°C to 0.85°C (Nicholls, 2015). The precipitation recorded that small global mean annual change of 1.1mm per decade is experienced. Projections predicted that warming will increase to a change of 5°C in 2100 that will be beyond the 1951 to 1980 baseline (Garcia, 2015). The change seems homogenous, but not always. For instance, tropics of Africa forests are warming with a rate of 0.29°C and South Africa at rate of 0.1°C to 0.3°C annually (Huynh & Resurreccion, 2014). Climate variability is negatively affecting the agriculture sector in many developing countries (IPCC, 2020). Crop productivity in developing countries is expected to decline under future climate (Jones & Thornton, 2017). Developing countries has been frequently affected by droughts and climate extremes over the last decades with serious shortfalls in food supply, in which South Sudan is not exceptional (Araya *et al*., 2018).

In Kenya, the projection of increase in temperature was expected to be 2.5ºC from 2000 to 2050, while rainfall intensity was expected to reduce. A prediction of any slight increase in drought will cause great effect on food security and availability of water within the areas of ASALs in the Northern and Eastern margin of the country. Areas along the coast will be affected with rising of the sea level together with floods and saltwater interference. The rift valley will be vulnerable to drought, flood together with landslide (Amadi, 2018).

Floods and droughts were the main climatic variables affecting the livelihoods in South Sudan. The environmental pollution caused by human activities has resulted in increase in weather events such as rainfall and drought causing negative impact in socio economic activities of the people of South Sudan. These impacts resulted in loss of grazing land, death of animals, crop failure and habitat destruction both in water and forest ecosystem (UNEP, 2018). Farmers who are currently food insecure could suffer from the changes of temperature and rainfall patterns (Deresa, 2017). Climate change could affect the production of maize, beans, wheat, vegetables, and sugarcane, either negatively or positively depending to the climatic conditions where the crops are grown. African economies are relying heavily on climate thus, the changes in climate could affect future agricultural production (Araya *et al*., 2018). Thus, there is

need to find the best adaptive strategies which will go hand in hand with enhancing famers yields in Jubek State. In South Sudan rainfall has reduced by 50mm annually with an increase of 1℃ in mean temperature since 1960. Moreover, this study suggested that rainfall would continue to fluctuate for the next 30 years, (Deresa, 2017).

South Sudan is a landlock country in North eastern Africa, covering a population of 13,0096,000 and low population growth rate of about 2.9% per year. The larger population residing in the rural area was about 81.8%. Urban population living in slums was about 95%. The economy is less by USD 9 billion per year and the GDP is 759 USD per capital. South Sudan is one of the lowest developed countries in Africa with Index of 0.42 percent. Only few populations have access to electricity of about 4.5% of the total population. It has a tropical climate whereby it experiences increased rainfall season to drier season. The population were mostly affected by floods and drought with estimated effects from 7,900,000 to 1,140,000 people during the year from 1996 – 2016 (Worldometer, 2017).

Furthermore, the rainfall season is bimodal, from March - May a short rain while from October -November a long rain. The experience of rainfall variability in the upper regions was very low compare to the semiarid region which have moderate variability. For many years the population of the tropical savannah has suffered with variability of dryness within their region as the temperature rises from 1979-2015.The projection of variability (rainfall) across the country is expected to rise to 600mm/year by the year 2100 as predicted by the GCM projections. **(**World Bank, 2016**)**

The GHG emissions from agricultural practices, land use and forestry as per estimation of (2014-2017) by FAO analysis were based on the following; burning of crop residues (0.02%), burning of savannah (21.5%), crop residues (0.1%), cultivation of organic soils (0.1%), enteric fermentation (11.1%), manure management (0.5%), manure applied to emission soils (0.2%), and manure left on pasture (8.7%), making total of 43. 1% of annual from agriculture. In land use and forestry, the estimation of 2015 analysis of land use covered, the total area of wood vegetation by density (10-30%) savannah, 30-50% wood land 50-100% dense forest. The total estimation of woody vegetation was 66% of the total land area covered by trees. The total hectares covered by vegetation's includes (4 million hectares of dense forest which is about

50% of canopy cover), (7 million hectares of moderate dense woodland which is about 30-50% canopy cover), and 31 million hectares of Sudanese Acacia Savannah. Carbon stock from forest biomass areas estimated to be 495 million tones (Global Forest report, 2017**)**.

Furthermore, the South Sudan Intended Nationally Determined Contributions (NDC) documents have been submitted to UNFCCC as to priorities in regulation, policies and standards for investing in low carbon emission. Thus, the estimation per calculation in investment (50 billion USD) for mitigation and adaptation strategies up to 2030. The areas priorities were, energy, transport and AFOLU. Those sectors chosen can increase the use of clean energy through hydro- and solar power, introduce emission standards for vehicles and protect forest from deforestation by afforestation.

2.2: Farmers Climate Perceptions and Awareness

Awareness is a general knowledge that guide people's behavior towards climate change and adaptation (Vecchio *et al.,* 2020). The studies by Ferdushi *et al., (*2019) done in Sylhet area of Bangladesh had explored the level of climate awareness within a sample of 378 respondents, using a severity index (SI). The results showed that SI index values ranging from 69.2% to 93.5% have high percentage of rice farmers who are aware of climate change and its impacts. Ochieng & Koske, (2013) did a research study in Kisumu area of Kenya and analyzed teachers' perceptions by the use of weighted Likert scale and the results showed that teachers from Kisumu schools had perceived climate variability and its threat to communities' livelihoods' ($p < 0.05$). This suggested that teachers were significantly aware that climate is changing and it imposes effects on human livelihoods.

Moreover, 68% of farmers from Kwa-Zulu-Natal, South Africa, perceived effects of climate variability based on their impression and experience (Hitayezu., Wale., & Ortmann, 2017). This study from Kwa-Zulu Natal South Africa explained why different people have different opinion on climate and its effects in the surrounding. Community in climate awareness determine the level and the amount of water harvested for their farms, irrigation and in their households for domestic use (Asfaw., Simane., Hassen ., & Bantider, 2018). Further, Amare & Simane, (2017) in Muger River of the Blue Nile in Ethiopia studied factor that determine water harvesting and conservation in farms. However, the study found that water conservation was positive

and significantly affecting farmers awareness about forth coming weather events. The study suggested that building resilience in adaptation strategies is a key in reducing smallholder farmer vulnerability. The measure to be adopted should consider site-specific agro-ecological system requirements, practice mixed cropping and livestock agriculture system since such measures could reduce the vulnerability of smallholder farmer on climate variability.

Climate variability has led to over-abstraction of water resources by farmers in irrigated farming, mostly in ASALs where extreme droughts limits the water availability (Pagliacci *et al*., 2020). However, involvement of the communities on decision making would make them perceive water abstraction and water harvesting in a different ways and can lead to environmental conservation (Kahsay *et al*., 2019). Karim and Thiel, (2017) confirmed in their study that, more than 80.1% of the Village Disaster Management Committee (VDMC) and 50% of non-VDMC believed that the adaptation methods to climate variability such as water harvesting and conservation works to increase water and food security. This showed community had perception towards water harvesting as a good practice that would enhance their livelihoods (Berhanu & Beyene, 2015).

2.3: Effects of Climate Variability on Agriculture in Africa

There have been many reports by IPCC, (2020) that said, there is an emergency of climate variability effects of rainfall and temperature on world's economy sectors such as agriculture, environment and natural resources. This weather extremes are affecting food security and livelihoods mostly in Africa where agriculture is rainfed. Therefore, there is need to adapt to these variations.

IPCC, (2014) posited that, Climate variability causes floods and droughts that are stressors to crop yields in Africa. Nonetheless, rural households `are likely to experience greater uncertainty in their rural production, and the negative shocks and trends from increased climate variability will affect rural livelihoods such as agricultural production, thus exposing rural household welfare to greater levels of risk. Studies by Abeje and Alemayehu, (2019) have showed that not only the amount, but also the timing of rainfall is essential to ensure stable crop development and secure the efficiency of farm inputs. Further noted that, by 2030 most of the potential

agricultural activities will reduce due to effects of droughts and floods by every season (Zhou *et al.*, 2012).

The probability of projections for multiple crop yields and circulation models are not significantly projecting. As such there will be crop losses in 2030 in East Africa with the exception of cowpea in Kenya. However, the previous study was done on Ethiopia, while the current study is being conducted in Southern Sudan focusing on whether farmers level of awareness of climate variability could have effect on their crop yields.

In west Africa, the probability of projection in temperature was expected to rise from 0.2 to 0.5 in the coastal and western Sahel regions and rainfall will increase from 5-8% in the semi-arid region by the year 2050, (Partey *et al.*, 2018). Furthermore, this will cause reduction in agriculture by an average of 20%, cereals by 40% and the duration of dry spells and drought was expected to project by 5% by Regional Climate Model (RCM). In west Africa the impacts of drought have resulted in reduction of grains which affects the market value, increased in prices, food shortages and malnutrition. Also, some of the impacts was related to conflicts, increased price in agricultural inputs, pest and diseases, and poor infrastructure (Ajayi &llori, 2020).

In South Sudan. The most impacted crops with climate variability were sorghum and maize with a percentage of about 70% (WFP, 2014). This effect of continuous extreme weather events and insecurity of the country led to food insecurity and displacement among the communities as a result of decrease in food production and availability (RSS, 2015). Since the land is still under development, farmers and agro pastoralists do experience weather changes in the beginning of the rainfall season whereby the rain delayed and affects crop growth, flooding causes death to animals, diseases and displacement to safe areas. (UNDP, 2017).

2.4: Determinants of Climate Adaptation Methods

The adoption of agricultural technologies on climate issues is always characterized by number of factors that are normally households and economic dependence, for example gender, age, level of education, experience of the farmer, perception of the farmer, and influence from the market. However, many researchers have done studies

on factors which affect the choice of farmers adopting climate smart agriculture such as (Amadu *et al.,* 2020); (Imran *et al.,* 2019); (Khatri-Chhetri *et al.,* 2017); and (Olorunfemi *et al.,* 2019).

The adoption of CSA requires financial aid to implement on farm level, however most of the farmers are constrained to financial access (Imran *et al.,* 2019). Therefore, institutional capacity such as banks and cooperative societies are required to promote effective adoption. For example, civil society help to disseminate information, build capacity and mobilize resources which are necessary such as funds (Campbell *et al.,* 2014).

2.5: Farmers Adaptation Strategies

Adaptation strategies to effects of climate change and variability reduces the negative effects and makes them adjust appropriately. Adaptation is the measure to reduce the risk of losses and to develop a capacity to cope with unavoidable risks, (Mndeme *et al.* 2016).

2.5.1: Crop Adaptation Strategies

2.5.1.1: Drought Resistant Crops Varieties

Planting of crops in areas which are prone and dry helps to reduce vulnerability to effects of climate variability. For example, irrigation is less required in wheat than compared to rice in dry seasons. Therefore, it has been tried by smallholder farmers to adapt to climate variability in areas of Nigeria, Senegal, Burkina Faso and Ghana (Martignago *et al*., 2020). And, nomad communities have also adopted such crop varieties to improve their livelihood. In South Sudan, rice farming was introduced as a drought resistant crop that withstand longer periods of dry season. Seasonal floods often wash away fields across most of the areas leaving them food insecure (WFP, 2021)

2.5.1.2: Diversified crops

Diversified crops have quality value to produce new crops feasible to long term drought resistant. Crop diversity is an adaptation measure that is practiced in both irrigated and non-irrigated areas. In Southern Africa for example, land use is manipulated leading to land use conversion, such as the shift from livestock farming to game farming. Diversification therefore serves as security to crop failure against rainfall changing patterns (Barbieri *et at.*, 2019).

2.5.1.3: Changing of Planting Dates for Different Crops

Due to climate change and its adverse effects, long-term crop is affected with rainfall patterns, prolonged drought and planting dates. In Tanzania, staggered planting is practiced by many farmers due to long variability; crops are planted just before the onset of the rains on uncultivated land or just after the rains. These farm practices are done purposely to distribute risk by ensuring maximum utilization of raindrops at the field and avoid losses (Mabuku *et al.,* 2019).

2.5.1.4: Mixed Cropping

Planting different crops in the same piece of land, this is also mainly practiced to avoid and reduces losses through growing cereals, legumes and nuts together. This help in manipulations of nutrients to maturity by optimizing drought tolerance, input required and end use of wasteful products. Nkiaka and Lovett, (2019) analyzed adaptation measures used in Africa to reveal that most countries except Cameroon and South Africa adopt planting of different crops in the same piece to avoid total loss.

2.5.1.5: Enhanced irrigation efficiency

Water has become a limited factor for agricultural yield therefore efficient irrigation will become an alternative adaptation tool to solve such a problem, mostly at dry seasons. Much expectation has revealed climate variability will lead to decrease in fresh water availability and reduce soil moisture during dry spell. Crop water demand increase as adverse climate conditions perceive hence leading to continuous low yielding varieties intensification. For example, Egypt, Kenya, and South Africa, farmers significantly adapted to efficient irrigation methods. As temperature increase, farmers tend to irrigate more frequent to avoid plant withering (Byellich *et al.*, 2013). In South Sudan, farmers get adapted to irrigation during dry season through water from the shallow wells (WFP, 2021).

2.5.1.6: Adaptation to Water and Soil Conservation

Soil and water conservation is an increasingly practiced technique in many parts of Africa like Burkina Faso, Kenya, Senegal, and Niger. Everest, (2021) revealed that farmers of Tanzania at Kamenyanga and Kintinku timely ensure water doesn't get wasted due to vaporization. And hence practices like burying crop residue to supplement soil fertility and burning of crop residue for quick release of nutrients in the soil. Farmers of Tanzania use ridges made along contours to minimize soil erosion

and encourage root penetration for moisture conservation. In Senegal and Burkina Faso, local farmers have improved their adaptive capacity by using traditional pruning and fertilizing techniques to double tree densities in semi-arid areas. These help in holding soils together and reversing desertification. Ochilo *et al.*, (2019) posited that farmers in Sahel conserve carbon in soils through the use of zero tilling practices in cultivation, mulching and other soil management techniques. Natural mulches moderate soil temperatures and extremes, suppress diseases and harmful pests, and conserve soil moisture.

2.5.2: Livestock adaptive strategy

Farmers for livestock have adapted to climatic and environmental changes that are traditionally explained by building knowledge. For example, change in livestock practices as diversifying, intensifying the integration of pasture management for livestock, altering the time of operations, conservation of nature and ecosystems. Most of the local livestock breeds are adequately adapted to harsh environment. Most important is to capacity build livestock keepers to improve their adaptive capacities on climate change. In addition, training in agro-ecological technologies and practices for the production and conservation of fodder improves the supply of animal feed and reduces malnutrition and mortality in herds (Kelly *et al*., 2018).

South Sudan is economically and politically distressed due to many years of civil wars from 1955-1972 and 1983-2005 and 2013–present. This has also affected the ability of the country to generate data, which helps with key national and local decision-making processes (BRACED, 2017). Further, adaptation and climate resilience research in South Sudan is subsequently extremely limited. Weak institutions and economic mismanagement have hampered political processes and outcomes. Few studies or institutions have researched key areas related to natural resource management, environmental conditions, livelihood strategies, decision-making processes at the local level and/or climate related vulnerability. Furthermore, research carried out has tended to be short-term in nature

CHAPTER THREE: METHODOLOGY

3.1: Study Area

Jubek State is situated in southern part of South Sudan. It extends from 4°30′N and 31°30′E to 3º45′0′N and 30º45′0′E. It covers about an area of 18,505 km2. Its elevation is ranging between (432-1289m) above sea level (Adam Juma *et al*., 2020). The state has fourteen counties namely: Bungu, Ganzi, Dollo, Rejaf, Lodu, Luri, Gondokoro, Mangalla, Liria, Oponi, Wonduruba, Rokon, Nyarkenyi and Lobonok. The study is done in five counties which were Liria, Gondokoro, Rejaf, Lodu and Luri, (GoSS, 2020). The map showing the study area is as shown in Figure 3.1

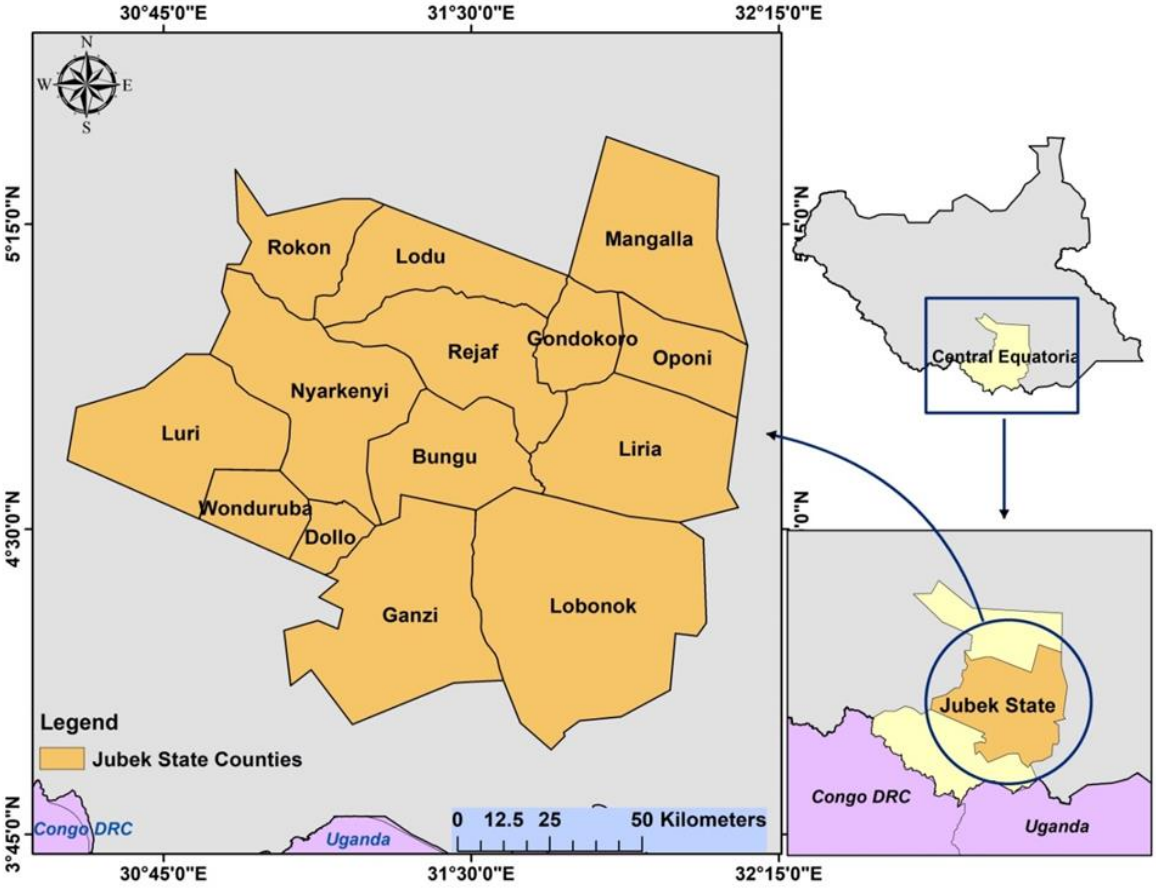

Figure 3.1: The Jubek State in South Sudan

(Source: Adapted from http://www.South 12 Sudan Map.com)

Jubek State which has typical tropical and dry climate was situated near the equator. It has a combination of high temperatures and significant rainfall throughout the year.

Temperatures remain relatively consistent changing from 31.1°C to 37.9°C. The highest temperature reaches up to 38°C and the lowest reaches 20°C.

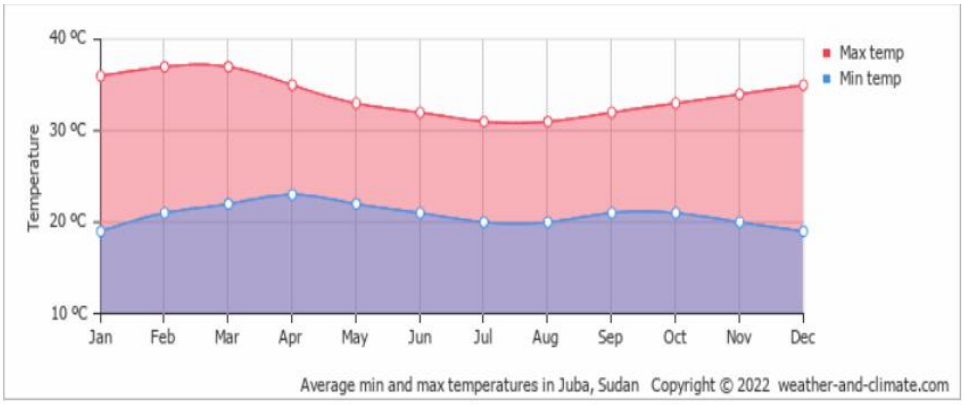

Figure 3.2: Monthly weather averages over the year.

Source: Average min and max temperature in Juba, Sudan Copyright © 2022 weather-and-climate.com

In Jubek State, wet days varies significantly throughout the year. The wetter season last for 6 months, from May to October with a 100mm of rainfall and above. The month with the most wet days was May with an average precipitation of 150mm of rainfall per year.

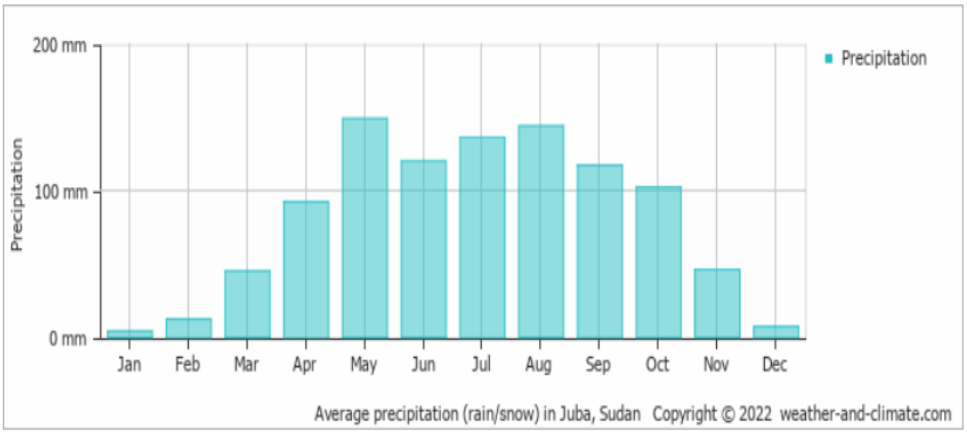

Figure 3.3: Monthly Average precipitation over the year

Source: Average precipitation (rain/snow) in Juba, Sudan Copyright © weather-and-climate.com

In Jubek State, the land use and land cover were divided into ten categories (crop land, tree-cover areas, grassland, shrub-cover areas, build-up areas, vegetation aquatic, bare areas, open water, lichen and mosses, sparse vegetation, snow and ice).

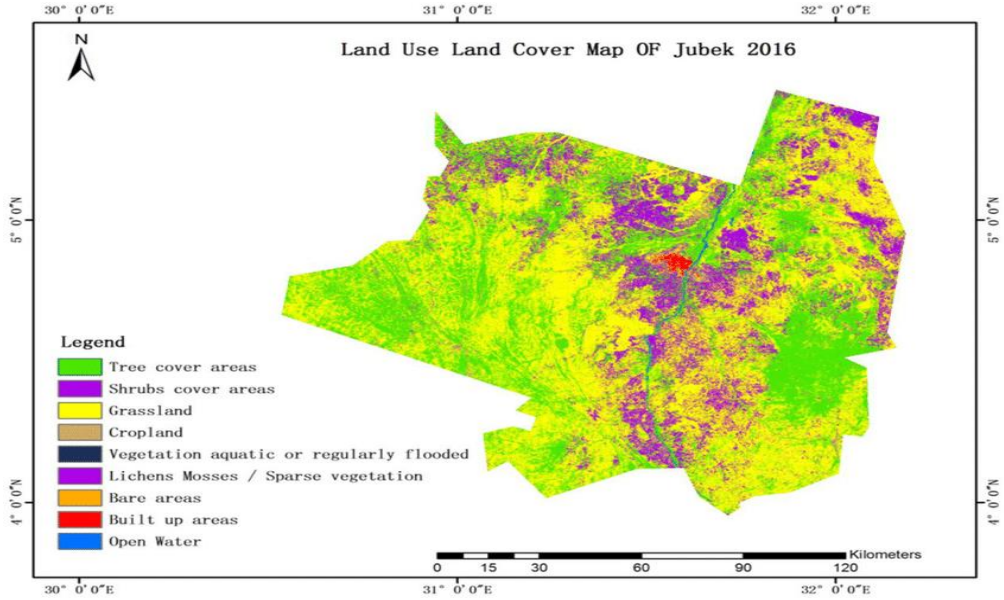

Figure 3.4: Jubek State vegetation cover

(Source: Land use land cover map of Jubek State researchgate.net)

3.2: Characteristic of study area

Jubek state has relatively rugged terrain characterized by hills, dry plains and rugged escarpments which influences its climate tropical wet and dry climate. It lies in Equatorial region. The state has two rainy seasons i.e., the "long rains" (March – July) and the "short rains" (August – November). The rainy season is from March to October (and sometimes to November) and is the right period for cultivation. The annual total precipitation is ranging from (600mm- 1,300 mm/ year) and between April to October, with more than 100 millimeters of rain falls per month. The hottest maximum temperature reaches 35º C in February, (Adam Juma *et al.*, 2020). The soil characteristics is sandy and clay- loamy. The crops grown were maize, sorghum groundnuts, sweet potatoes, cassava and vegetables (Lupai, 2014).

Furthermore, the people practiced crop rotation whereby sorghum as the staple crop is rotated with groundnuts in the same portion of the land. Mixed cropping was also practiced, e.g., maize with cowpeas in the same farm. Shifting cultivation was practiced in big fields because the field is big enough and also it is very far from their

homes. During the time of conflict of 2013 to 2016 most of the population ran away and the lands remain uncultivated for years. After they were back, they have to clear it first so as to start the new growing season.

3.3: Study Design

This study used qualitative research design. It involves the interviewer in gaining more experience and interaction with the farmers knowledge on how they get adapted to the climate challenges, how they perceive climate variability and what is causing it, what are the problems facing them and the methods of adaptation they are using.

3.4: Population

Population is the total number of individuals having the same characteristics (Mugenda 2003). In this study, the target population are the small-scale households head growing crops and having challenges of climate variability, stayed for 8 years or more in the five Counties of Jubek State. The population of the households was obtained from the South Sudan National Bureau of Statistics (SSNBS, 2020) of about 115,419 households. Five counties represented the study respondents of the sample size (Luri, Liria, Rejaf, Lodu and Kondokoro).

3.5: Sampling Procedures

Jubek State (Central Equatoria State) lies in the equatorial region, was characterized by wet and low variability climate. In this region several crops were grown such as maize, sorghum, groundnuts, sweet potatoes, etc. The State have fourteen Counties and further divided into sub-location called payams (villages) with high rainfall of equatorial region. The first step was, five Counties were selected randomly for the study. The five Counties were purposively selected due to, 1. Majority of the household depend on rain-fed cultivation where several crops were grown including sorghum and maize which are the staple food contributing to the house food and income source. 2.This is where you can get small-scale households who over stayed for more than 8 years and experienced climatic challenges and the way they adapt to it. This was in agreement with (Farida, 2014) who stated that, in good environment, there is increase in economy of mixed cultivation. In the second step, due to climate

change and variability, equatorial region that experienced extreme climatic events since 1979-2014 (UNDP, 2016).

The five Counties were further divided into sub-location called Payams (villages). The study used Stratified random sampling technique to identify the payam households' heads during the research survey. It is a method of identifying subgroups in a population having the same characters such as climatic challenges. Multi stage sampling was used to divide the population into smaller group call cluster. Also, the purposive sampling was use to get the knowledge of Key Informants about climate variability in the area and to choose the best fit participant to answer the guided questionnaire based on the specific objectives. The five counties represent the strata and selected randomly. Since the researcher has the list of the Payams (villages) with their population within the five Counties given from the commission, then select randomly from each County as shown in the (Table 3.1). The sub-location (Payam) was the sampling frame and group into five representing the counties. The process of obtaining sub-location sample size from the target population was based on the list of household's number and population density (Scheaffer *et al*, 2006).

3.6: Sample Size

The number of Households sampled was selected from the entire household population of the five counties and was based on the type of crop grown in farms. This confirms to the statement by Orodho, (2002), which stated that sample size should confirmed to the population as such the larger the sample size the smaller the sampling error. The sample size was determined by using the formula recommended by Yamane, (1967) as follows:

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

$$\eta = \frac{115{,}419}{1 + 115{,}419 \times (0.05)^2}$$

$$\eta = \mathbf{399}$$

Where;

n= Sample size

N= Households Population size

e =level of precision which is 0.05

After getting the sample size of the entire household's population, then the procedure of stratified random sampling was used to get the sub-location (payams) in the five counties. According to Kombo *et al.,* (2006), to identify subgroups in a population that have the same characters and to separate into equal subsets, must apply the method of stratified random sampling. From the list obtained from the counties commission, the sample size of each Payam was calculated by the formula below and shown in the (Table 3.1).

$$n = \frac{p}{\mu \, x \, S^n}$$

Where **n** –sample population of the division

P-population of the household in the location

μ-the total households in the division

s^n- total sample size of the households in the division.

Table 3.1: Number of households sampled during the study

County	Sub-location	No. of HH	No. of HH per sub-location
Liria	Langabu	1750	1750/115419x399=6
	Ngulere	2456	2456/115419x399=8
	Liyangari	2037	2037/115419x399=7
	Ngangala	3109	3109/115419x399=11
Luri	Sombe	2117	2117/115419x399=7
	Rombur	3260	3260/115419x399=41
	Kuda	2493	2493/115419x399=9
Gondokoro	Mori	3265	3265/1154191x399=11
	Mononyik	1760	1760/115419x399=6
	Logumera	1501	1501/115419x399=5
	Kangu	3995	3995/115419x399=14
Lodu	Nyain	20962	20962/115419x399=72
	Joppa	12423	12423/115419x399=42
	Kworojik	15777	15777/115419x399=56
	Walang	13965	13965/115419x399=48
Rejaf	Tokiman	8339	8339/115419x399=29
	Kolia	6176	6176/115419x399=21
	Guduge	10034	10034/115419x399=34
Total		**115,419**	**399**

3.7: Data Collection Instrument

Both quantitative and qualitative data were collected for this research using open and closed-ended questionnaires to gain information from Jubek State farmers, and the State Department of Agricultural office.

A semi-structured questionnaire was administered to households sampled during the study in selected homes so as to give a systematic response of the large number of households at the same time. Focus Group Discussion to gather information about climate variability and the methods of adaptation. Interview guide questionnaire was used to get information from the Key Informants on what they know about climate change, and variability challenges on the crops and how they are adapted to it. During the interview, Notes and photograph were taken. The photograph was to see how they are responding to the questions concerning climate variability and its effects. The same instruments were used by (Mwaniki, 2016) and (Monica, 2018). The period for collecting the data was from April to December 2020.

3.8: Data Collection Procedure

The permission consent from Kenyatta University was used to request permission from the Ministry of Agriculture, National security and Meteorological Department to carry out the research in the area. The list of the households and the chiefs in each county was given to the researcher from the counties commission. With the list of households obtained from the commissions, a systematic sampling method was used whereby taking every households by selecting the name as per the number of households sampled in the sub- location (payam). By starting the survey, the first household was selected randomly by calling the name, then the sub-chief showed the house.

The procedure followed every 10 houses, in case the household was not present or stayed for less than eight years, the researcher moved to the next house until all the 399 targeted household was obtained. The 399 questionnaires were administered to the households but 8 of them declined remaining with 391 which was filled completely. The questionnaires comprised both close-ended and open-ended questions. The 391 filled questionnaires showed 97 % as a return rate in which is more than 80% recommended by (Okaka, 2016). Three research assistants were

recruited in administering the questionnaires to the households, due to the large number of respondents, to record accurately and to communicate in their language fluently. They were trained on how to interview the respondents using the semi-structured questionnaires and to introduce the purpose of the research. They assured that, the information was kept secretly.

Individual interviews using semi-structured questionnaire and key informant interview guide with the same similar question related to climate change and variability and method of adaptation was attributed to the households. The interview questions were asked in their language to enable them understand and express better and to be noted correctly. This was then followed by taking notes and photographs to show their attitudes in responses. After the questionnaires were filled completely and collected, it was arranged systematically by the research assistants then given to the researcher. After house survey, the researcher and the research assistants collected data from 3 focus group discussions. The group compose of male alone 7 participants, female alone between 25-30 participants and both male and female 10 participants. For the Key Informant 5 participants with the used of open- ended interview guide having similar question of the semi -structured questionnaire used in the survey. They all shared their knowledge about climate and the way they adapt to it.

In the focus group discussion, some of the participants the local farmers were trained by the NGOs project programs done in the rural areas so as to boost their agricultural livelihood. Five Key Informants from the agricultural department at the payam local administration were selected purposely to share their knowledge in effects of climate change and variability on the crops. After all the interviews were finished, the same letter of permission from Kenyatta University was given to metrological department for the past 30 years climatic data of temperatures and rainfalls to determine the trends of annual, monthly and seasonal climatic variables. A pre-test procedure was done to compare the reliability of the farmers regarding climate variability.

Kathuri and Pals, (1993) indicated that the smallest number that can give meaningful results on data analysis in a survey is twenty (20), while other researchers Perneger *et al*., (2014) recommended a sample size of at least thirty (30). Therefore, the number twenty-three (23) is higher than the minimum recommended number for pre-test

samples. The pre-test data was then subjected to Cronbach's alpha reliability test for internal consistency.

The advantage of Cronbach's alpha analysis procedure was to give both inter – and intra – item correlations (i.e., consistency) between the items being measured. A reliability coefficient of $0.60<\alpha<0.70$ is usually considered reasonable and acceptable for social studies of this nature (Santos & Reynaldo, 1999).

Accordingly, Cronbach's alpha test was run to determine the overall reliability coefficient for a set of key independent and dependent variables to be assessed in the regression model of the study. The test results were presented in (Table 3.2). The results indicated that Cronbach's alpha is (0.802, 0.704 and 0.947) for farmers' Perceptions, socio-economic factors and suitability of adaptation measures on climatic variability. The three combined gave an overall reliability coefficient of 0.946, which indicated a high level of internal consistency for our scale with this specific sample, hence; adequate to proceed with the inferential statistical analysis.

Table 3.2: Reliability test between dependent and independent variable correlation

Parameter	**Cronbach's Alpha**	**Cronbach's Alpha based on Standardized Items**	**No. of items**
Farmers' Perceptions	0.802	0.704	19
Socio-Economic Factors	0.704	08603	17
Suitability of Adaptation Measures on Climatic Variability	0.947	0.772	28

Using the rule of George and Mallery, (2010), a reliability coefficient above 0.9 implies excellent; above 0.8 is good; above 0.7 is acceptable; above 0.6 is questionable; above 0.5 is poor; while that below 0.5 is unacceptable. Thus, the

reliability for both individual items 0.802, 0.704 and the overall reliability (0.947) were between the acceptable and excellent levels.

3.9: Data Analysis

In the process of data analysis, data was checked and arranged properly. The qualitative data was analyzed, interpreted, coded and summarized. The direct quotations from the farmers were manual and its part of the analysis regarding their adaptation methods and challenges (Bryman, 2013). The process of data analysis was divided into two. First it began with analysis of interview data. The important points from the field-notes were highlighted regarding climate variability and adaptation methods, since it is important to know the general ideas and compare their issues. The second is classification and categorization of the data. Field noted were arranged properly and coded. Tables and figures were presented to add more understanding.

Climatic variables (rainfall and temperature) for the past years as an introduction were scrutinized for missing values and computed using data covering 1981 to 2023; a period selected for the study. The data were statistically analyzed using modified Mann-Kendall test with Sen's slope estimator (Mann, 1945) in R-Programing Studio to determine the trends of annual, monthly and seasonal climatic variables, then presented in graphic design which was drafted in Excel 2020.

A structured questionnaire was administered to respondents by requesting to choose on most appropriate answer to them. Likert-type items that represent similar questions were combined into single composite variables. Likert-scale data was analyzed by use of mean, standard deviation and frequency; these processes are known as descriptive statistics. The inferential statistic was computed, entered and coded in Statistical Package for Social Sciences (SPSS). Logistic regression model was used to analyze independent and the selected dependent variable. The main objective of this study was to establish a viable mechanism for climate change adaptation for different crops yield by the farmers. Therefore, after analyzing farmers' perceptions and determinants of adaptive strategy, the research was able to evaluate the viability of adaptive mechanism for crops production in the five counties.

3.10: Ethical Consideration

Before conducting interviews, the research proposal letter was submitted to the state officials and the Payam authorities. The head chief of all counties read the proposal letter before approving the conduction of the data collection. He then gave copies of the research proposal to all sub-chiefs. This was meant to inform them about the research topic, purpose and above all to gain their consent.

According to Creswell (R009), participant must fill consent before the researcher takes questions however, in this study the consent of the respondent was made verbally. This became possible because the chiefs were asked before and also at the beginning of every interviews with focus group discussion the research topic and purpose were explained. In addition, the choice offer sites of interviews and group discussions was left to the participants. The research assistance and the guide.

Due to the insecurity in the areas, data was collected from limited areas according to the national security directions and guidance. So, this becomes a challenge to get more information from far areas.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1: Characteristics of the Respondents

The reason for knowing the socio-economic characteristics of respondents is to get the different type of people affected by climate variability. The independent variables of the respondents such as the marital status, gender, code of employment, level of education and type of farming were classified into their frequencies and percentages. This were the variables that influence the decision of households to choose a specific type of adaptation strategy so as to cope with climate variability effects on the farms and yields, (Table 4.1)

Table 4.1: Demographic Characteristics of Respondents

Variables	**Characteristics**	**Frequency**	**Percentage**
Marital status	Married	253	64.7
	Single	138	35.3
	Total	**391**	**100.0**
Gender	Male	269	68.8
	Female	122	31.2
	Total	**391**	**100.0**
Code of employment	Employed	253	42.5
	Not employed	138	57.5
	Total	**391**	**100.0**
Level of education	No education	111	28.4
	Primary	137	35.0
	Secondary	109	27.9
	Tertiary	34	8.7
	Total	**391**	**100.0**

Type of farming	Crop farm	186	47.6
	Livestock	119	30.4
	Mixed farm	86	22.0
	Total	**391**	**100.0**

4.1.1: Marital Status of the Respondents

The study sought to examine the marital status of the small-scale farmers. This is due to fact that marital status is often an important variable in the overall management of farmlands and considered to be an initial foundation of family commitment and responsibility among the targeted community. Majority of the respondents 253 (64.7%) were married and 138 (35.3%) were single, (Table 4.1).

In this study, the married households are more than the unmarried in terms of percentages was due to the fact, they practiced adaptation methods so as to earn more food and other necessities of life such as health and education for their families and children. While the single farmers are mainly involved in subsistence farming This great number of marital status of households showed some level of family responsibilities and sharing of knowledge about farm practices from different stand-points. This result was in relation with (Njoku, 2005).

4.1.2: Level of Education of the Respondent

The study sought to examine the level of education of respondents. The level of literacy is assumed to be obtained from schooling: formal and non-formal education. The South Sudan system of education (8-4-4) provides some element of environmental education regardless of the levels. Hence, it was important to examine this variable in relation to on-farm and management. Four levels of education (1-4) were considered for the study. The levels ranged from no education (28.4%), primary (35.0%), secondary (27.9%) to tertiary (8.7%) or college or university. Results of the distribution in terms of education of the respondents were shown in (Table 4.1).

Generally, the level of literacy of the five counties reveals that 28,4% were illiterates. The level of education of respondent has substantial impact on the adoption of adaptation strategies to climate variability such as the use of making decision about

agricultural inputs, giving technical advice. Belay *et al.*, (2017) posited that education level of households need to be improve as it has a vital contribution to adopting adaptation methods and improve agricultural production.

4.1.3: Gender of the Respondents

The study sought to analyze the gender of the respondents. The findings were hereby presented in (Table 4.1). The mean age for male households (n=269) was 68.8% out of the sampled population and that of the female households (n= 122) was 31.2% out of the sampled population. In this study results, the males were more due to the fact; they were ready and easily in getting information about climate change and adoption strategies. While the females were limited due to their busy schedules at homes These results were in line with the one showing the percentage of around 16% of rural households was headed by men (CSA, 2012).

4.1.4: Type of Farming

The study also sought to analyze the type of farming used by the households. Farming played a great role in the economy of their livelihood. Crop farming was the dominant character being practice by the farmers in their farms (Table 4.1). Farming in Jubek State was the main character. According to respondents' answers, majority of them are crop growers, since they are small scale farmers growing crops for their food and source of income. During the past several years of civil war, the homesteads population don't keep livestock in their homes due to insecurity of cattle raiders. Ylipaa *et al*, (2019) found that types of farming are main source of livelihood in Vietnam and thus could influence the adaptations method employed by farmer to make better yields.

4.2: Jubek State Climatic Variability (1981-2023)

Climate variability in South Sudan varied within the three rainfall regions, equatorial, semi-arid and tropical savannah regions. Equatorial region was characterized by wet and annual rainfall of about 1230mm/year. This region had the highest amount of rainfall with a low variability since its near Lake Victoria. Rainfall was throughout the year with maximum of 180mm/month. Usually long rain is from March-May(150mm/m). Short rain is in November with a mean temperature of about 22ºC. In this region warm temperature occurred between February-March and between Dec-Aug is the coolest. Tropical savannah region was characterized by annual rainfall of

about 1050mm/year. Rainfall increment was all over the region up to the borders of Ethiopia and Democratic Republic of Congo. Rainfall occurred once a year from March-November with a low variability yearly. The maximum mean temperature is about 28ºC (UNDP, 2017).

Furthermore, in semi-arid region, it was characterized by drier or wetter climate than the other regions. There was a long-term variability in this region from 1979-2015 according to analysis done. The trends seem to be less in the second half of the period with a non-significant trend in rainfall from 1979-2014.The majority of population are within the tropical and equatorial regions and they are experiencing low variability compared to semi-arid with moderate variability. According to analysis done, semi-arid and equatorial region showed non- significant increase in trends of rainfall and frequency of high rainfall events.

This study analyzed climate variable of maximum temperatures, minimum temperatures and rainfall patterns as the main atmospheric conditions that would affect agricultural activities in Jubek State, South Sudan. The study found that there was a positive change in temperature and a positive change in rainfall variability. Moreover, the maximum temperature showed significant increase ($p < 0.05$) as from 1981 to 2023 as shown in the (Table 4.2).

Table 4.2: Temperature variability versus rainfall variability (1981-2023)

Variables annually	Coefficient (tau)	Sens' slope	p-value	Implication
Minimum Temperature	0.195	0.024	0.087	Increasing
Maximum Temperature	0.235	0.179	0.039	Increasing
Rainfall	0.391	0.167	0. 025	Increasing

From the study results of maximum and minimum temperature condition in Jubek State, there was a positive and significant change in increase as from (1981-2023). The maximum temperature was increasing in Jubek State; this result implies that temperature conditions in Jubek State was increasing speedily.

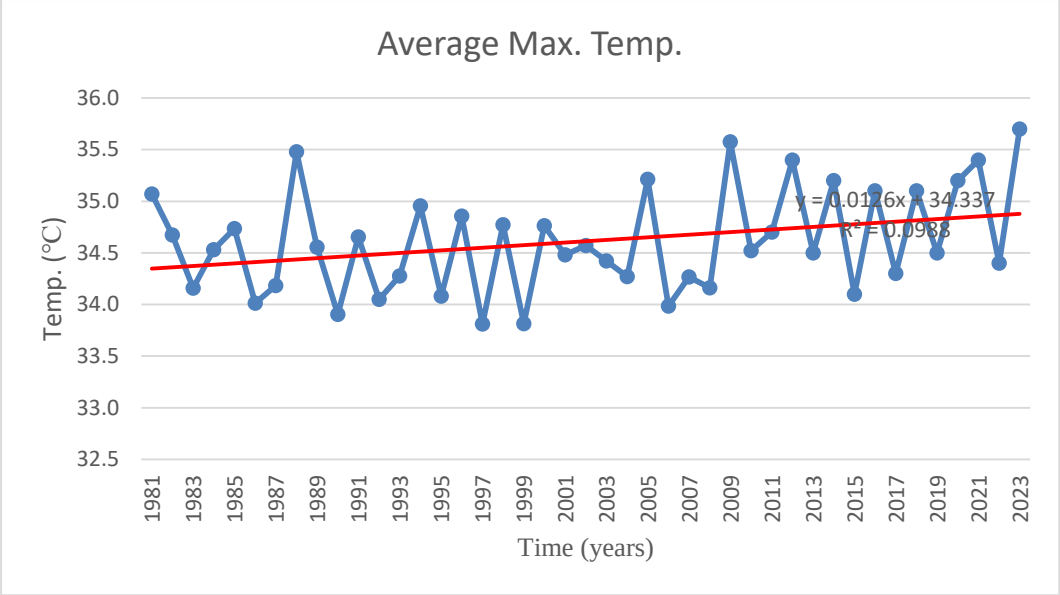

Figure 4.1: Average Annual Max Temperature from (1981-2023)

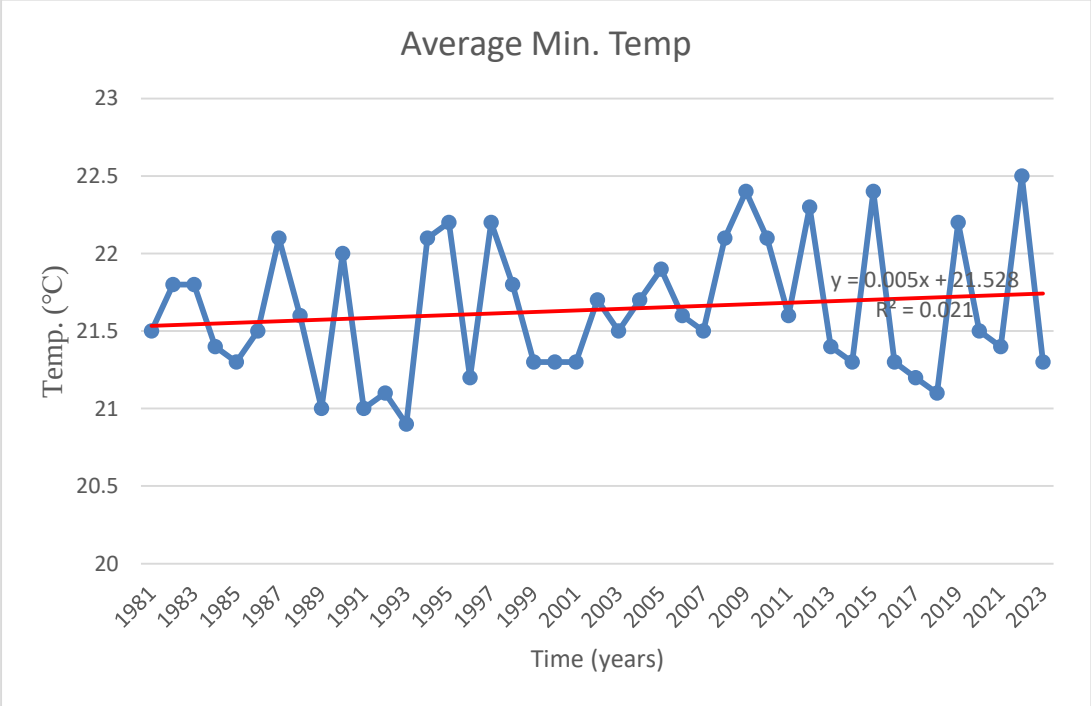

Figure 4.2: Average Annual Min Temperature from (1981-2023)

On the other hand, the annual average rainfall trends were not significant though it was positive. These results showing that there was a slight increase in annual rainfall between 1981 and 2023 in Jubek State, with the year 2016 indicating the highest amount of rainfall year during the study periods and year 2005 indicating the lowest amounts of rainfall as shown in Figure 4.3

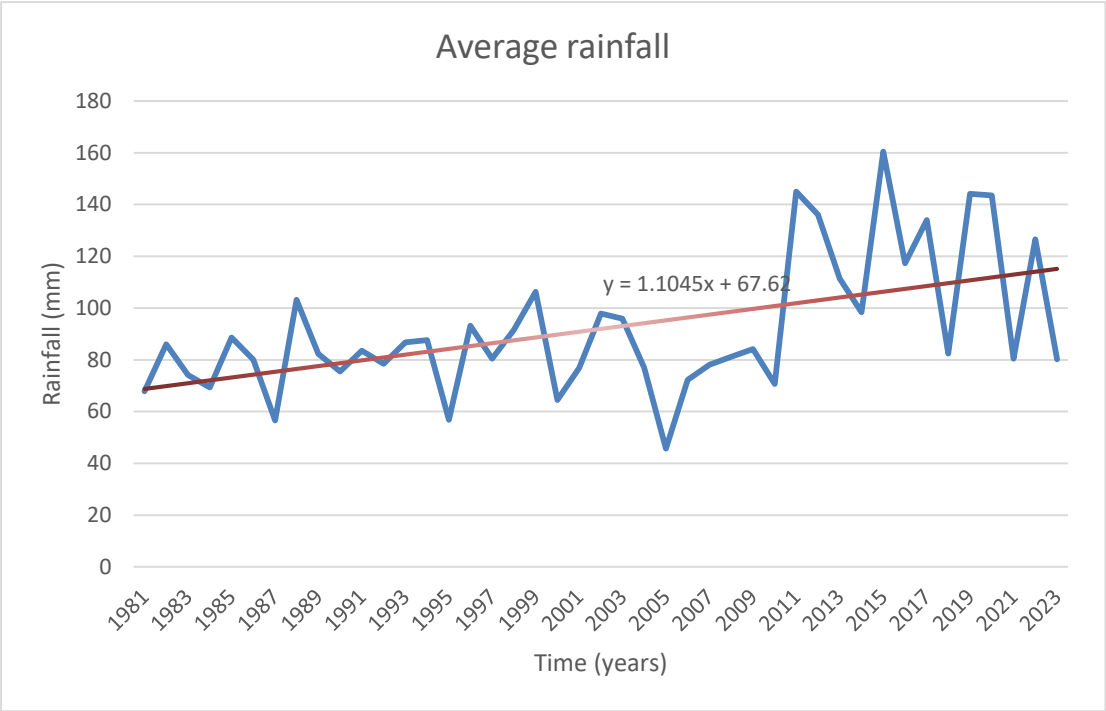

Figure 4.3: Annual Average rainfall of Jubek State from (1981-2023)

This results when compared to the past historical analysis of climate variability trends within the three regions of South Sudan (Equatorial. Semi-arid and Tropical Savannah regions) as discussed above, it showed that tropical region has a positive but non-significant increase in trends of total rainfall and its frequency. This is in relation to this study, since Jubek State lies in the equatorial s region.

The same results showed by this study on temperature and rainfall variations had been shown by other studies globally. Umar *et al.*, (2019) found that there was change and variation in the climatic variables in the Hadejia River Basin (HRB) of Nigeria. Further, the study reported that there was increasing temperature and rainfall though was not significant within the year of analysis (1980-2015). However, most studies have found that world's temperature was increasing alarmingly than rainfall changes; (Bathiany *et al.*, 2018); (Saha *et al.*, 2014); & (Shrestha *et al.*, 1999) have confirmed, as it was found in this study in South Sudan (Figure 4.2 and Figure 4.3).

4.3: Small Scale Farmers Perceptions about Climate Change and Variability

Farmers perceptions and awareness was one of the objectives in this study, and is important to get the knowledge of farmers about climate change. For a researcher to communicate with a farmer about the effect of climate change happening around, the farmer must understand what is climate change and its effect (Okaka, 2016).

According to the questionnaire attributed to the farmers, they were asked whether are aware and experienced effects of climate change and variability on the farms. Their experienced was rated in likert- Scale.

From the results in Table 4.3, it was found that there was reliable consistency of Cronbach's Alpha (α) = 0.63 with the 6 items that were scrutinized, and the chi square report showed that majority of the farmers were aware of climate change and its surrounding phenomena in the selected counties. the significant awareness (X^2 = 104.92; df = 5; p= 0.000). Most of the items were weighing mean ranging from 3.00 to 4.00 which showed that farmers were aware. The findings were in agreement with those of Ochieng & Koske, (2013) who found in different parts of Kenya that farmers were significantly aware of climate change and its effects, when the analysis of the same were done.

The results from the Likert-Scale showed that farmers were normally aware of issues relating to climate change and its effects and some farmers were neutral about two issues. The two issues indicated that there was no change in climate and they have no idea about its effects, (Table 4.3).

Table 4.3: Awareness on climate change in Jubek State

Climate variability Statements	W. mean	Std. dev	Awareness level
1. There is climate variability	3.79	0.84	Aware
2. Climate change is caused by increased in technology	3.77	1.11	Aware
3. Climate variability leads to crop failure	3.01	1.20	Aware
4. Climate change is caused by deforestation and cutting of trees	2.54	0.97	Neutral
5. Farmers had attitude to shift climate variability	3.27	1.09	Aware
6. Climate change came as a results of government instability in Sudan	2.52	0.86	Neutral

The information shared from Key informant interview revealed that the occurrence of climate factors has been varying between years with some seasons receiving early, onset rainfall and high temperature, while in the other years they receive less rainfall with frequent drought and flood and becoming more unpredictable and unreliable.

Plate 4.1: Key informant interview from the local officers

Photo taken by homestead 15th June. 2020 Rejaf County (N4º48′, E31º38′)

From the expression obtained from focus group discussion, it was revealed that climate change and variability is taking place in Jubek State. The main indicators pointed out were increased high temperatures, low rainfall, floods and drought.

Plate 4.2: Focus Group Discussion under the tree (both men and women)

Photo taken by the candidate 23th. April. 2020 Liria County (N4º60′ E31º36′)

It was more interesting in getting information from an elderly farmer who was able to explain the phenomenon of climate change due to the experience and knowledge of previous climatic conditions in the county. She stated that:

Plate 4.3: Showing a female household explaining effects of climate change in the area. Photo taken by candidate 21st April 2020, Liria County (N4º60′ E31º36′).

"I have heard about climate change. Here in my Payam Langabu, sometimes we harvested little when there is little rain. Mostly the sun has destroyed most of our

crops. This year we planted during the first rains but when it stopped, the heat followed and destroyed the crops"

Another female respondent further stated that:

"*The government lack commitment in addressing us about the climate change. Here we just see the first rain of April, when it started with good amount then we put the seed in the ground. Sometimes the first rain might delay and we have to wait"*

Farmers were critically aware that; 1) There was climate variability 2) Climate change is caused by increased in technology 3) crop failure is caused by climate variability 4) Climate change is caused by deforestation and cutting of trees 5) Farmers had attitudes to shift climate variability 6) Climate change came as a results of government instability in South Sudan.

A focus group discussion was carried out in mononyik payam based on male interview under the tree. In this focus group discussions, there was a mixed reaction of opinion about the effect of climate variability on their farms. Farmers narrated climate variability effects on their farms differently. A household respondent said,

Figure 4.4: Male focus group discussion giving opinions on the effects of climate variability on their farms

Photo taken by homestead 20th.May.2020 Kondokoro County (N4º58′, E31º37′)

"*For the past three years ago, we use to get some of the agricultural tools like the improved seeds, hoes and insecticides from the NGOs. But this year they didn't come due to insecurity of rebels (cattle raiders) who usually comes to abduct children to exchange with cattle, goats and sheep*". Another male homestead also further explained:

"Mostly the fowl army worms are the one destroying our crops. We use traditional ways of preventing diseases from destroying our crops by spreading ashes all over the leaves and the stems of the plant.".

Another one also said: "*once, the NGO came and dug for us borehole using generator, supplying the water to a big plastic tank. Thieves came and stole the generator and the big plastic tank leaving us not to irrigate during dry season. So, it become for us difficult to cultivate during dry season*"

From the point of view of respondents, there is climate variability in their expressions such as drought, pest and diseases. Lack of climate information and infrastructure (boreholes). Impact of drought without adaptation can result to food insecurity and poverty. This study results were in relations to Islam *et al.,* (2017) and Somboonsuke *et al.,* (2018) who found that most of the food insecurity and poverty are some of the impact of climate variability and climate change.

4.4: Socio- Economic Factors Influencing Adoption of Climate Adaptation Methods in Jubek State

Agricultural practices and inputs such as fertilizers, early warnings, crop insurance and irrigation can contribute to food security and technology for growing business if it is adopted, (Leake & Adama, 2015). The farmers in Jubek state have shown some of the method how they are adopting regarding their age, gender, marital status, etc. some of the NGOs and Government have tried to build farmers field schools and making programs in training the farmers to improve agricultural technologies so as to increased productivity and income from the farm products.

Factors that always influence adaptation methods in small scale agriculture are termed socio-economic factors (Mozzato *et al.,* 2018). The descriptive statistics of socio-economic factors which would have effects to the used of adaptation strategies were shown on the Table (4.4)

Table 4.4: Descriptive statistics of Socio-economic factors to adaptation methods

Variables	Obs.	Mean	Std. Dev.	Min	Max	Description
Dependent variable						
Climate adaptation	391	0.245	0.431	0	1	Dummy
Independent variables						
Gender of the farmer	391	0.312	0.463	0	1	Dummy
Age of the farmer	391	41.08	9.213	23	71	Continuous
Type of farming	391	1.744	0.795	1	3	Continuous
Farmers' marital status	391	0.647	0.478	0	1	Dummy
Code of employment	391	0.425	0.495	0	1	Dummy
Sources of income	391	0.524	0.500	0	1	Dummy
Level of education	391	2.168	0.940	1	4	Continuous
Size of the household	391	4.926	2.501	0	15	Continuous
Size of the farm	391	2.526	1.771	0	8	Continuous

As from the objective, to analyze how socio-economic factors influence adaptation strategies on crop yield, the data obtained from the field was computed and used for analysis using logistic regression model and the results were presented in (Table 4.4).

4.4.1: Gender of Household Head

Gender is defined as either male or female. From this study it showed that the male-headed household was more capable of using climate adaptation method due to their connection with social net such as radio in which they get information and knowledge about weather forecast. This study results showed that there was a positive and significant correlations between the gender of the household head, and the use of

climate adaptation methods, ($p < 0.01$) in curbing the effects of climate change (Table 4.8). The descriptive analysis found that 79% of the male household head were using climate adaptation methods while only 21% of the female household head were using the climate adaptation in their farms as shown in (Table 4.5).

Table 4.5: Gender percentage on adoption of climate adaptation methods

Variable	Gender	Yes	No
Gender of the household	Male	233 (79%)	36 (37.5%)
	Female	62 (21.0%)	60 (62.5%)

Moreover, the study found that gender disparity had a probability of 22.5% to increase and shift the use of climate adaptation methods by small scale farmers in Jubek State

The results from this study was supported by Thinda *et al.,* (2020) and Ylipaa *et al.,* (2019), studies which were done in South of Switzerland respectively, they found that gender has greater role in understanding the adoption of climate adaptation methods among small scale famers; however, males had dominated the chance of adopting to climate change effects as compared by counterpart females in the society.

4.4.2: Age of the Household

Regarding the age of the households, it showed that the youngest was 23years and the oldest was 71 years with a mean average of 41 years. Age matter in experienced in climate change challenges. During the interview, the older farmers answered according to their experienced during the past years. The older farmers can perceive the local climate condition and have a high probability to adapt to the changing climate than the younger farmers.

Household age was found to be positive and insignificant to influence the adoption of climate adaptation strategies so as to combat effects of climate variability ($p > 0.05$; Table 4.8), the facts remains that the increase of farmers age could increase the adoption of adaptation methods. However, age had a probability of 0.1% of making farmers to adopt adaptation methods though was not significant. The same results were reported by Muriu-Ng'ang'a *et al.,* (2017) study which found that farmers age were directly proportional to water harvesting as an adaptation method for farming.

4.4.3: Type of Farming

The types of farming employed by the community in Jubek State included crop farming (47.6%), pastoral farming (30.4%) and mixed farming (22.0%). Thus, these results deduced that crop farming was mainly practiced by Jubek state community. The binomial logistic regression results showed that types of farming practiced by farmers was negative and insignificant factor that determine adaptation used by farmers ($p > 0.05$, Table 4.8). However, types of farming had a probability of 0.5% to affect the method of adaptation employed by farmers in their farms. Ylipaa *et al.,* (2019) found that types of farming are main source of livelihood in Vietnam and thus could influence the adaptations method employed by farmer to make better yields.

4.4.4: Household Marital Status

Marital status of a household has an important role in farm management. The fact, the married households have responsibility of providing food to the table and have enough time to shared information about farm management. The marital status of a household was found to be positively correlated and influenced the choice of adaptation employed by farmer in the farm, there was a significant determination of marital status to adaptation ($p < 0.01$, table 4.8). Moreover, marital status had a probability of 11.5% to influence the use of adaptation methods in the farm. The households who were married are sampled to be (87.7%) and reported to use adaptations method more as compared to single/widows (68.8%) farmers, see (Table 4.6).

Table 4.6: Households marital status to adaptations adoption

Adaptation	Agreed	Married	Single/widows
	Yes	87.7%	68.8%
	No	13.0%	31.2%
		100%	**100%**

The same results found by Duong *et al.,* (2020) and Mabuku *et al*., (2019) showed that marital status of a farmer could influence the determination of adaptation methods use in the farm to produce yield. Therefore, the results deduced that farmers who are married had much responsibilities and share of knowledge from the partners

(Gram *et al.,* 2018). Also, the results resonated well with those of Ndichu, (2021) who noted that climate change will affect all human societies in all their activities but in different ways and to different degrees. However, women's access to adaptive strategies depends on their marital status, while this is less in the case for men. More so, woman's marital status is a vital factor in determining her access to adaptive strategies, it is a less important factor in the case of men. Also, the findings were in line with those of Kinuthia, (2018) who suggested for more awareness creation, training of farmers is important on how to identify and deal with changing climatic conditions.

4.4.5: Code of Employment

In Jubek State, some farmers were employed and unemployed. This study found that 57.5% of the farmers are not employed thus mainly depend on farming as the source of livelihoods and 42.5% of the farmers had some alternative employment sources of livelihoods. The results showed that employment code was positively and significantly correlating with adaptation choice of the farmer, ($p < 0.01$; Table 4.8). These results deduced that employment could influence the farmers adaptations choice in farm since farming could be the main source of livelihoods or otherwise. However, employment codes had 27.5% probability of increasing the rate of adaptation by the farmer in Jubek State. In agreement with other studies; Duong *et al.,* (2020) Ochieng *et al.,* (2016) and Thinda *et al.,* (2020) found the same results as in this study, these are confirmation that employment status influence the adoption of adaptation methods by farmers in their farms and this would help to curb level of poverty.

4.4.6: Source of Income

As enumerated by other studies around the world, income from the farm plays a critical role in the economy and farmers' livelihoods (Lloyd & Dennison, 2018). The farm income of farmers showed highly negative and insignificant influence to farmers' adaptations use in Jubek State ($p > 0.05$; Table 4.8). Moreover, the source of income results from this study, was not influencing farmers to use adaptations as found in other studies such as (Ojo & Baiyegunhi, 2020) in South-west of Nigeria and (Yomo *et al.,* 2020) in Ghana. They found that farmers income from agriculture were significantly marking the behavior of using adaptations method to increase the income. However, the source of income would negatively determine farmers use of

adaptations method by 10.0%; probability), as diversity of income source increase the adaptations use by the farmers reduce the farm. Belay *et al.*, (2017) stated that more income sources would lead to farmers abandoning climate adaptation methods.

This was echoed by the male homestead from Rombur Payam (Luri county) who said that:

"*In my farm, I normally grow my crops without using fertilizers, I harvest little amount which is not enough for selling, household feeding for the other season and even I can't pay school fee and my children are not going to school. Since these fertilizers are very expensive to buy. I don't have any other job; I depend on my farm only"*. From the point of view, lack of money stops farmers from getting the necessary resources and technologies that facilitate increase in production and adaptation to climate variability. This result is supported by Abid *et al.*, (2015) who showed that lack of money is the major limitation to hinder rural households to adopt climate change adaptation methods.

4.5.7: Level of Education

In regards to the farmers' level of education, there was a negative correlation between farmers' level of education and adoption of climate adaptation methods, though was not significant ($p > 0.05$; Table 4.8). Most of the farmers had primary education 35.0%, however most of the farmers also had no education 28.4%, secondary education 27.9% and tertiary 8.7%. The disparity in level of education shows that most of the farmers were illiterate and therefore education could not influence their adoption to adaptation methods. However, level of education had 2.0% probability of influencing farmers to adapt to effects of climate change.

The results from interview were in line with other studies such as Enete, (2013) and Onyekuru & Marchant, (2016) found that farmers' level of education were statistically associated with farmers' use of adaptation methods. The findings of this study on the influence of level of education on climate variability adaptation are supported by numerous other research that revealed that the level of education (literacy level) to be positively related to adaptation to climate change and variability (Nti, 2012; Mabe *et al*., 2014; Obayelu *et al*., 2014; Rakgase & Norris, 2014; Uddin *et al.*, 2014; Abid *et al*., 2015; Fadina & Barjolle, 2018). This is because more educated

farmers are more knowledgeable on climate change and on better agricultural production methods which they adopt to minimize loss and improve productivity in the face of changing climate and weather extremes.

4.4.8: Size of the Household

Household is the number of individuals in the family that depends and gather from the farm (Khanal, Wilson, Lee, *et al.,* 2018). In this study it was found that household size was significantly and positively correlated to adaptation methods (Table 4.8), the results showed that as the number of family increase the adaptation adoption advances. The highest family had 5 people and the lowest number family had one person with a mean of five persons per household and a standard deviation of 2.5 which is similar with the reports of CSA, (2012) which showed an average of a household in rural areas had about five individuals. This study deduced that family size had a probability of 1.5% to improve the use of adaptation methods. Belay *et al.,* (2017) and Han *et al.,* (2018) researches studies also found the same results as it is in this study. It can be inferred that the larger the size of the household, the better the chance of adapting to climate change to increase the household yield. A female homestead from Mononyik, payam stated that:

"*I am cultivating with my children who are four in number, my husband is old and sick and can't dig for many hours. Although my children are in the town for studies. Their aunt always allows them to come and help me when they are for holidays. It is always very expensive to hire laborers to work in your farm as other farmers do. So, we always work together with my children and harvest well".*

4.4.9: Size of the Farm

The size of the farm has greater role in crop farm production. As from the general questionnaire, the size of the farm falls between 0.5 acre and 8 acres. The average land holding was 2.5 acre per household. The size of the land cultivated by farmers is negatively and significantly related to the adoption of climate adaptation methods in relevant to climate variability ($p < 0.05$; Table 4.8). A unit increase of hectare of land cultivated would decrease the likelihood of using climate adaptation methods by 2.3% probability. The facts that the farmer with larger size of land to cultivate has less fear of taking risk as the counterparts with smaller sizes. Farmers with the large size of cultivated land have a high probability of having many farm plots with different soil physical and chemical characteristics that have been impacted by climate change

differently. This result affirms with studies done by Kassem *et al.*, (2019) in Delta Nile of Ethiopia and Vecchio *et al.*, (2020) in Italian farmers, found that size of the farm cultivated by the farmers would increase as adaption methods risk also increase. Most of the farmers with large number of hectares would increase their adaptation methods to avoid the risk on the farm hence yield increase.

As from the objective, to analyze how socio-economic factors influence adaptation strategies on crop yield, the data obtained from the field was computed and used for analysis using logistic regression model and the results were presented in (Table 4.7).

Table 4.7: Effects of Socio-economic factors on adaptation methods in Jubek State

Socio-economic factors	Coefficients	Std. Error	z -value	p-value
Gender of the farmer	1.658	0.283	5.87	0.000***
Age of the farmer	0.007	0.015	0.49	0.625
Type of farming	0.034	0.180	0.19	0.850
Farmers' marital status	0.849	0.332	2.56	0.011**
Code of employment	2.013	0.684	2.94	0.003***
Sources of income	0.736	0.692	1.06	0.288
Level of education	0.150	0.150	1.00	0.318
Size of the household	0.109	0.056	2.21	0.028**
Size of the farm	0.161	0.087	2.05	0.041**
Constant	3.101	0.910	3.41	0.001***

NB: *** $p < 0.01$ and ** $p < 0.05$ shows the level of significance

Therefore the results from the logistic regression model used in this study as method of analysis showed that gender of the farmer, farmers marital status, code of employment, size of the family (household size) and size of the farm could significantly influence the adoption of climate adaptation methods in Jubek State, South Sudan ($p< 0.05$).

Therefore, the study portrayed that, age of the famer, type of farming, source of income and level of education, have influence on adoption of climate adaptation methods though were not significantly influencing the use of adaptation methods. The findings collaborated with Njuguna, (2020) who found a statistical and significance

between farm size, unpredictable temperatures, access to extension services, adoption of improved crop, Age and Sex would have effect on adaptation to climate change.

4.5: Adaptation Strategies Used by Small-Scale Farmers in Jubek State

Adaptation strategy is the best method of combating climate change and variability effects so as to increase productivity among the small-scale farmers. Farmers should be able to adapt in order to reduce the negative impacts of climate change. Adaptation to climate change is a two-step process which requires that farmers perceive climate change in the first step and respond to change in the second step through adaptation. According to the questionnaires attributed to the households sampled during the interviews, each and every respondent was asked whether they are using adaptation strategies in their farms. Some of them agreed they are using and some are not using. After that the primary data was arranged, group and analyzed to get the descriptive statistics of their adoptions, frequencies and percentages, (Table 4.8).

Table 4.8: Descriptive Statistics of adoption to adaptation strategies

Variables	**Adoption**	**Frequency**	**Percentage**
Improved seeds	Used	262	68.8
	Never used	129	31.2
	Total	**391**	**100.0**
Early warning	Used	181	46.3
	Never used	210	53.7
	Total	**391**	**100.0**
Shifting of planting date	Used	140	35.8
	Never used	251	64.2
	Total	**391**	**100.0**
Avoidance of flood prone areas	Used	21	5.4
	Never used	370	94.6
	Total	**391**	**100.0**
Pest control	Never Used	139	35.5

	Used	252	64.5
	Total	**391**	**100.0**
Fertilizers	Used	220	56.3
	Never used	171	43.7
	Total	**391**	**100.0**
Use of shallow irrigation	Used	158	40.4
	Never used	233	59.6
	Total	**391**	**100.0**
Farm insurance	Used	348	89.0
	Never used	43	11.0
	Total	**391**	**100.0**
Government and NGOs support	Used	215	55.0
	Never used	176	45.0
	Total	**391**	**100.0**
Shifting of harvesting periods	Used	291	74.4
	Never used	100	25.6
	Total	**391**	**100.0**
Use of mulches	Used	222	56.8
	Never used	169	43.2
	Total	**391**	**100.0**
Crop rotation	Used	184	47.1
	Never used	207	52.9
	Total	**391**	**100.0**

Jubek State farmers practice farming activities in respect to the adaptation methods used. In this study several adaptation methods were found to be used by farmers which included the following; improved seeds, early warning, shift of planting dates, controlling of pest invasion, use of fertilizers, use of shallow irrigation methods, insuring of farms, Support from external partners e.g., NGOs, shift of harvesting periods, use of mulch and use of crop rotation. This study found that several of the

methods were used in the farm by the farmers and would have a significant impact on crop yield harvested to the effect of climate variability.

The same results were posited by Tessema *et al.,* (2013) and Legessa *et al.,* (2013) who found out that majority of rural areas farmers in their areas have employed several adaptation methods to the adverse impact of climate change. This is in agreement with the majority of the focus group discussion and the Key informants' interviews.

To evaluate adaptation strategies on crops in Jubek State, the data obtained from the field was also computed and used for analysis using Poisson regression model and the results of descriptive statistics of farmers to climate adaptation methods and yields are presented in (Table 4.9)

Table 4.9: Descriptive statistic of farmers to Climate adaptation methods and yields

Variables	Mean	Std. Dev.	Min	Max
Dependent variable				
Yields (No. of Bags/acre)	14.14	9.381	0	58
Independent variable				
Use of improved seeds	0.312	0.463	0	1
Early weather warning	0.463	0.499	0	1
Shifting of plant dates	0.642	0.480	0	1
Avoiding flood prone areas	0.947	0.226	0	1
Controlling of pest invasion	0.644	0.479	0	1
Using fertilizers	0.437	0.497	0	1
Use of shallow irrigation	0.646	0.479	0	1
Insuring of farm	0.109	0.313	0	1
Receiving support from Gov't/NGOs	0.451	0.498	0	1
Shifting of harvesting periods	0.744	0.437	0	1
Use of mulch	0.568	0.497	0	1
Crop rotation	0.639	0.481	0	1

4.5.1: Use of Improved Seeds

The use of drought and pest resistant crops would help the famers to avoid delay of the seedlings to emerge from the ground and increase more production in yield. Moreover, the study noticed that the use of improved seeds in the farm would increase the yield by 20.5%. The study also found that use of improved seeds by the farmers had positive and significant increase to the yield of crops (IRR >1; $p < 0.01$, Table 4.11). A total of 68.8% respondents reported that they are using improved seeds to improve their yields and number of bags produced in the farm.

Improved seedlings provide the crops a healthy growth and prevent stunted growth that may occur to crops when growing. Adego *et al.,* (2019) in Northeastern part of Ethiopia and Elum *et al.,* (2017) in South Africa provinces showed that improved seeds crop such as maize and cassava and beans were significantly improving the yield of crops. This adaptation options could improve food security in the areas. This was supported by a household from Rombur payam who stated that: "One *of the organizations called ACORD used to come and supply us with improved seeds at the beginning of the planting season. After we harvested well, we eat some of the seed and keep some for the next season. In case the crop failed due to unreliable rain, we get seed from other relatives and friends ".*

Some of the households from the Focus Group Discussion explained how they get improved seeds as an adaptation method to boost their crop productivity. She stated that:

"One of the NGOs called FAO usually at the beginning of the rainy season comes and support us with drought tolerance crop seeds and fishing net so as to support our income during rain variability". Another one also stated that*: "The same FAO and ACCORD Organizations introduced a well-coordinated program on short- maturity seeds and tools to help revive our farming activities. This program usually involves the officers from the ministry of Agriculture. Forestry and cooperative and rural development. They show us how to use the seed".in deed the seeds are good they take 60-70 days, and we harvest much quantity"*

Another one also echoed:

"Sometimes, some of the extension workers from the ministry of agriculture do come and organize training with us the local farmers, on how to practice smart agricultural practices and access to market (the use of improved seed to harvest good crops)".

And also, during the field survey, one of the fields planted with improved seeds was captured according to what they have said

Plate 4.4: Maize crop with improve seeds

Photo taken by candidate 11th July. 2020 Luri County (4º52′, E31º29′)

4.5.2: Early Weather Warning

Early weather warning of farmers by climate experts is one of the preparation tools that help farmers to prepare themselves before onset of the rains (Joseph Awange *et al.,* 2022). As it was captured from the Focus Group Discussion, farmers in Jubek State responded according to whether they use the method of adoption or not.

Plate 4.5: Women Focus Group Discussion in adoption of climate adaptation strategies

It was found that 46.3% of the farmers were using the early weather warning method while the majority are not using it as an adaptation method in preparation of the farm for farming activities. Also 53,7% of the respondents complained that lack of access to climate information was one of the barriers that hinders them to adopt climate change adaptation measures. Lack of knowledge and skills, income and information to adopt the risk reduction as reported by the households' respondents. This information can be acquired through government institutions such as the extension officials. But the absents of these officials have made them to live on their own traditional methods, A household from Kworojik payam explained that:

"I am happy with my children helping in farm work. They have interest in learning about agricultural work. Since they know it is the source of food to every family. Further he said*, "when the rain is good, we harvest enough food. But this year the weather is too hot and it destroyed our crops. Although our land is productive, we are still using our old traditional method of cultivation by using hoes, pangas and machetes. We don't have any information given to improve our farming methods".*

Another household also echoed, *"For us here, when the clouds are forming, it indicates that it is going to rain, and when the weather is getting hot and hotter it indicates that also it is going to rain. And when the rain started, we cultivate our crops". But this rain sometimes will stop and our crops will start wilting and some will die and then we get less harvest".*

Also, a Key Informant from the Rejaf County shared his knowledge about crop production by saying:

"I know, a farmer can increase production through practicing and application of the agricultural practices such as quality seed, early warning and Pest control. Since agricultural productivity depends on the quality of seeds with which farmers sow in fields, need to carry out field productivity zoning, need to monitor crops growth more often, to practice accurate weather prediction, regular scouting and using crop protection methods".

Therefore, the study found that there was a negative and significant correlation between early warning information and yield production of crops ($p < 0.01$;), though IRR < 1 which means the production of crop was just times the common yield produce. The results implied that when the early warning for weather updates is in time, the farmers will be able to make better decision on land preparation. The preparation made by farmers help them understand the onset and offset of rains so as to plan for better sowing and harvesting.

From all the responses, for a small holder farmer to improve productivity, he/she requires information skills and attitude like the early weather warnings, fertilizer uses and drought resistant varieties. Extension services mostly increases efficiency of farms resulting to increase in food production (Lupai, 2014). Further, the results showed that the early warning as an adaptation method had a probability of 9.6% to reduce the risk of crop failure due to poor timing of rains. In conformity, other studies such as Amare & Simane, (2017) in the Muger Sub basin of the Upper Blue Nile basin of Ethiopia and Panda, (2016) in drought affected areas in India. The studies also found that early warning to farmers about weather change could make them plan and prepare for the forthcoming of rains so as to minimize the crop failure due to rainfall sufficiency.

4.5.3: Shifting of Planting Dates

Shifting of planting dates mainly rely on weather pattern that inform the farmers the correct time of planting. From the descriptive statistics of adoption, 15. 35.8% of the household's respondents reported that they are using shifting of planting dates as a method of timing onset of rains and the number of yields made depends on the timing of rainfall. The study also found that there was 16.8% probability of shifting planting dates. This would reduce the risks of plant failures due to untimed preparation of farm activities.

The study found that, there was a negative and significant relationship between shifting of plant dates and the number of expected yields expected (IRR< 1; p > 0.01) shown in Table 4.9).

Mostly in Jubek State of South Sudan the rainfall season is bimodal where it started from April – July, then August – September. In the first season the rain is short with variation. The farmers mostly grow vegetables such as okra tomatoes cowpeas, groundnuts and eggplants which takes less time and maize which is mostly eaten green. Sorghum which is the main staple food is grown in the second season, it is the longest rainy season with good amount. the sorghum varieties take from (90-120) days e.g., lodaka (120days) and merese (90days). This assertion was supported by a female household in Ngangala payam who stated that:

"I mostly cultivate alone with my last born in my farm of 1 acre. My husband is blind and my other children were in the town for schooling. I mostly grew groundnuts and maize mixed in the first season of rain so that I harvest quickly and take to the market. After I will use some of the money to hire laborers to clear, plough and cultivate the sorghum in the second season".

The findings are in line with those of Mabe *et al*., (2014) who found that families with large household sizes had low probability of shifting the cropping calendar. Ironically, availability of cheap family labor was used to explain why households with more family members in Narok East are less likely to stagger planting dates or use terraces. With more family members, farmers can use planting pits instead of terraces, and they can all finish the planting in one or two days rather than doing it in phases. However, Mabuku *et al.,* (2019) found that changing of planting dates by the famers would reduce chances of causing failure risks. The foundation of adaptations is based on weather patterns that changes phenomenally and would help to increase number of bags yields.

4.5.4: Avoidance of Flood Prone Areas

Flood and drought are some basic effects of adverse effects of climate variability (Khanal *et al.,* 2018). Most farmers avoid areas which are prone to floods during high number of rains, the erratic rainfalls that occur in some of the seasons affects crops production in Jubek State. In this study, it was found that avoiding flood areas had positive and non-significant relationship with yield production by farmers, (p >

0.05; table 4.11). The result inferred that Jubek State avoidance of flood prone areas was directly proportional to the yields, when farmers' crops are not destroyed by floods. Therefore, this would lead to an increase in the number of bags of yield. It was found that 94.6% of the farmers do not use avoidance of flood areas as a method of evading crop failure. One of the factors that reduce harvest is the flood. Since Kondokoro and Rejaf county were both along the Nile River. They are mostly affected with floods during heavy rainfall. In Mori Payam, there is always a problem of crop loss. A female household from the Payam made this clear by saying,

"The big problem facing and disturbing our lives here is the flood. The Rainwater coming to us from the mountain of Bilinyang usually destroy our crops when we compare to the sun. The sun is better because it doesn't destroy all the crops completely but the floods destroy it completely just within three days due to its stagnant water".

The respondent view from the point of vulnerability showed the negative impact of flood on their crops. The way climate risk was threating on crop productivity is visible on their field. Farmers from Jubek State have no capacity to avoid areas which are prone to floods. However, avoidance of floods areas had a probability of 8.9% to increase the number of bags that are harvested. The study by Ferdushi *et al.,* (2019) noticed that avoiding of flood prone areas in Haor area of Bangladesh would improve the production of yields and reduce risks of loss.

4.5.5: Controlling of Pest Invasion

The method of controlling pest and rodents from the farm by farmers is a way of reducing organism that feeds on crops. From the descriptive statistic results of adoption, 64.5% of the farmers reported that they were using intensified pest control and management to reduce the rodents that feed on crops and pests that may cause pathogen diseases.

Controlling of pest invasion would increase the number of bags harvested in the farm by 11.4% probability. The results on the effect of climate adaptation method, showed that the use of pest control was positively and significantly correlate to the yields that were obtained by farmers in their farms, ($p > 0.05$; Table 4.11). This results simply implies that the improved use of pests in the farm would increase the number of bags obtained in the farm, number of bags greatly depend on the pest invasion. 35.5% of

the farmers reported that they were not using intensified pest control and management to reduce the rodents that feed on crops and pests that may cause pathogen diseases.

The findings resonate with those of Plaas *et al.*, (2019) found that pest control in the farm would help reduce the pathogen and disease that may affects the yields of bags, the intensification of pest control and management would help farm production significant in the farm or out the farm during post-harvest management. A male household from Kolia payam explained how they protected their plants from diseases.

"For us here we don't use pest control, it is very expensive and far to go and get in the town. Since the income we get is too small to afford. We just used our traditional way of spreading the neem ash all over the leaves and at the foot of the stems of the plants so that it avoids the insects and the spread of the diseases". We constructed a well storage stores(huts) for keeping the grains and clean them all the time

Another female homestead also echoed that:

"The birds are the one always eating our sorghums. For you to chase them the whole day is making someone to get tired, we just tie muskrats to fear them to come near the crops when it has started to put heads."

From the point of vulnerability, lack of technology, skills and poverty, the farmers have no income to purchase pesticides to help their crops. That's why they use the traditional method so as to control and maintain their crop products.

4.5.6: Fertilizers Use

The use of fertilizers by farmers in the farm is an improvised soil fertility method. From the descriptive statistic results of adoption, it was found that 56.3% of the farmers were using fertilizers to increase soil fertility so as to increase the number of bags of yields. And also, the results from the Poisson regression analysis on effects of climate adaptation, showed that the use of fertilizers was positive and significant in relationship with crop yields, ($p > 0.05$, Table 4.9)

This implied that increase use of fertilizers would increase the number of bags, the number of bags harvested were directly proportional to the use of fertilizers.

According to the respondents' answers, most of the farmers in the rural areas of the counties use rain-fed farming and adjust to climate variability by crop rotation. Planting of leguminous crops such as cowpeas and groundnuts rotated with cereals (maize and sorghum). While the farmers employing irrigation practiced offset climate variability with a greater use of fertilizer application and the one concentrating on vegetables since some of it takes 45 days. A male household from Logumari payam explained,

"Sometimes we concentrate on vegetables during the dry season by irrigating because it can grow quickly for meeting the needs of the family. Sometimes the money we get from the vegetables is used to buy fertilizers and hiring of laborer".

However, the use of fertilizers in the farm were found to increase the number of bags of yield by 8.1%. Therefore, the use of fertilizers were practically better methods to increase the number of bags. Some of the studies such as Marconi *et al., (*2015); Shirsath *et al.,* (2017) & Wielemaker *et al.,* (2020) were unanimously agreed that use of fertilizers in the farm would increase soil fertility and hence improve the number of bags harvested and better yields.

4.5.7: Use of Shallow Irrigation

The use of shallow irrigation in the farm is the ancient way of improvising water resource to plants. From the descriptive statistic result of adoption, 59.6% of the farmers reported that they are not using shallow water irrigation in their farms, most of the farmers have no access to irrigation facilities and therefore it would depend on the rainwaters. The study also found that use of shallow irrigation water was positively and significantly correlated to crops yields in the Jubek State, $p < 0.05$; IRR > 1 as shown in the (Table 4.9). These results implied that the increase use of shallow water irrigation would increase the number of bags (yield) from the farm. The use of shallow irrigation would increase the yields of crops by 8.6%, thus water forms the necessity for plants to grow. . Most of the researches have reported that shallow water irrigation is better to improve the yields of crops in the farm and specifically arid and semi-arid areas (ASALs).These findings collaborated with those of Amare & Simane, (2017b) and Ndunda & Mungatana, (2013) found the same result that wastewater and shallow floods waters are important and significantly influence the production of crops. A household from Guduge payam explained that, mechanical

tools such as generators and water pumps are some of the agricultural implements that we lack. Rain invariability have made the availability of these tools very necessary as narrated.

"We always harvest little food because we lack generators for pumping water into the fields. And the little money we get from our produce is not enough to buy generators and pipes. The Nile water passes through our place but it is difficult to make it reach the farms. One of the NGO's had promised to supply us with generators, but the July violence disrupted the whole process"

A female household also echoed that:
"*The sun has destroyed most of our crops. This year we planted during the first rains but when it stopped, the heat followed and destroyed the crops. You can even see with your own eyes (pointing to the crops), how the crops are struggling to grow. Without generators, our situation will remain as it is; no proper harvest".*

Small scale farmers who don't have generators use other ways. Women get water from the river and some from the stream carrying on the head by using jerricans or buckets for irrigating crops. They use their heads for carrying water. And in some areas, the distance between the water source and the farm is too long, as narrated by a female household,

"The problem facing us a lot here, we use to carry water with our heads to water or irrigate our plants and now it's affecting our health seriously. This work of Digging and watering plants consumed all our energy. What we are seeing, the best way to reduce is by using generators and water pumps in irrigating our farms. These items were very expensive we can't afford".

4.5.8: Farm Insurance

The farm insurance is one of the best modern methods farmers getting compensated when droughts and floods destroyed their crops According to the respondents, the farmers were mostly assured by the NGOs. From the descriptive statistics, 89.0% of the farmers reported that they are using farm insurance as the main way of compensation if the crops are destroyed in the farm by floods. The study results found that farm insurance was negative and significant correlated to the yields from the

farm, $p < 0.01$; IRR < 1 as shown in the (Table 4.9). This result implied that number of risks due to flood and drought could have reduced due to the increasing finances to farms.

However, the study reported that farm insuring had 13.3% chances of reducing the risks that may occur due to floods and droughts. Therefore, most of the NGOs in South Sudan are advising farmers in Jubek State to adopt the use of farm insurance in their farms by giving training in agricultural practices and crop management. From the focus group discussion one of the respondents narrated,

"I use to grow sorghum only. But I got less harvest due to the poor farming methods and weather conditions. But later, we were introduced to dry season vegetables production and how to access water from the shallow wells in dry season by WFP." Further she said, now I can grow sorghum, beans, okra, onions and even leafy vegetables for my family to eat."

From this narration, NGOs are giving them ways to support strategies and development of work force skills for their livelihood and income diversification to improve resiliency so as not to depend highly on rain-fed agriculture. The noticeable research found that farms compensation due to flood risks in the farm would increase the chances of forming adaptation methods that could prevent floods in the farms as reported by (Amadu *et al.,* 2020 & Yomo *et al.,* 2020) studies from Southern Malawi and Ghana respectively

4.5.9: Support from Government and NGOS

The government of South Sudan and Non-Governmental Organization have tried to support farmers with advisory support, financial support, marketing support and material resource support that would enable friendly environment for farmers to counter the effects of climate change (Antwi-Agyei *et al.,* 2014). From the descriptive statistics results of method of adoption, 55.0% of the farmers who were sampled reported that they were getting NGOs support in either way such as seeds donations, fertilizer donations and financial support that would make it easier to operate in the farm. The study found that supports from NGOs were positive and significantly influenced the yields gained by farmers in their crop field ($p < 0.01$). The number of bags obtained from the field could be determined by the support farmers receive from the NGOs as seeds, fertilizers or advisory supports, Moreover, the study found that

support from well-wishers and donations from NGOs would increase the yields from the farm by 19.5% probability.

The same report was posited by Paleari, (2019) who found that financial access would make farmers to adapt with modern technologies against the effects of climate variability in farms. A female household from the focus group discussion narrated how they get support from the NGOs.

"*One of the NGO called Brac established four collective demonstrations and pilot project farms. from each of 10 acres of land, they select 20 of us the women and divide us into groups to work on each farm every day. .and all the produce goes to the famers cooperative where we get loans to support our farms and other business for our livelihood".*

Another one also said, *"mostly we receive our seeds from FAO and NPA organization".* Another one also said: *"sometimes we use our own seed retained from the previous year's harvest. We purchase local seed from the market or borrowed from the relatives".*

BRAC is a development organization base on empowering farmers by alleviating poverty and changing their lives. It started in Bangladesh in 1972. It mostly focusses on women who are. more affected by poverty. In South Sudan, it is established in 2007. It delivers microfinance and other training programs such as projects in which they organized group of farmers specially the women to improve their socio-economic activities.

4.5.10: Shifting of Harvesting Periods

Changing of harvesting periods reduces the risks of floods destroying the farm before harvest, and also helps in managing the post-harvest losses. From the descriptive statistics of adoption method, 74.4% of the farmers reported that they could shift the time of harvest depending with weather situation so as to reduce the risks of losing yields to floods or rodents during drought. It was found that there was positive and significant correlation between the timing of harvest and number of bags of yields the farmer obtained from the field, ($p < 0.01$; Table 4.9). This result implied that correct timing of the crop field harvests would increase the number of bags by reducing the risks of rodents and pests.

A household from the focus group discussion explained how they shift harvesting period.

"I use to grow sorghum only. But the yield is low, sometimes the rain stops when my crop was almost to the ripening stage. We face a lot of shortages in food and other things. But later we were train by the WFP partners on some farming practices such as timely planting, crop spacing, mulching, mixed cropping and irrigation from the shallow wells. I will go and get water from the shallow well to irrigate my vegetable during the dry season. About the pest we were told to burn the neem leaves and wood then spray ashes all over the plants".

Rural Farmers in Jubek State were improving their food security and building resilience against climate shocks as floods and drought in agriculture through training in farming practices such as timely planting crop spacing and shifting harvesting period. Most of the trainings were don't by the NGOs projects. they organized trainings in crop management practices in some of the areas affected with climate change. They also promote farmers with organic methods for pest control such as using neem ash.

Moreover, the results showed that timing of the harvesting periods would increase the yield by 19.2% when post-harvest losses are reduced, (Table 4.10). The findings agreed with those of Enete, (2013) and Lelea *et al.,* (2014) found that farmers should take precautions to reduce the post-harvest losses of crop yields due to rodents and climate variability effects such induction of aflatoxins that affects yields e.g., maize and sorghum.

4.5.11: Use of Mulches

Water and soil conservation are one of the best ways to reduce the effects of climate variability through maintaining soil water percolation and soil fertility stabilization. From the descriptive statistics of adoption method, 56.8% of the farmers reported that they are using mulching. This could help soil remain wet during dry season and prevent soil erosion when there is high rainfall.

This study results found that use of mulch was positively and significantly influencing the amount yields that were harvested in the farm ($p < 0.01$). This result implied that mulching was directly proportional to the number of yields produced by the farmers in the field, the rate of using mulch was reducing evapotranspiration and conserves water during dry periods and also use of mulch could reduce erosion during rainy seasons hence soil conservation.

As mentioned previously, Farmers in Jubek State improve their food security and building resilience against climate risks as flood and drought in agriculture through trainings in farming practices given by some of the NGOs. This practice includes mulching, mixed cropping, and use of shallow wells for irrigation. This statement is supported by one of the Key informant who stated that:

"Normally we encourage the farmers the use of organic manure such as crop residues, dungs for those with cattle and compost".

Also, a household from the women focus group stated the same,

"I normally collect the dry leaves of the mango and the banana, place them at the foot of the maize plant since it is sensitive to drought. Sometimes during weeding, the same weed removed will be left at the foot of the plant to cover the sun from getting down".

The process of mulching with the rural farmers in Jubek State are mostly covering the soil with the dead plant materials. during weeding, the same grass can be used to cover and protect the soil in annual crops like the vegetables and maize.

It was also found that the use of mulching would increase crop yields by 9.0%, therefore farmers are encouraged to adopt mulching since it a natural water and soil conservation and not expensive. The findings relate with some studies such as Grum *et al.,* (2017) and Holden *et al.,* (2018) in Northern Ethiopian and Malawi respectively, found that soil water holding capacity depend on the amount of mulch applied by the farmers to reduce erosion, and conserve moisture during the dry spell seasons.

4.5.12: Crop Rotation

Crop rotation is the changing of different crops in the same piece of land at different times, this helps to maintain soil nutrients and shuffle the different in different seasons.

In spite of soil degradation when one crop planted every season, the study found that only 47.1% of the sampled farmers were planting legumes and maize interchangeable in the different seasons to maintain soil nutrients. The Poisson regression model results found that the number of yields were positive but insignificant correlated with the crop rotation mechanism, ($p > 0.05$; Table 4.9), crop yields depend on the soil nutrients that is contained in the soils.

From the respondents' answers in the focus group discussion, some crops are planted in the first season and then followed by another in the second season in the same piece

of land e.g., leguminous crop such as groundnuts is planted in the first season then followed by cereal crops such as maize and sorghum in the second season. The legumes help the soil in fixing the nitrogen. During the field visit in one of the farms. A household was captured weeding her groundnuts crop planted in the first season.

Plate 4.6: A field of Groundnuts crop

Photo taken by candidate 25th April. 2020 Liria County (N4º60′ E31º36′)

"I mostly grow groundnuts in the first season because it is the first contributor to the household's farming income. Then after I will plant lodaka (grain) in the second season with the good amount of rainfall".

Moreover, the study deduced that only 3.4% probability of crop rotation would lead to increase of crop yields. In contrast, Holden *et al.*, (2018) and Plaas *et al.*, (2019) found that crop rotation had higher chances to maintain soil nutrients to increase crop yields. The soil conservation mainly depended on the crop rotation since different crops uses different soil nutrients.

During the household survey, respondents were asked whether they have been practicing climate adaptation strategies in their farms. It has been found various of them were practiced to the adverse effect of climate variability. As from the results of analysis done, the findings in table 4.10 showed that use of improved seeds, early

weather warning, shifting of planting dates, controlling of pest invasion, using of fertilizers, use of shallow irrigation, insuring of farm, receiving support from Government or NGOs, shifting of harvesting periods and use of mulch are the best methods practices which could be used to control climate variability in Jubek State.

Table 4.10: Effects of climate adaptation methods against crop yields

Explanatory variable	Coefficients	IRR	Std. Error	p-value	z-value
Use of improved seeds	0.205	1.227	0.030	0.000***	6.83
Early weather warning	-0.096	0.907	0.028	0.001***	-3.43
Shifting of plant dates	-0.168	0.846	0.028	0.000***	-5.96
Avoiding flood prone areas	0.089	1.093	0.062	0.146	1.45
Controlling of pest invasion	0.114	1.121	0.029	0.000***	3.95
Using fertilizers	0.081	1.083	0.029	0.005***	2.80
Use of shallow irrigation	0.086	1.089	0.029	0.003***	2.95
Insuring of farm	-0.133	0.876	0.044	0.003***	-2.96
Support from Gov't/NGOs	0.195	1.216	0.029	0.000***	6.60
Shifting of harvesting periods	0.192	1.211	0.033	0.000***	5.78
Use of mulch	0.090	1.095	0.029	0.002***	3.14
Crop rotation	0.034	1.035	0.029	0.244	1.17
Constant	2.178	8.826	0.082	0.000***	26.60

The findings revealed that use of improved seeds, early weather warning, shifting of planting date, controlling of pest invasion, using of fertilizers, use of shallow irrigation, insuring of farm, receiving support from Government or NGOs, shifting of harvesting periods and use of mulch have statistical and significance effecte to climate variability because the p value is less than 0.05.This means any increase or decrease of these factors could influence the climatic variability among the small

holder farmers at Jubek State. The findings are in agreement with those of Okumu, (2013) who established that extension service, membership to social, educational attainment and economic group, access to water were the major factors influencing adaptation uptake, thus enhancing these aspects will be key to enhance adaptive capacity at the household level.

However, the study also found that smallholder farmers in Jubek State rarely apply or use such methods. This could explain perennial low yield among small holders' farmers in Jubek State. The findings resonate with that of Kiarie, (2016) who cited lack of improved seeds, lack of capital, lack of information about proper adaptation mechanisms, lack of necessary farm inputs, lack of timely climate forecasting information on the expected climate changes and shortage of water for as challenges to climate adaptations strategies among the small-scale farmers in Kijabe, Kenya.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1: Summary

Farmers perceptions and awareness was one of the objectives in this study. The research study found that there was a reliable consistency of Cronbach's Alpha 0.63 with the six items scrutinized and the chi- square report showed that farmers were aware of climate change surrounding and its phenomena in the selected counties. The neutral farmers have no idea about the effects.

The factors that always influence adaptation method in a small-scale agriculture are term as socio-economics factors. The results from the logistic regression model used in this study showed that the gender of the farmer, marital status, code of employment, size of the farm and family could significantly influence the adoption of climate adaptation method in Jubek State, South Sudan.

During the household survey, respondents were asked whether they have been practicing climate adaptation strategies in their farms or not. It was found that several of adaptation methods were practiced and could have a significant effect on crop yield harvested in the five counties.

As an introduction, climatic variables of temperature and rainfall patterns for the past years was analyzed to determine the trends of the past when compared to the resent study. The study found there was a positive and significant change in temperature. Although the annual rainfall trends were not significant but it has a positive slight increase in trends.

5.2: Conclusion

Results of this study on perception and awareness showed that majority of households are aware about climate variability in the selected counties of Jubek State. Most of the households had attitude that climate variability caused crop failure which leads to less production. Some of the households also lack climate information and infrastructures to adapt to climate change and variability so as to combat food insecurity and poverty

The logistic regression model results for socio-economic factors from this study showed that, the gender, marital status, code of employment, household and family size could significantly influence the adoption of climate adaptation methods in Jubek State of South Sudan. Also, the study portrayed that age, type of farming, source of income and level of education have influenced on adoption of climate adaptation methods though they were not significantly influencing the used of adaptation methods.

The results for determination of adaptation strategies from this study also showed that, several adaptation methods were used by the households such as improved seeds, early weather warning, etc. These adaptation methods used have a significant impact on crop yield harvested except avoidance of flood prone areas and crop rotation.

The results from analysis of climatic variables as the atmospheric conditions that affects crop yields and caused food reduction and unavailability have shown significant increase in maximum and minimum temperature and a slight increase in rainfall trends.

5.3: Recommendations

i. The government should deploy more agricultural extension officers to create more awareness on climate information, train farmers on modern ways of farming practices and install infrastructures such as bore holes for irrigation during dry season to increase productivity.

ii. The government and the NGOs should focus on awareness creation of farmers on better production techniques and climate change adaptation strategies through mass media, agriculture extension and creating affordable credit schemes such as cooperative societies to enhanced adaptive capacity of small-scall farmers in Jubek State.

iii. There is need for both the National Government and NGOs to promote crop insurance to the farmers who are affected with floods to adapt to flood prone areas and also to establish more extension service centers for practicing good agricultural activities to increase production in the areas.

5.4: Areas of Future Studies

The research identified some gaps that should be studied to complete the research.

i. There is need to investigate the effects of water and soil conservation as an adaptation method of climate change.
ii. There is need to determine the economic effects of climate variability on livelihoods production.
iii. There is need to build adaptation model that would make community to integrate constrains that affects crop rotation and flood prone areas strategy due to climate variability.

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APPENDICES

APPENDIX I: QUESTIONNAIRE

My name is Diana Achuk, I am a student from Kenyatta University School of Agriculture and Environmental Studies Department of Environmental Science and Education. I am carrying out a research study on my topic, *Adaptation to climate variability by small scale farmers' in Jubek state, South Sudan*. You are being asked to take part in this research study. This information is provided to tell you about the study. Please read this form carefully. Your response will be recorded and name will be kept secret. Therefore, I am pleased to ask you to respond by [√] and explain appropriately.

A. RESPONDENT'S GENERAL INFORMATION

Questionnaire No…….

Date of interview … ……...

Name of the respondent …….

Gender…… [0] = Male; [1] = Female

Age of the respondent……. (Year) ……

County…… Cell: …….

Sub-location (payam) …….

Types of farming practices …… [1] Crop farming [2] Pastoralism [3] Both

B. SOCIO-ECONOMIC CHARACTERISTICS OF THE HOUSEHOLD

1) Marital status of the household head:

   [0] = Married [1] = Single / Widow

2) What is the employment code of the household head?

   [0] = Not employed [1] = Employed [2]= Other (specify)

3) What is the type of your farm?

   [0] = Crop Farming [1] = Pastoralism [2] Mixed Farming

4) What are the main sources of your income?

[0] = Crop Farming [1] = Salaries and wages,

5) What is the level of your education? ……

[0] = No education [1] = Primary [2] =Secondary [3] = Tertiary

6) What is the size of your household?.....

7) What is the size of your farm?.....acres

8) How many bags of these crops do you harvest per season?

a. Maize……... b. sorghum…….

9) What is your annual income? …… SSP

C. CLIMATE CHANGE AWARENESS & PERCEPTION

To what extent are you aware and perceive climate change parameters?

1 = Extremely Unaware [ ] 2= Unaware [ ] 3= Neutral [ ] 4= Aware [ ]

5= Extremely Aware [ ]

D. CLIMATE ADAPTATION STRATEGIES

Are you using any of this climate adaptation methods to improve your yields?

Yes or No

1. Improve seeds [ ]
2. Early warning [ ]
3. Shifting of planting date [ ]
4. Avoidance of flood prone areas [ ]
5. Pest control [ ]
6. Fertilizers [ ]
7. Use of shallow irrigation [ ]
8. Farm insurance
9. Government and NGOs support [ ]
10. Shifting of harvesting period [ ]
11. Mulches [ ]
12. Crop rotation [ ]

Do you experience any challenges when using any of the above climate?

Adaptation methods?

a. [ ] Yes No [ ]

b. Kindly Explain

……..

APPENDIX II: KEY INFORMANT INTERVIEW GUIDE

My name is Diana Achuk, I am a student from Kenyatta University School of Agriculture and Environmental Studies Department of Environmental Science and Education. The goal of this research survey is to collect data from farmers of Jubek State with the topic, *Adaptation by small scale farmers* to *climate variability in Jubek State, South Sudan.* Kindly assist by giving your response to the best of your ability. Your co-operation will be treated with strict confidentiality

1. Are you aware of climate change and variability?

a. Yes [ ] No [ ].

b. Kindly Explains

……

2.What are some of the perceptions do you think farmers held in regards to effects of climatic variability on agricultural yields in Jubek State?

…….

3. Do you think socio-economic factors influence climate adaptation methods in Jubek State?

a. Yes [ ] No [ ].

b. Kindly Explains

……

1. Are there any adaptation strategies being utilized by small-scale farmers to improve the crop yields in Jubek State?

a. Yes [ ] No [ ]

b. Kindly Explain

APPENDIX: III MONTHLY CLIMATIC DATA (1981-2023)

1. Climatic Data of Monthly Rainfall (1981-2023)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	AVERAGE
1981	0	14.6	73.7	49.2	96.1	91.3	102.5	120.2	173.6	18.2	73.4	1.8	814.6	67.88
1982	14.8	0	18.3	110.8	244.3	213.1	76.1	115.9	64.4	171.1	3.4	0.5	1032.7	86.06
1983	0	0	9.1	55.1	89.7	165	111.4	132.5	118	154.7	51.3	3.5	890.3	74.19
1984	0	0	1.9	106.7	125.6	85	272.1	67.5	96.8	24.8	49.3	2.5	832.2	69.35
1985	5.9	0.5	116.2	156.2	205.2	140.3	75.6	74.8	143.2	85.4	51.1	9.5	1063.9	88.66
1986	2.7	38.9	42.2	100	94.6	200.7	151.4	89	99.7	112.5	27.7	1.9	961.3	80.11
1987	0	5.5	24.3	78.4	245.7	46.3	20.6	40.4	86.7	66.8	60.8	3.3	678.8	56.57
1988	3.9	10.1	20.5	80.3	184.6	133.9	231.9	162.7	247.2	91.4	35.7	36.7	1238.9	103.24
1989	0	0.5	102.4	73.9	114	151.9	157.7	93.5	128.9	53.3	107.2	4.9	988.2	82.35
1990	2.5	27.1	55.8	49.7	106.8	13.9	142.5	213.4	98.3	127.5	48	21.1	906.6	75.55
1991	3	35.1	19.4	172.1	144.6	57.9	154.4	173.4	95.6	128.2	16.2	2	1001.9	83.49
1992	44.5	0	18.5	69.2	106.8	88.9	136.7	113.6	65.8	263.9	18.9	15.2	942	78.5
1993	11.4	3.1	39.4	153.8	189.4	127.8	266.8	41.4	48.9	78.2	27.3	53.5	1041	86.75
1994	2.5	0	4.5	128.1	105.9	108.2	250.3	179.1	100.4	102.5	68.7	0.5	1050.7	87.56
1995	0	9	45.1	57.2	136.5	39.7	100.3	65.9	113.7	109.7	4	0.7	681.8	56.82
1996	19.9	59	102.3	170.9	115.3	133.4	98.6	136.7	134.2	148.1	0	0.2	1118.6	93.22
1997	1.5	0	20.4	180.2	79.9	55.9	81.7	101.1	61.7	244.3	106.7	31.9	965.3	80.44
1998	17.2	3	21.3	138.7	77.1	183.2	187.6	63.4	42.7	294.2	70.7	0	1099.1	91.59
1999	0	0.5	32.2	320.3	100.7	188	106.8	149.3	142.4	205.3	29.2	0	1274.7	106.23
2000	0	0	4.8	52.7	62.5	154.9	136.9	68.5	90.9	175.3	25.8	1.1	773.4	64.45
2001	0	7.4	16.7	107.6	150.4	177.7	108.9	78.4	80.6	151.1	42.8	1	922.6	76.88
2002	0	1.5	91.5	87.6	43.2	206.7	148.6	127.5	175.6	209.9	48	34.2	1174.3	97.86
2003	4.6	30	66.1	71	218	91.2	148.8	177.3	148.5	50.1	145.7	0	1151.3	95.94
2004	7	1.2	2	164.9	68	129.9	88.5	219.4	52.5	92.8	97.3	0	923.5	76.96

2005	0	0	32.6	93.1	149.2	129.9	0	0	36.7	91.1	15.7	0	548.3033	45.69
2006	0	9	71.9	39.2	133.5	73	58.1	260	142.6	33.2	3	43.6	867.1	72.26
2007	0	1	10.8	33.4	177.6	130	194.6	107.6	172	74.5	35	0	936.5	78.04
2008	9.5	0	5.8	85	117.5	67.7	98.3	85.8	263.7	188.7	51.5	0	973.5	81.13
2009	59.5	35.5	12.2	265.5	58.6	39.3	111.5	168.5	144.9	55.8	58.4	0	1009.7	84.14
2010	6	26.5	31	44.5	122.6	129.5	194.2	60.5	93	110.5	15	15	848.3	70.69
2011	4.7	22.04	48.72	59.4	189.38	217.79	180.16	260.25	255.5	217.4	256.6	27.4	1739.34	144.95
2012	0.91	7.8	25.7	123.4	260.96	205.15	218.06	214.8	253.39	162.5	145.1	16.1	1633.87	130.16
2013	22.8	9.6	80.7	50	121.7	128.4	214.4	196.35	214.2	156.9	141.7	0.2	1336.95	111.41
2014	0.43	9.2	26.45	84.03	189.4	117.71	122.88	182.08	148.81	260.9	36	2.99	1180.88	98.41
2015	6.1	85.7	99.19	149.5	272.73	259.9	259.09	226.16	157.26	244.36	149.72	15.76	1925.47	150.46
2016	7.9	2.63	91.27	185.66	235.5	192.67	230.33	163.33	166.67	102.34	11.8	17.7	1407.8	117.32
2017	1.9	33.4	51.6	130	196.7	239.2	271.8	256.1	262.7	113.3	51.8	0	1608.5	134.04
2018	0	24.4	35.12	46.33	119.3	234.44	74.7	222.9	58.11	136.01	28.3	8.8	988.41	82.37
2019	2.3	21.2	30.1	61.3	178.4	373.3	195.7	290.5	236.8	255.7	53.7	30.6	1729.6	144.13
2020	6.8	3.9	15.2	55.1	214.3	208.6	314	319	269.4	226.6	83.9	5.5	1722.3	143.53
2021	5.6	10.3	35.4	110.1	130.6	120.4	145.7	130.9	105.5	114.3	45.6	10.7	965.1	80.43
2022	38.1	63.7	107.6	114.4	157.5	140.8	165.9	206.2	181.9	206.9	136.1	79.4	1519.1	123.59
2023	5	8.2	40	88.4	136.3	119.4	131.2	151.7	120.1	111	43.5	6.8	961.6	80.13

2. Climatic Data of Monthly Minimum Temperature (1981-2023)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE	TOTAL
1981	20.2	21.0	23.9	24.2	22.8	21.8	20.8	21.0	20.9	21.1	20.4	20.3	21.5	258.2
1982	22.0	20.4	23.9	24.2	22.8	21.9	21.3	20.8	21.4	21.3	20.8	21.1	21.8	261.8
1983	18.6	22.0	24.3	23.9	23.7	22.8	22.0	21.4	21.0	21.2	21.4	19.1	21.8	261.5
1984	18.0	21.5	24.2	23.4	23.1	21.7	20.9	20.7	20.7	20.8	20.8	21.0	21.4	256.8
1985	22.9	19.8	23.0	22.3	22.2	21.0	19.7	20.5	21.0	21.3	21.4	20.2	21.3	255.4
1986	19.0	22.5	22.6	23.3	22.9	21.1	20.8	20.9	21.0	21.3	21.5	20.6	21.5	257.5
1987	19.6	23.0	23.5	23.8	22.0	22.4	21.9	22.0	21.6	21.9	22.0	21.1	22.1	264.8
1988	21.2	23.5	24.3	23.6	22.5	21.2	20.6	21.0	21.1	21.0	21.1	18.5	21.6	259.7
1989	16.2	19.1	22.9	23.3	21.8	22.0	20.6	20.8	21.0	21.4	21.5	21.0	21.0	251.7
1990	20.6	22.4	23.0	23.7	23.0	23.0	21.2	21.3	21.4	21.5	21.7	21.5	22.0	264.5
1991	21.6	22.4	24.3	22.2	22.2	22.7	21.2	21.2	21.3	21.0	21.0	19.3	21.7	260.6
1992	19.1	19.5	22.9	23.8	23.1	22.0	20.8	20.9	20.8	21.3	20.0	18.9	21.1	253.1
1993	17.8	19.4	22.6	23.3	22.4	21.8	21.0	20.7	20.7	21.3	18.9	20.6	20.9	250.7
1994	21.8	22.1	23.5	23.5	22.5	22.9	21.8	21.3	21.2	21.9	20.9	21.3	22.1	264.7
1995	21.6	22.1	23.6	24.9	23.1	22.9	22.0	21.6	21.3	21.6	21.4	20.7	22.2	266.6
1996	20.6	20.7	22.4	22.4	22.5	21.4	21.0	20.8	20.9	20.9	20.6	20.2	21.2	254.3
1997	21.1	19.5	25.0	23.5	22.6	22.8	22.0	22.0	22.3	22.2	22.0	21.3	22.2	266.3
1998	20.7	21.9	24.0	24.8	23.9	22.4	21.6	21.2	21.1	21.2	20.2	19.0	21.8	283.8
1999	20.4	22.8	23.4	22.3	22.2	21.5	20.6	20.5	20.6	20.7	20.9	20.1	21.3	255.8
2000	19.7	21.2	22.9	23.9	22.8	21.9	20.8	20.6	20.7	21.3	20.9	19.3	21.3	256.0
2001	18.4	21.5	24.1	24.0	23.1	21.2	21.1	21.0	20.4	20.7	20.4	19.3	21.3	255.3
2002	19.5	22.1	24.0	23.8	22.6	22.2	21.8	21.1	20.6	20.8	21.4	20.0	21.7	259.9
2003	20.8	22.3	23.7	24.3	23.0	21.5	20.6	20.6	20.4	21.3	20.8	18.6	21.5	258.1
2004	20.3	19.8	25.0	23.2	23.2	22.1	21.3	21.4	21.0	21.5	21.2	20.1	21.7	281.6
2005	19.3	23.8	24.7	25.4	22.8	22.1	20.9	21.1	21.1	21.3	20.8	19.7	21.9	263.1

2006	21.9	23.6	23.7	23.9	22.1	21.5	21.1	20.4	20.6	20.8	20.6	18.9	21.6	259.1
2007	19.6	22.3	23.7	24.0	23.0	21.7	21.0	20.7	20.6	20.7	20.9	20.1	21.5	258.3
2008	21.2	22.3	24.1	23.3	23.0	22.7	21.4	21.4	21.6	21.8	21.3	20.6	22.1	264.7
2009	21.7	23.8	23.7	23.1	22.9	22.4	21.8	21.6	21.6	22.0	21.9	22.6	22.4	269.2
2010	22.4	24.8	25.0	25.0	23.7	22.8	21.7	21.8	21.9	21.9	22.3	21.2	22.1	274.5
2011	22	21	18	20	18	19	20	18	21	20	18	21	21.6	236.0
2012	20	20	24	20	19	20	17	19	17	18	21	21	22.3	258.3
2013	21	19	20	25	23	20	20	20	26	26	23	20	21.4	284.4
2014	25	26	27	25	24	23	22	22	22	24	24	25	21.3	310.3
2015	20	21	21	21	20	20	19	20	20	20	19	20	22.4	263.4
2016	17	21	20	22	22	20	19	20	21	20	19	22	21.3	243.0
2017	21	21	19	20	20	20	18	18	20	20	18	20	21.2	235.0
2018	19	22	20	19	26	19	18	20	18	18	19	18	21.1	236
2019	21	21	24	23	16	19	20	21	19	18	20	19	22.2	241
2020	18	18	22	22	19	21	20	18	19	18	19	20	21.5	234
2021	24	22	26	29	24	29	26	25	24	23	24	22	21.4	298
2022	26	22	24	23	25	20	21	22	25	20	26	22	22.5	276
2023	20	20	22	26	24	26	20	20	23	20	22	20	21.3	263

3. Climatic Data of Monthly Maximum Temperature (1981-2023)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE	Total
1981	37.3	37.2	37.9	36.9	33.8	32.1	31.9	32.7	34.8	35.2	35.6	35.4	35.1	420.8
1982	37.7	37.9	35.7	36.2	33.5	32.9	30.4	31.5	32.2	35.1	35.2	37.8	34.7	416.1
1983	37.5	37.3	38.6	35.7	33.0	31.5	30.8	30.6	33.5	32.4	33.0	36.1	34.2	409.9
1984	35.4	39.0	39.8	36.0	35.1	32.7	31.9	30.7	32.2	31.9	34.0	35.7	34.5	414.4
1985	35.6	38.7	38.9	35.5	33.7	32.3	30.5	31.6	32.7	35.8	35.0	36.6	34.7	416.8
1986	38.1	36.5	36.4	32.3	32.4	31.4	30.5	31.3	32.5	34.7	35.6	36.5	34.0	408.2
1987	37.6	37.4	35.7	34.9	33.9	31.0	30.2	33.1	32.7	34.5	35.1	34.2	34.2	410.2
1988	37.4	39.1	37.7	36.4	32.6	31.9	34.0	34.5	35.3	34.6	35.0	37.3	35.5	425.7
1989	36.5	39.1	38.3	36.5	33.6	32.8	30.4	31.3	32.0	33.7	34.6	35.8	34.6	414.7
1990	33.4	35.6	35.9	35.3	33.3	30.1	32.3	33.0	34.0	35.2	34.7	33.9	33.9	406.9
1991	36.2	36.3	36.6	36.3	34.7	34.8	31.7	31.5	32.7	33.6	35.2	36.2	34.7	415.9
1992	36.7	38.0	38.4	33.8	31.5	32.3	30.3	31.4	32.7	33.4	34.5	35.4	34.0	408.6
1993	35.5	35.6	38.6	35.9	34.9	32.9	31.6	31.0	33.3	33.0	34.3	34.8	34.3	411.3
1994	35.3	37.5	37.7	36.7	32.6	31.9	31.9	32.4	33.9	35.8	36.7	37.0	35.0	419.5
1995	37.4	38.1	38.3	36.1	33.2	32.1	30.5	31.1	32.8	32.9	32.3	34.2	34.1	409.0
1996	36.9	37.9	37.7	37.0	34.5	34.3	32.1	32.9	32.4	32.9	33.9	35.8	34.9	418.3
1997	36.7	37.4	34.6	33.3	32.5	31.4	31.7	31.3	32.6	33.9	33.9	36.6	33.8	405.7
1998	36.8	37.2	38.8	33.2	33.3	34.5	33.7	32.9	37.1	34.0	32.6	33.4	34.8	417.3
1999	36.8	39.2	36.8	32.5	32.3	32.5	30.9	31.6	33.0	32.0	34.3	33.8	33.8	439.6
2000	37.1	38.1	38.0	36.4	34.0	33.3	30.4	31.6	33.9	33.0	35.7	35.8	34.8	417.2
2001	35.8	38.7	37.6	36.2	34.3	31.4	30.9	31.5	32.9	33.3	34.2	37.0	34.5	413.8
2002	35.3	39.4	36.7	36.1	34.5	32.7	32.7	32.3	33.7	33.1	33.9	34.6	34.6	414.9
2003	37.7	38.0	37.5	35.8	33.1	31.5	31.0	31.1	32.8	35.1	33.7	35.8	34.4	413.1
2004	36.2	37.0	38.3	33.3	33.9	32.2	31.8	31.6	32.7	34.2	34.5	35.7	34.3	411.2
2005	37.0	40.7	38.4	38.4	32.7	32.1	30.5	31.6	32.9	33.4	35.9	38.9	35.2	422.6

2006	38.9	39.4	35.8	35.4	31.3	31.9	31.6	30.5	31.8	33.5	33.5	34.4	34.0	407.8
2007	35.6	38.0	38.2	36.3	34.2	31.1	30.3	30.6	31.5	34.5	34.9	36.0	34.3	411.2
2008	36.5	37.1	37.2	34.9	33.1	32.6	31.4	30.9	32.3	32.4	34.9	36.6	34.2	409.9
2009	36.7	37.6	36.9	33.5	33.4	33.4	32.9	32.7	32.8	34.1	35.2	35.7	35.6	414.9
2010	38.1	37.6	37.6	37.3	33.8	32.1	30.3	31.3	32.3	32.8	35.3	35.9	34.5	414.3
2011	37	38	32	32	32	33	34	30	34	34	33	37	34.7	406
2012	35	37	34	35	33	33	33	31	33	34	35	34	35.4	407
2013	36	39	32	36	31	33	33	30	32	33	32	33	34.5	434.5
2014	37	38	38	36	33	31	30	30	31	32	35	36	35.2	442.2
2015	37	38	38	34	31	31	30	30	31	32	34	36	34.1	402
2016	37	39	36	37	33	33	31	31	32	34	30	32	35.1	405
2017	35	37	37	37	32	31	30	31	33	34	34	35	34.3	406
2018	36	35	35	34	34	33	30	31	31	33	32	30	35.1	394
2019	35	40	37	33	32	30	30	32	32	35	33	34	34.5	403
2020	37	38	36	35	33	31	33	32	32	34	32	31	35.2	404
2021	36	38	38	36	31	31	33	31	33	34	35	36	35.4	412
2022	36	37	37	38	33	32	31	32	32	34	33	37	34.4	412
2023	38	39	37	37	34	32	32	31	34	33	35	35	35.4	417

Climatic Data of Monthly Maximum Temperature (1981-2023)

APPENDIX IV: PLATES

Plate 1: A female homestead on her way home

Photo taken by candidate 21^{sth} April 2020, Liria County (N4º48′, E31º38′)

Plate 2: Focus group discussion (both male and female

Photo taken by the candidate 23th. April. 2020 Liria County (N4º48′, E31º38′)

Plate 3: Key informant interview from the local officers in Rejaf County

Photo taken by homestead 15th June. 2020 Rejaf County (N4º48′, E31º38′)

Plate 4: Male focus group discussion

Photo taken by homestead 20th.May.2020 Kondokoro County (N4º58′, E31º37′)

Plate 5: Female focus group discussion

Photo taken by homestead 10th July. 2020 Luri County ($4^0$52′, E31^{0}29′)

Plate 6: Maize crop with improve seeds

Photo taken by candidate 11th July. 2020 Luri County ($4^0$52′, E31^{0}29′)

Plate 7: Sorghum crop affected with drought

Photo taken by candidate 5th Nov. 2020 Ladu County (N4º58′, E31º37′)

Plate 8: sorghum crop without agricultural practice

Photo taken by candidate 20th June. 2020 Rejaf County (N4^{0}48′, E31^{0}38′)

Plate 9: Groundnut crops planted after maize

Photo taken by candidate 25th April. 2020 Liria County (N4º60′ E31º36′)

APPENDIX V: GRADUATE SCHOOL AUTHORIZATION LETTER

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Our Ref: N50EA/39215/2017 **DATE:** 29th September, 2020

Ministry of Agriculture in Jubek State
Metrological Department,
SOUTH SUDAN.

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MS. DIANA ACHUK ANANIAS – REG. NO. N50EA/39215/17

I write to introduce Ms. Diana Achuk Ananias who is a Postgraduate Student of this University. She is registered for M.Env.Studies degree programme in the **Department of Environmental Science & Education.**

Ms. Ananias intends to conduct research for a M.Env.Studies thesis Proposal entitled, **"Adaptation of Small Scale Farmers to Climate Variability in Jubek State, South Sudan."**

Any assistance given will be highly appreciated.

Yours faithfully,

KENYATTA UNIVERSITY OFFICE OF DEA'S 29 SEP 2020 GRADUATE SCHOOL P.O Box 43844-00100 NAIROBI

PROF. ELISHIBA KIMANI
DEAN, GRADUATE SCHOOL

APPENDIX VI: APPROVAL OF RESEARCH PROPOSAL LETTER

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke
P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Internal Memo

FROM: Dean, Graduate School
DATE: 29th September, 2020

TO: Ms. Diana Achuk Ananias
C/o Department of Environmental
Science & Education
REF: N50EA/39215/2017

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge receipt of your Research Proposal after fulfilling recommendations raised by the Graduate School Board of 11th September, 2020.

You may now proceed with your Data collection, subject to clearance with the Ministry of Agriculture in Jubek State.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking and Progress Report Forms per semester. The Forms are available at the University's Website under Graduate School webpage downloads.

Thank you.

KENYATTA UNIVERSITY * OFFICE OF DEAN * 29 SEP 2020 GRADUATE SCHOOL P.O. Box 43844-00100 NAIROBI

JULIA GITU
FOR: DEAN, GRADUATE SCHOOL

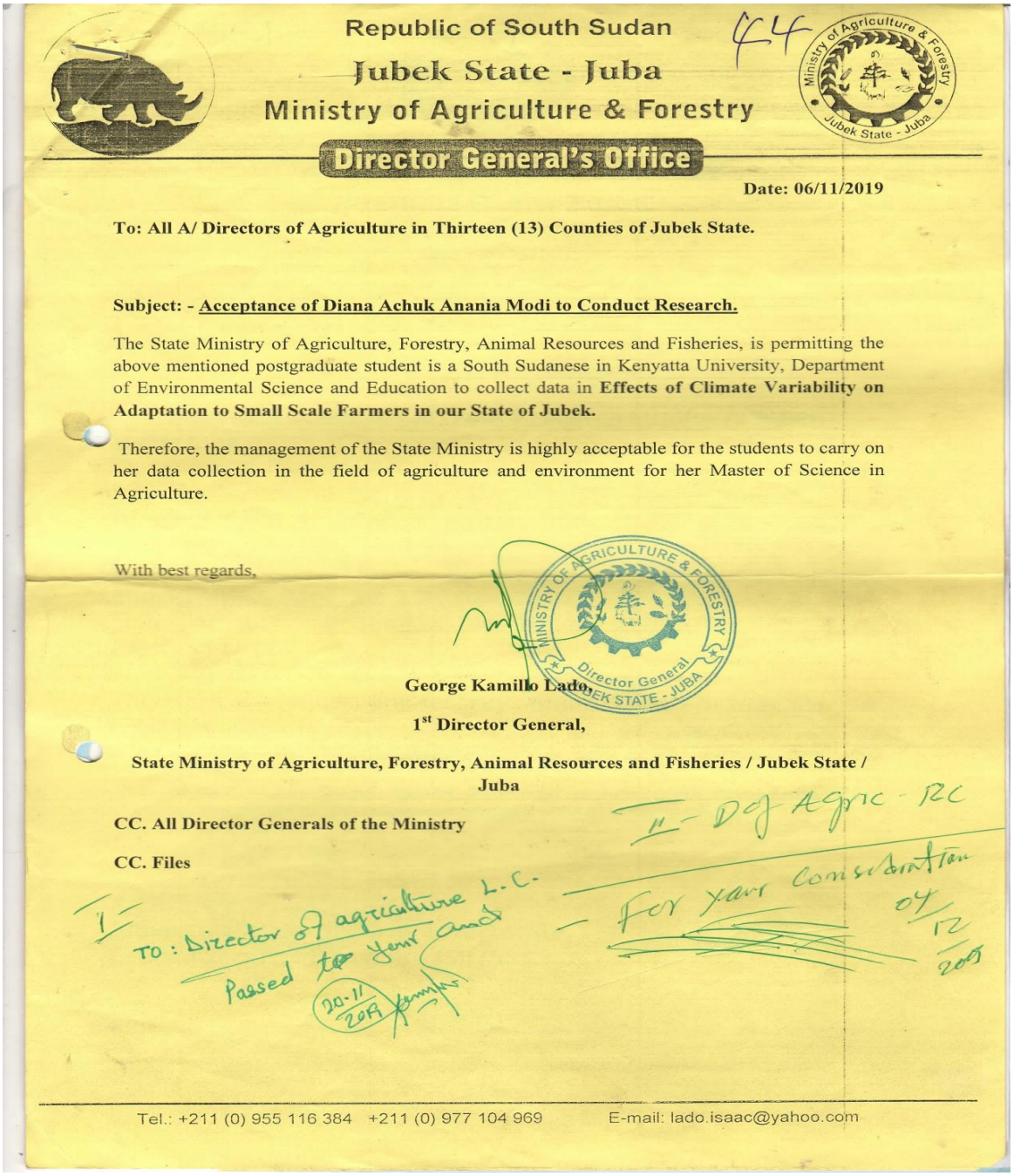
CC. Chairman, Department of Environmental Science & Education

Supervisors:

1. Dr. James Koske
   C/o Department of Environmental Science & Education
   Kenyatta University

2. Dr. Samuel Otor
   C/o Department of Environmental Science & Education
   Kenyatta University

APPENDIX VII: RESEARCH ACCEPTANCE LETTER FROM SOUTH SUDAN



Republic of South Sudan
Jubek State - Juba
Ministry of Agriculture & Forestry
Director General's Office

Date: 06/11/2019

To: All A/ Directors of Agriculture in Thirteen (13) Counties of Jubek State.

Subject: - Acceptance of Diana Achuk Anania Modi to Conduct Research.

The State Ministry of Agriculture, Forestry, Animal Resources and Fisheries, is permitting the above mentioned postgraduate student is a South Sudanese in Kenyatta University, Department of Environmental Science and Education to collect data in **Effects of Climate Variability on Adaptation to Small Scale Farmers in our State of Jubek.**

Therefore, the management of the State Ministry is highly acceptable for the students to carry on her data collection in the field of agriculture and environment for her Master of Science in Agriculture.

With best regards,

George Kamillo Lado,

1st Director General,

State Ministry of Agriculture, Forestry, Animal Resources and Fisheries / Jubek State / Juba

CC. All Director Generals of the Ministry

CC. Files

Tel.: +211 (0) 955 116 384 +211 (0) 977 104 969 E-mail: lado.isaac@yahoo.com

The Republic of South Sudan
Ministry of Interior
South Sudan National Police Service
Police Head-Quarters
Jubek State

COMMISSIONER OFFICE.

Date :- 8/11/2019.

Minister of Agriculture & forestry
Jubek State.

Subject:- Diana Achuk Anania Modi.

Reference to your letter dated 6/11/2019 regarding the research of the mentioned post graduate student to conduct research in the countries of Jubek State. Be inform that the administration of Jubek State police HQs have no objection. She had granted permission to carry on her research in the secure countries. Any necessary assistance render to her by other government security organs is highly appreciated.

Thanks.

JUBEK STATE POLICE HQ'S COMMISSIONER OFFICE

Sign.....
Lt/Gen. John Jol BodBod
A/IGP & Commissioner of police
Jubek State.

Cc :- file

Confidential Office Tell: