THE IMPACT OF CLIMATE CHANGE ON RURAL AGRO-PASTORALIST COMMUNITIES IN AWEIL EAST COUNTY, SOUTH SUDAN

BY

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DECLARATION

I declare that this dissertation is my original work and it has not been presented for a degree in any other University

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APPROVAL

I certify that this dissertation has been compiled under my supervision and approved; it is now ready for submission.

Signed**:** ……..……...……

Dr. Barakagira Alex (PhD)

Supervisor

DEDICATION

I am very delighted to dedicate this research dissertation to Almighty God who protected and kept me healthy during the entire period of this study, to my family and lastly but not the least to Arvind Das, Country Representative for Netherland Red Cross in South Sudan, who encouraged and inspired me, enabling me come this far.

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DEFINITION OF KEY TERMS

The definitions of some concept and terms (such as resilience, vulnerability, and adaptation etc.), are increasingly becoming more important within the global change research community; though they do have diverse and somewhat separate definitions depending on context. In this study, broad definitions of commonly used terms in the thesis are provided.

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.

Adaptive capacity: This refers to the ability of a system to adjust its characteristics or behavior in order to expand its coping range under existing climate variability or future climatic conditions.

Adaptive strategies are longer-term (beyond a single season) strategies that allow people to respond to a new set of evolving conditions (biophysical, social and economic) that they have not previously experienced. The extent to which communities are able to respond successfully to a new set of circumstances will depend upon their adaptive capacity.

Weather is the temperature, humidity, precipitation, cloudiness and wind that we experience in the atmosphere at a given time in a specific location.

Climate is the average weather over a long time period (30 – 50 years) in a region.

Climate variability refers to natural variation in climate that occurs over months to decades. El Niño, which changes temperature, rain and wind patterns in many regions over about 2 – 7 years, is a good example of natural climate variability, also called natural variability.

Climate change: As defined by IPCC refers to the change of the state of the climate that can be identified (for example by using statistical tests) by changes in the mean (average value) and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Exposure is employed to refer to the presence (location) of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage.

Extreme events comprise a facet of climate variability under stable or changing climate conditions. They are defined as the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends („tails“) of the range of observed values of the variable.

Mitigation refers to the elimination or reduction of the frequency, magnitude, or severity of exposure to environmental, economic, legal, or social risks, or minimization of the potential impact of a threat or warning.

Resilience: The ability of a system to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring preservation, restoration, or improvement of its essential basic structures and functions.

Risk: This refers to the interaction of physically defined hazards with the properties of the exposed systems, such as sensitivity or vulnerability. Risk can also be from the combination of an event, its likelihood and its consequences. Risk equals the probability of climate hazard multiplied by a given system's vulnerability.

Sensitivity: It is the measure of a system to be affected

Climate Information; includes, historical data, analyses and assessments based on these data, forecasts, predictions, outlooks, advisories, warnings, model outputs, model data, climate projections and scenarios, climate monitoring products, etc., and can be in the form of text, maps, charts, trend analyses, graphs, tables, Geographic Information System(GIS) overlays, photographs, and satellite imagery.

Absorptive capacity; is seen in the ability of individuals, households and communities to minimize exposure to shocks and stresses through preventative measures and appropriate coping strategies to avoid permanent, negative impacts of livelihood shocks and stresses.

Climate Resilient Agriculture can be defined as 'agriculture that reduces poverty and hunger in the face of climate change, improving the resources it depends on for future generations.'

Climate Risk Management (CRM) is an approach to decision making in climate-sensitive activities (for example, agriculture and food security, health, tourism, management of water and

energy resources, urban planning and design, transportation, etc.), that seeks to reduce the vulnerability associated with climate risk (both variability and change), and aims to maximize the positive and minimize the negative outcomes for these sectors.

National Meteorological Service (NMS): For the purposes of this paper, an NMS is "an organization established and operated primarily at public expense to carry out those meteorological and related functions which governments accept as a responsibility of the State in support of the safety, security and general welfare of their citizens and in fulfillment of their international obligations under the Convention of the World Meteorological Organization".

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LIST OF ACRONYMS AND ABBREVIATIONS

AfDB	African Development Bank
BRACED	Building Resilience and Adaptation to Climate Extremes and Disasters
CIS	Climate Information Services
DFID	Department for International Development
EBA	Ecosystem Based Adaptation
FAO	Food and Agriculture Organization
FEWS NET	Famine Early Warning Systems Network
FGD	Focus Group Discussions
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GoSS	Government of South Sudan
ICPAC	IGAD Climate Prediction and Applications Centre
IPCC	Intergovernmental Panel on Climate Change
MOEF	Ministry of Environment and Forestry
NAPA	National Adaptation Programme of Actions on Climate Change
NGO	Non-Governmental Organizations
SSMD	South Sudan Meteorology Department
TEK	Traditional Ecological Knowledge
UN	United Nations
UNFCC	United Nations Framework Convention on Climate
UNOCHA	United Nations Office for Coordination of Humanitarian Affairs
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene
WFP	World Food Programme
WMO	World Metrological Organization

ABSTRACT

The study examined the impact of climate change on rural agro-pastoralist communities in Aweil East County, South Sudan. The objectives of the study were; to determine patterns and trend of climate variability and change in Yargot Payam of Aweil East County from the year 2007-2017; to assess the impacts of climate change on the rural agro-pastoralist communities in Yargot Payam of Aweil East County; to determine the adaptation strategies devised by the rural Agro-pastoralist communities in order enhance their resilience to climate change impacts and to determine existing Community / local governance early warning mechanisms/policies of actions to mitigate the impacts of Climate Change.

The study was guided the primary data collection phase, which combined quantitative household-survey with comprehensive, targeted qualitative focus group discussions (FGDs), Key Informants interviews and observations of physical environmental changes. This mixed method of data collection was chosen to help triangulate information, provide a contextualized and confined analysis and yield a comprehensive dataset on the impacts of climate change in agro-pastoral communities as well existing adaptation strategies.

The study findings herein demonstrated that the effects of climate change on the agro-pastoral communities and their livelihoods in the study area are frightening. Climate change has altered the physical geography of the area leading to a disappearance of flora and fauna and other natural habitat that constituted the livelihoods of the local agro-pastoral communities. Declining precipitation and rising temperatures are making farming increasingly more difficult, unreliable rainfall that consequently results to recurring droughts and flash floods triggered by late arrival of unreliable heavy rains that causes destruction to crops, homesteads and key community assets such as dykes, roads, health and Water, Hygiene and Sanitation facilities. The findings also indicated low level of community awareness on climate change impacts and adaptation strategies, though local traditional mechanisms are practiced by the local agro-pastoral communities to respond to effects of floods and droughts.

The study recommended that strengthening agro-pastoral resilience to effectively tackle and eventually overcome the impacts of climate change through creating awareness aimed at changing individual attitude towards the use of land resources and ensuring that decisive actions are collectively taken and repeatedly practiced at local levels by the communities themselves.

CHAPTER ONE
INTRODUCTION

Background to the study

Globally, Climate Change has been and will always be a challenge to human livelihoods. Human-induced climate change has lent a complex new dimension to this challenge. Evidence shows that natural climatic variability, compounded with climate change, will adversely affect millions of livelihoods around the world (IPCC 2007) Climate change is a global phenomenon; however, its impacts vary locally, as do adaptation capacities, preferences, and strategies. Climate change vulnerability can be defined as 'the capacity to be wounded' by climate change impacts. In other words, vulnerability implies weak adaptive capacity, whereas strong adaptive capacity means reduced vulnerability (*Paavola, 2003).*

The impacts of and vulnerability to climate change is considered high in developing countries due to social, economic, and environmental conditions that amplify propensity to negative impacts and contribute to low capacity to cope with and adapt to climate hazards (Cutter, Boruff, and Shirley 2009). Extreme events such as droughts and floods have increased vulnerability among agro-pastoral communities who depend on climate sensitive livelihoods for survival. Since these occur regularly, they have been reducing long-term growth and affecting millions of people. In Africa, a continent that has contributed the least to the factors that lead to accelerated climate, its impact is believed to have been enhanced. This has been attributed to the continent's low adaptive capacity, over-dependence on agricultural sector, marginal climate and existence of many other stressors (Collier *et al.2008).* The negative consequences of climate change in Africa are already affecting the communities living across the width and breadth of the continent. Frequent flooding, recurring droughts, extreme weather conditions, and shift in marginal agricultural systems are few of its apparent impacts.

In South Sudan, adverse impacts of climate change include recurrent droughts, floods, increased biodiversity loss, species migration and encroachment of invasive plants, increased rural urban migration, changes in the vegetation types, soil fertility loss, and increased infestation of crop by pests and diseases and increased health risks (United States Government situational report 2011). Communities in South Sudan are vulnerable to climate change. Approximately 86 percent of the rural households in south Sudan rely on rain-fed agriculture and animal husbandry as their main source of livelihood. Limited data availability precludes the modeling of specific climate change scenarios in south Sudan, a regional analysis showed that summer rains declined by 15-20 percent, and temperatures rose by > 1◦C from the mid-1970s to the late 2000s in parts of the country (Famine Early Warning Systems Network- Informing Climate Change Adaptation Series, FEWS NET-2011). If the current trajectories are allowed to continue business as usual, in the future, rainfall is expected to become increasingly erratic, increasing the incidence of both floods and droughts. Indeed, 62 percent of rural households already claimed to have severely affected by droughts and/or floods from 2005-2009. Temperatures are likely to continue rising, which will intensify the effects of droughts. Research on the Sobat River and the Bahr-el Gazal River catchments indicated that an increase of 2◦C in temperature might cause the natural flow to flow to 50 percent of the current average. Future increase in the frequency and severity of extreme climate events will likely lead to; (i) food insecurity through failed crop yields, loss of livestock, (ii) heightened water scarcity for drinking and irrigation; (iii) worsening water quality; (iv) more soil erosion; (v) higher incidences of diseases such as cholera, typhoid and dysentery; (vi) higher frequency of fires as a result of droughts; (vii) lower availability of fuel wood; and (viii) internal conflict as a result of human competition for scarce resources.

Communities and government are extremely constrained in their ability to anticipate, and effectively respond to, climate change-induced disasters (i.e. droughts and floods). South Sudan has one of the worst human development indicators in the world, with at least 80 percent of the population under the poverty line and 65 percent in the extreme poverty. 27 percent of the population aged 15 years and above is literate, with significant gender inequalities: the literacy rate for males is 40 percent compared to 16 percent for females. 55 percent of the population has access to improved sources of drinking water. Over two thirds of the population is under 30 years. Over 80 percent of the communities in South Sudan are particularly reliant on natural resources for their livelihoods (Ministry of Environment and UNDP, 2011).

Problem Statement

For agro-pastoral communities, high livestock mortality and failed crops has devastating effects on their lives and livelihoods. Whilst agro-pastoralists for a long has used indigenous ways of adapting to shock and stresses imposed by harsh environmental conditions, increasing frequency of extreme weather events is now bringing new challenges that constraints some of the adaptation strategies.

In the study area of Aweil East County, extreme climate events have continued to inflict detrimental effects on health and livelihoods of the rural agro-pastoral communities. There are number of constraints that limit the integration of climate change adaptation into local government institutional frameworks and local community structures. Among these constraints is that there is limited knowledge and awareness of climate change impacts and vulnerability among the local communities and therefore climate change issue are not highly prioritized despite the major threats (BRACED 2017). Furthermore, the rural agro-pastoral communities in the study area rely heavily on traditional mechanisms to adapt and cope with a changed climate,

some of which may not be relevant for today (BRACED 2017). Meanwhile, the capacity of local government institutions mandated to address climate change issues at national and local levels have been weakened by a lack of technical knowhow and financial resources, and by the low priority assigned to environment and climate change issues by the government due to the ongoing conflict. For example, the Ministry of Environment has established a climate change unit, but it is not operational due to lack of financial and human resources (Netherlands Commission for Environmental Assessment. 2015. Climate Change Profile: South Sudan).

The study was carried in order to determine the impacts of climate change on the local agro-pastoral communities as well to understand these climatic patterns, household vulnerability level as well the existing adaptation strategies employed by the local agro-pastoral communities in the study area. The study also understands the local communities' knowledge, attitude and practices related to actions that attributes to climate change in their localities. It also aimed to create level of awareness among local government authorities in Aweil East County on their responsibilities towards mitigating the impacts of climate change in their respective communities.

Objectives of study

The study aimed to assess the impacts of climate change and adaptation strategies among the rural Agro-pastoralist communities in Aweil East. In order to achieve the stated aim, the following specific objectives were pursued:

1) To determine patterns and trend of climate variability and change in Yargot Payam of Aweil East County from the year 2007-2017.

2) To assess the impacts of climate change on the rural agro-pastoralist communities in Yargot Payam of Aweil East County.

3) To determine the adaptation strategies devised by the rural Agro-pastoralist communities in order enhance their resilience to climate change impacts.

4) To determine existing community / local governance early warning mechanisms/policies of actions to mitigate the impacts of Climate Change.

Research Questions

The study was guided by the following questions:

1) What are the pattern and trend of climate change in the study area?
2) What are the impacts of climate change on the rural agro-pastoralist communities in Aweil East?
3) What are the local adaptation strategies of the rural agro-pastoralist communities to climate change impacts?
4) What are existing Community level early warning mechanisms/policies of actions to mitigate the impacts of Climate Change?

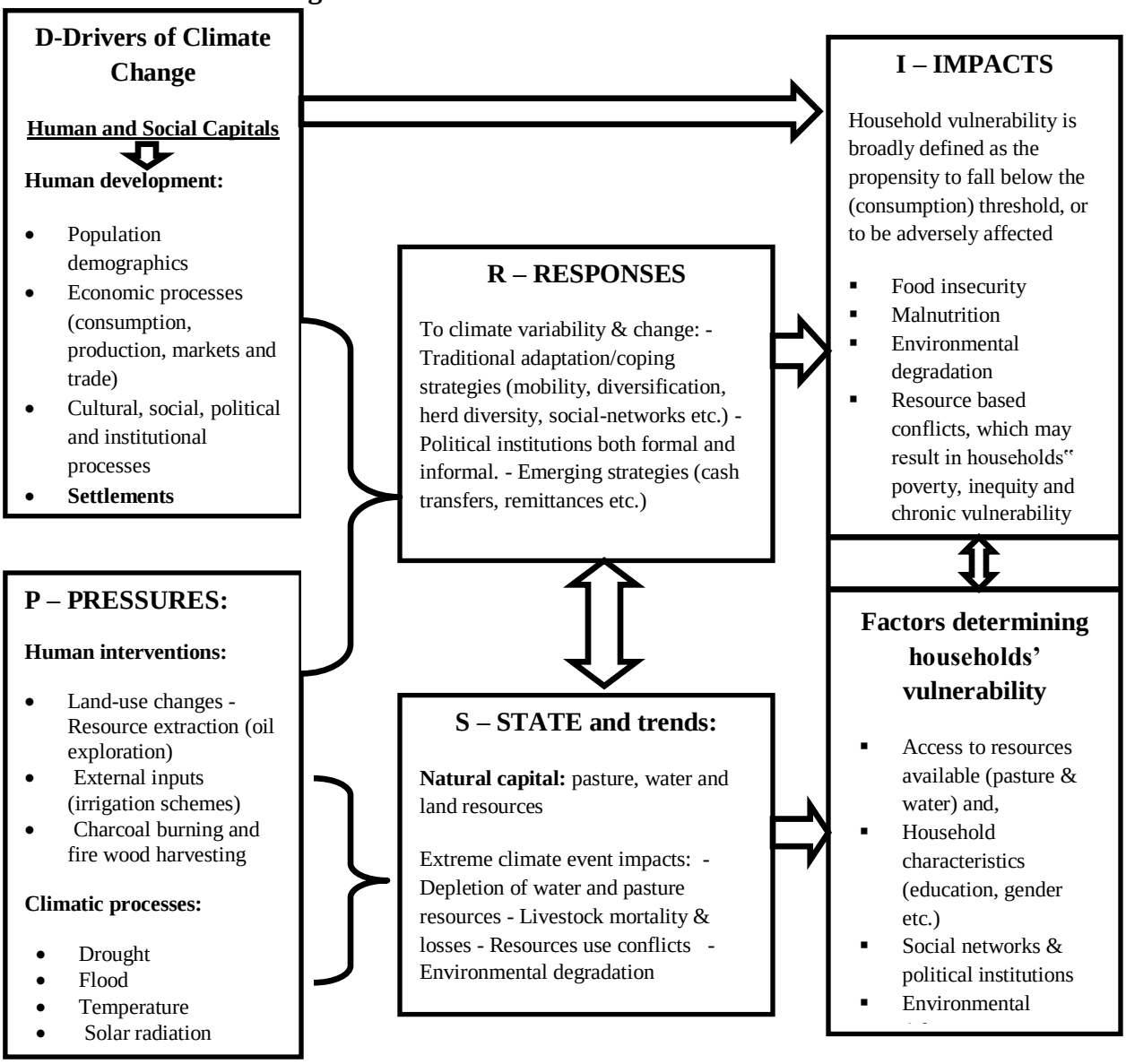
Justification of the Study

The study findings contribute scientific knowledge on the resilience of the rural Agro-pastoralists communities to adverse impacts of climate change especially in a wavering policy and socio-economic environment in Aweil East. Also, the study will set a stage for an understanding of local strategies used by the Rural Agro-pastoralist communities in Aweil East in coping and adapting to impacts of climate change for possible policy intervention. Lastly, the proposed study will contribute to already existing of efforts of the government of South Sudan and its development partners especially the United Nations Development Programme (UNDP) in South Sudan to strengthen the capacity of the local communities and local government authorities in Aweil East to be able to plan and implement a suite of adaptation interventions-such as Ecosystem based Adaptation (EBA), additional livelihoods and climate-smart agriculture that improve ecosystem services and reduce the vulnerability of the rural Agro-pastoralist communities to climate change.

Conceptual Framework

The study adopted a framework by Frankenberger *et al*. (2010) in their work on understanding climate change drivers, impacts, vulnerability and resilience to climate change. The framework was however modified to fit into and guided this study. It was organized in two variables in a sense that the first variables determined the impacts and vulnerability to climate change in an Agro-pastoralist community. These include human activity, environmental outputs, climate change, and impacts on Agro-pastoral systems. The second variable focused on management issues that aim at enhancing resilience of local rural Agro-pastoralist community to climate change and variability impacts including climate change adaptation strategies, these are determined by environmental processes at play and hazard and vulnerability of a given Agro-pastoral system.

Figure 1: Conceptual Framework on climate change drivers, impacts, vulnerability and resilience to climate change



As reflected in figure 1. Above, factors that determine adaptive capacity of individuals revolve around household characteristics, social networks and political institutions, bio-physical and environmental factors. Vulnerability is influenced by the build-up or erosion of the elements of resilience that determine the ability of a household to absorb stresses, and maintain essentially the same structure, function and feedbacks (Adger 2006). As such, vulnerability is a function of macro (economic, institutional and environmental setting) and micro (access to resources,

adaptation and coping strategies) factors at household level. A useful conceptual framework for vulnerability should not only describe the current state of the system under analysis (households), but should also capture a complex dynamics and sensitivity which is the degree to which a system is modified or affected by perturbations (Galloping 2006).

The resilience and vulnerability pathways (Figure 1.1) are viewed as processes rather than static states of a system. Households or communities those are able to use their adaptive capacity to manage the shocks or stresses they are exposed to and incrementally reduce their vulnerability are less sensitive and are on a resilience pathway. In contrast, households that are not able to use their adaptive capacity to manage shocks or stresses are sensitive to shocks and stresses are likely to go down a vulnerability pathway. The livelihood outcome depends on the needs and objectives that households are trying to realize. Resilient communities and households are able to meet their food security needs, have access to adequate nutrition, well protected environment and income security, health security, and are able to participate in the decisions that affect their lives (Frankenberger 2012). Vulnerable households experience deficits, or a high risk of deficits in each of these aspects. This study is framed to enhance understanding of the local adaptive capacities in shaping the sensitivity of households exposure to climate change, based on the vulnerability and resilience conceptual framework.

Hypothesized theory of agro-pastoral households' vulnerability to climate-induced stresses

In this study, the Driver, Pressure, State, Impact, and Response (DPSIR) model was used to explicitly explain cause and - effects relationship on how pastoralist households are impacted by climate change (Figure 1.2). Climatic extremes, particularly recurrent drought hazards have resulted in depletion of water and pasture resources which are critical for pastoral production systems in the rangelands (Schilling *et al.* 2012). The incidences of severe, recurrent droughts

seem to be on the increase resulting in deaths of large numbers of livestock, resource based conflicts, livestock diseases outbreaks and environmental degradation. In addition to drought, other important risk include human population pressure and settlements, land use changes and exploitation of key resources, disease outbreaks, raids and conflict are all restricting access to critical livestock grazing areas in the arid and semi-arid of South Sudan.

Arrangement of the Work

The study is organized into six chapters. Chapter 1 presents the background of the study, problem statement, research objective, research questions followed by scope of the study and conceptual framework of the study. The first chapter also describes the importance of the study and arrangement of the work. Chapter 2 contains the literature review and theoretical framework for the study. In this chapter, relevant theories, concepts and the theoretical framework of the study are presented. Chapter 3 introduces the methodology and strategies used in the research. This proceeded with field work in which the empirical findings of the research are stated and analyzed in chapter 4. Discussions of the findings are presented in Chapter 5 while Conclusions and recommendations of the overall research are found in chapter 6.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Climate change has significant impacts on human and natural systems due to increasing occurrence of uncharacteristic extreme weather events and the intensification of both frequency and severity of climate stressors, such as drought (Hulme et al. 2001). The manifestations of climate change have the potential to directly and severely impact communities that rely on climate sensitive production systems like agro-pastoralism (Bryan et al. 2013; Nicholson 2014). For example, the increasing frequency of drought events as observed between 2008 and 2016 in Northern Bahr-el Gazal State in South Sudan, and thereafter the continued seasonal floods underscored the need to examine adaptation strategies for long-term resilience to both floods and droughts in the study area of Aweil East. Studies carried earlier in Northern Bahr-el Gazal region show that vulnerability to drought and floods are arguably increasing on the back of climate change, and persistent food insecurity coupled with annual displacement provides compelling justification for recommending effective adaptation strategies in the study area (BRACED report, 2017).

2.2 Global Overview of Climate Change and its impacts

Climate change is now recognized as one of the most serious challenges facing the world – its people, the environment and its economies. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007) cleared that global warming is mostly due to man-made emissions of greenhouse gases (mostly CO_2). It is believed that most global warming we can now observe is attributable to emissions of GHGs that result from human activities, in particular land use changes such as deforestation particularly from developing countries, and the burning of fossil fuels specifically from developed countries. There is

consensus among many scientists that the anthropogenic cause of increment of greenhouse gas (GHGs) in the atmosphere is the main cause of the climate changes incidences experienced (Robledo and Forner, 2005; Louman and *et al*., 2009). These Global greenhouse gases (Carbon dioxide (Co_2), Methane (CH_4), N_2O, HFCs, PFCs and SF_6) emissions have grown since industrial time with increase of 70% between 1970s and 2004 (IPCC, 2007).

Climate Change refers to a "statistically significant variation in either the mean state of the climate or in its variability which may be due to natural processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC, 2001). According to (IPCC, 2001) there has been an unprecedented warming trend during the 20th century. The average temperature of the earth's surface has risen by 0.74°c since the late 1800s (IPCC, 2007). The current average global surface temperature of 15°c is nearly 0.6°c higher than it was 100 years ago. Most of the increase has been the consequence of human activity. A further increase of 1.5-6°C is projected from the period to 2100. Fourth Assessment Report of IPCC (2007) concluded "most of the observed increase in anthropogenic greenhouse gas concentrations". The average atmospheric CO_2 concentration has increased from 280 ppm in 1850 to 365 ppm at present, and could exceed 700 ppm by the end of the present century if emissions continue to rise at current rates (IPCC, 2001).

The effects of climate changes are multifaceted. Past and current emissions mean that an increase in temperature of 1°C to 1.5°C is inevitable. Yet the increase of 0.6°C that has already occurred is having a severe impact on global ecosystems and especially on poor people. To avoid the most serious impact of global warming and climate change, the global mean temperature should be limited to a 2°C increase above pre-industrial levels (UK Government, 2003). Temperature rises

beyond 2°C are likely to result in reduced crop yields in most tropical, sub-tropical, and mid-latitude regions and some ecosystems will be irreversibly damaged or lost. It will contribute to result in much more flooding in low-lying areas with decline in food production, an increase in disease, and the extinction of plants, animals, and entire ecosystems (IPCC, 2007). In addition to increases in temperature, global warming results in more extreme weather patterns: more rain, longer dry spells, stronger and more violent storms, more fires, and the spread of tropical diseases. As climate change pushes the world towards more extreme weather, more and more people will be exposed to recurrent disasters during their lives.

According to Schneider et al. (2007), Africa is likely to be the continent most vulnerable to climate change. With high confidence, Boko et al. (2007) also projected that in many French countries and regions, agricultural production, food security and water stress would likely be severely compromised by climate change and climate variability. These risks need to be managed. One promising approach is the use of insurance.

Climate change, and resulting increased temperatures, storms, droughts, and rising sea levels, will affect the incidence and distribution of infectious disease across the globe.[7] This is true in Africa, where malaria continues to have dramatic effects on the population. As climate change continues, the specific areas likely to experience year-round, high-risk transmission of malaria will shift from coastal West Africa to an area between the Democratic Republic of the Congo and Uganda, known as the African Highlands.

2.3 The Patterns and Trend of Climate Variability and Change in Africa

Africa is one of the most vulnerable continents due to lack of financial, technical and institutional capacity to cope with the impacts of climate change. Due to various anthropogenic activities, greenhouse gases are increasing in the atmosphere at an alarming rate which leads to extreme temperature and flooding, loss of soil fertility, low agricultural productions (both crops and livestock's), biodiversity loss, risk of water stress, and prevalence of various diseases (Magadza,C.H.D, 2000). It is predicted that the temperature in Africa continent will rise by 2 to 6°C over the next 100 year. The below are the significant impacts of climate Change in most African countries especially in the sub-saharan Africa countries.

Drought

Drought has had significant impacts on food insecurity and affects the life of African people and its trend is increasing in 21th century (IPCC, 2007). According to Emergency Events Database (EM-DAT) more than 100 million people were affected by drought in Africa. Kenya was affected by drought seven times over 1991-2008, which affects about 35 million people. Ethiopia also experienced six drought times over 1983-2008. Other African countries were also affected by drought several times (Table 1). From Africa continent, Eastern African countries (that is, Burundi, Eritrea, Ethiopia, Kenya, Uganda, Tanzania, Rwanda, and Somalia) were among the vulnerable countries to the effects of drought due to its dependency on rain-fed agriculture. Feyssa and Gemeda (2015) also justify that climate change mainly affect the rain-fed agricultural sectors in technological and economically less developed countries in Africa. Due to drought, by 2100, arid and semi-arid regions of Africa are expected to expand by 5-8%, or 60-90 million hectares, resulting in agricultural losses of between 0.4-7% of gross domestic product (GDP) in Northern, Western Central and Southern Africa ((IPCC), 2007). Extreme events like flooding and droughts are not similar across the continent, some regions will experiences higher rainfall

(the equatorial belt regions), even in drier areas there is a possibility of higher frequency of more intense downpours, which may bring flooding (Conwa, 2009).

Flooding

Flooding leads to immediate deaths and injuries of people, as well to outbreak of infectious diseases like malaria, diarrhea and exposure of people to toxic substances. According the flood portal of European Commissions Joint Research Center, Institute for Environment and Sustainability (2010), more than 1 million people were affected in over 20 African countries and approximately about 500 lives were lost and over 1.2 million people were displaced from their homes. The LDCs more suffer from climate change related disasters like floods. They lack institutional, economic, and financial capacity to cope with the impacts of climate change and to rebuild the infrastructure damaged by natural disasters (BRACED, 2017). Flooding is occur everywhere in the world however, the degree of its impacts is depend on the adaptive capacity of a country, that is, the developed countries has high adaptive capacity while the poor countries, suffer more to the impacts of flooding. The frequency of flooding across the world varies from 2 to more than 1000 years.

Climate change on food security/ food productions

Climate change will affect the production of crops. Climate is a primary factor for agriculture productivity, such that any environmental change affects plant and animal production (Shongwe et al., 2014). With increasing frequency of droughts and floods associated with climate change, agricultural production will decline and the state of food insecurity and malnutrition will increase (Kumsa, and Jones, 2010). It is estimated that African farmers are losing about US$28 per hectare per year for each 1°C rise in global temperature (Kumssa and Jones, 2010). The African Partnership Forum (APF, 2007), described that, climate change can no longer be considered as

an environmental problems only, as it also become a major threat to sustainable development and poverty reduction. Climate change can hinder sustainable development of nations by minimizing yield production which leads to food insecurity. All crops are not affected equally by climate change. Crops such as rice, wheat, beans, maize and potatoes are highly affected and other crops like millet, which resist high temperature and low levels of water may be less affected (Huq et al., 2004). Sub-Saharan Africa (SSA) is the most susceptible and vulnerable places to climate change and variability anywhere in the world (Barr et al., 2010; Hummel, 2015). It is also estimated to be the most food-insecure region in the future (Thomson et al., 2011).The impacts of climate change on smallholder farmers, who depends only on rain-fed agriculture are among the most disadvantageous and vulnerable groups (Tetteh et al., 2014). Similar to crop productions, climate change also adversely affects livestock's productions. According to (Getu, 2015) agriculture and livestock keeping are amongst the climate sensitive sectors. The negative impacts of climate change are more severely felt by poor people in developing countries who mainly depend on the natural resources base for the livelihoods.

Climate Change on Development

Africa faces the biggest development challenges of any continent because of an increase in the number of people at risk of water stress, exposure to malaria, and a drop in agricultural yields (Frankhauser and Schmidt-Traub, 2011). Climate change has the potential to undermine sustainable development, increase poverty, and prevent the realization of the MDGs (IPCC, 2009). Failure of achieving the MDGs correlates with areas where high climate vulnerability is expected to occur (Yohe *et al*., 2007). It is obvious that climate change and variability will seriously hinder future development of a nation. The biophysical effects of climate change on agriculture induce changes in production and prices, which play out through the economic

system as farmers and other market participants adjust autonomously, altering crop mix, input use, production, food demand, food consumption, and trade (Oxfam, 2009).

Climate Change on Human Health

Climate change also causes scarcity of water resources and severe floods that leads to outbreaks of waterborne diseases. African countries suffer serious health problems because of climate change according to United Nations Economic Commission for Africa (UNECA, 2011). UNECA justified that, Africa is the most susceptible continent to climate change related health problems due to the existing poverty and weak institutions to deal with health challenges posed by climate change. Change in rainfall will affect the presence and absence of vector and water borne pathogens (IPCC, 2001). Any changes in temperature and precipitation will boost the number of disease-carrying mosquitoes that leads to malaria epidemics (Lindsay and Martens, 1998). The problem of Malaria is associated to climate change. According to World Health Organization (WHO, 2003) malaria epidemics in Zimbabwe have been closely linked to climate variability caused by El Nino. Climate change can affect the well-being of human beings either directly or indirectly.

Climate Change on Livestock Health

Climate change impacts on vector borne diseases, for example predictions of climate and population change on tsetse fly density indicates that tsetse populations and animal trypanosomiasis will decrease in the semi-arid and sub humid zones of West Africa. In addition to vector borne diseases, helminth infections of small ruminants will be influenced by changes in temperatures and humidity (Bare, 2011).

2.4 The Impacts of Climate Change on the Rural Agro-Pastoralist Communities

Agriculture in South Sudan is vulnerable to climate variability as most of the production is rain fed and therefore dependent on seasonal rains for optimal crop performance. Droughts and increasing variability negatively impact the economy and nutrition status of South Sudanese who depend on agriculture for their livelihoods (UNEP, 2011). Recent evidence suggests reductions in yields of sorghum, the staple grain of the majority of the population, of 5–25 percent between 2000 and 2050. (6) In a country of 12 million people, South Sudan is home to 38 million cattle, goats and sheep, which provide livelihoods for about 80 percent of the population. Livestock are raised in a variety of production systems, including pastoralism, which depends on access to grazing land and watering points. Climate change can exacerbate existing tensions over land use among and between farmers and pastoralists as they compete for increasingly scarce resources. For example, pastoralists might change their migration patterns in search of water and fodder, thus coming into contact with existing agricultural lands and other pastoralists.

2.4.1 The Impact of Climate Change on Water Resources in South Sudan

Climate change could reduce water availability in the country, which will have several impacts on agriculture, ecosystems and water and sanitation services. Situated in the Nile catchment area, South Sudan receives water from the highlands of neighboring countries, which flows into the country's low and vast clay basin. In contrast to the Nile, these catchments are highly sensitive to seasonal temperature variation. For example, a 2°C increase in temperature could cause the average natural flow in the Equatorial Lakes and Bahr el Ghazal sub basins to fall by 50 percent. Additionally, rivers previously considered permanent have been drying up and becoming seasonal over the last two decades. Decreasing water levels due to climate change would heavily impact the one-third of the population that still relies on surface water for domestic use. After

decades of war, access to water supply and sanitation services is severely constrained; piped water is practically nonexistent. More than 60 percent of the population relies on wells and boreholes for access to water (National Adaption Programmes of Action (NAPA) to Climate Change policy document (draft 2016-9).

2.4.2 The Impact of Climate Change on Ecosystems in South Sudan

A diversity of ecosystems provides South Sudan with a wide range of environmental services, such as provision and maintenance of water resources, flood mitigation and food sources, all of which could be affected by climate change. South Sudan is home to the largest designated Ramsar wetland, the Sudd, which is pivotal in regulating weather patterns in the Sahel, Horn of Africa and greater East Africa region (The SUDD 2007). The Sudd acts as a barrier to the southward encroachment of the Sahara Desert; its preservation is consequently expected to be South Sudan's most significant contribution to buffering against climate change impacts at the regional level. (11) South Sudan has diverse natural forests and woodlands that cover about 33 percent of total land area and contain rich biodiversity. These forests provide direct benefits in the form of income, food and fodder, as well as indirect benefits through environmental protection (shade, wind belts) and improved agricultural production (from mulching and nitrogen fixation).

Three decades of low rainfall and periodic severe drought have led to disputes over water resources. Water rights continue to be a source of tension between South Sudan and Sudan. Across the region, access to water from the Nile has sparked conflict between nations. There is concern that climate change may exacerbate South Sudan's existing instability –nationally, regionally and locally. A hotter, drier climate with intermittent droughts may see a southward shift in the Sahel, leading to declines in tree density and tree species, limited tree growth and

increased incidence of wildfire. (1, 10) Overall, degradation of ecosystem services, in part caused by climate change, causes friction between competing forms of land use and competition for resources within land use sectors, which often leads to social conflicts and instability.

2.4.3. The Impact of Climate Change on Public Health situation in South Sudan

Climate change has had far-reaching affects to human health in South Sudan, and includes, but is not limited to, the following: heat stress, air pollution, asthma, vector-borne diseases (such as malaria, dengue, schistosomiasis (also referred to as swimmer's itch or snail fever) and tick-borne diseases), water-borne and food-borne diseases (such as diarrheal diseases).

Climate change is global in nature, potential changes are not expected to be globally uniform; rather, there may be dramatic regional differences. The latest report by the International Panel on Climate Change (IPCC, 2014) also highlights that vulnerability to the impacts of Climate Change can be due to gender and other factors, including class, ethnicity and age. It is now widely recognized that people who are socially, economically, culturally, politically, institutionally, or otherwise marginalized are especially vulnerable to climate change and also to some adaptation and mitigation responses (UN Women, 2017). Differences in vulnerability and exposure arise from no climatic factors and from multidimensional inequalities. These differences shape differential risks from climate change. Over 75% of households in South Sudan are dependent on rain-fed crop farming or animal husbandry as their primary source of livelihood; this makes the population extremely vulnerable to impacts of climate change.

2.5 The Adaptation Strategies Devised by the Rural Agro-Pastoralist Communities in Order Enhance their Resilience to Climate Change Impacts.

Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. The Intergovernmental Panel on Climate Change (2007) defines adaptation as adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. It also refers to actions that people, countries, and societies take to adjust to climate change that has occurred. Adaptation has three possible objectives: to reduce exposure to the risk of damage; to develop the capacity to cope with unavoidable damages; and to take advantage of new opportunities. The adaptation used in Africa was discussed under crop and livestock adaptation strategies (F.A, 1988

Emphasis on more drought-resistant crops in drought-prone areas could help in reducing vulnerability to climate change. For example, wheat requires significantly less irrigation water compared to dry season rice. The use of drought-resistant crop varieties have been tried by smallholder farmers as adaptation methods to climate change in Nigeria, Senegal, Burkina Faso and Ghana (Ngigi, 2009). Also, strategies against drought were adopted by nomadic pastoralists living in the desert margins of Kenya (Langill and Ndathi, 1998).

Crop diversification: Diversification towards high value crops is feasible in the medium to long term. Crop diversity is a high priority adaptation measure 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 (P, 2008). In Kordofan and Drafur states of Western Sudan, food crops have replaced cash crops, and more resilient crop varieties

have been introduced (DFID, 2004). In Tanzania, farmers diversify crop types as a way of spreading risks on the farm (Orindi and Eriksen 2005; Adger *et al*., 2003).

Crop diversification can serve as insurance against rainfall variability. For example in Tanzania, to avoid crop production risks due to rainfall variability and drought, staggered plating is very common to most farmers whereby crops are planted before rain onset (dry land) on uncultivated land. Others were planted immediately after rain, while still other plots were planted a few days after the first rains. Tilling the land commences in fields which were planted prior to cultivation on the third week after the onset of rain which also enables destroys early geminating weeds and reduces weeding. These were done purposely to distribute risk by ensuring that any rain was utilized to the maximum by the crop planted the in dry field (Lema, 2009).

Mixed cropping: Mixed cropping involves growing two or more crops in proximity in the same field. The system is commonly practiced in Tanzania where cereals (maize, sorghum), legumes (beans) and nuts (groundnuts) are grown together. The advantages of mixing crops with varying attributes are in terms of maturity period (e.g. maize and beans), drought tolerance (maize and sorghum), input requirements (cereals and legumes) and end users of the product (e.g. maize as food and sunflower for cash). A research conducted by Mendelsohn *et al.* (2000) on analyzing adaptations made in Africa reveals that in all countries apart from Cameroon and South Africa, the planting of different varieties of the same crop is considered to be one of the most important adaptations. Different planting dates are also considered an important adaptation in Egypt, Kenya and Senegal.

Improved irrigation efficiency: Success of climate change adaptation depends on availability of fresh water in drought-prone areas. It should be emphasized that most adaptation methods provide benefits even with the lower end of climate change scenarios, such as improved irrigation efficiency. As water becomes a limiting factor, improved irrigation efficiency will become an important adaptation tool, especially in dry season. Climate change is expected to result in decreased fresh water availability (surface and groundwater) and reduced soil moisture during the dry season, while the crop water demand is expected to increase because of increased evapo-transpiration caused by climate change and the continuous introduction of high-yielding varieties and intensive agriculture (Selvaraju *et al.*, 2006).

In Egypt, Kenya, and South Africa, significant numbers of farmers have adapted by increased use of irrigation. In Gambia, South Africa, and Sudan, farmers employ such adaptation measures as irrigation water transfer, water harvesting and storage to cushion the effects of rainfall variability (Nkomo *et al.,* 2005 and Osman *et al*. (2005). As temperature increases, farmers tend to irrigate more frequently. Irrigation is clearly an adaptation strategy to warming. When precipitation increases, they tend to irrigate less often and resort to natural rainfall more often. Farms in the deserts reduce irrigation when temperature increases. Similarly, when precipitation increases, farms close to the deserts increase irrigation. Adopting soil conservation measures that conserve soil moisture: Soil conservation techniques are increasingly practiced in Burkina Faso, Kenya, Senegal, and Niger.

A study carried out by Lema and Majule (2009) in Manyoni District of Tanzania revealed that farmers in Kamenyanga and Kintinku ensure proper timing of different farming activities, burying of crop residues to replenish soil fertility, burning crop residues to enhance quick release

of nutrients and allowing livestock to graze on farmlands after harvesting crops so as to improve soil organic matter. In Tanzania, farmers used contour ridges as a strategy to minimize soil erosion to encourage better root penetration and enhance moisture conservation (Lema and Majule, 2009). 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. Nyong *et al.* (2007) noted that local farmers in the Sahel conserve carbon in soils through the use of zero tilling practices in cultivation, mulching and other soil management techniques.

Planting of trees (afforestation) and agro-forestry; Tree planting is the process of transplanting tree seedlings, generally for forestry, land reclamation, or landscaping purposes. It differs from the transplantation of larger trees in arboriculture, and from the lower cost but slower and less reliable distribution of tree seeds. In silviculture the activity is known as reforestation, or afforestation, depending on whether the area being planted has or has not recently been forested. It involves planting seedlings over an area of land where the forest has been harvested or damaged by fire or disease or insects. Rural farmers in most of the Africa countries have been planting trees as a way of adapting to the effect of climate change (Bationo, (2001).

Agro-forestry is a rational land-use planning system that tries to find some balance in the raising of food crops and forests (Adesina *et al.*, 1999). A practice similar to this has been described in a part of south western part of Nigeria to raise shade tolerant crops, such as cocoyam in essentially a permanent forest setting (Adesina, 1988). In addition to the fact that agroforestry techniques can be perfected to cope with the new conditions that are anticipated under a drier condition and

a higher population density, they lead to an increase in the amount of organic matter in the soil thereby improving agricultural productivity and reducing the pressure exerted on forests. In the drier parts of the Sahel, baobab (*Adansonia digitata*) and acacia (*Acacia*) trees is usually planted.

2.5.1 Livestock adaptation strategies among Agro-pastoral communities in Africa

Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. The following have been identified by several experts (IFAD, 2009; FAO, 2008; Thornton et al., 2008; Sidahmed, 2008) as ways to increase adaptation in the livestock sector:

Production adjustments: Changes in livestock practices could include: (i) diversification, intensification and/or integration of pasture management, livestock and crop production; (ii) altering the timing of operations; (iii) conservation of nature and ecosystems; (iv) modifying stock routings and distances; (v) introducing mixed livestock farming systems, such as stall-fed systems and pasture grazing.

Adaptation strategies that are applied among pastoralists in the Sahel region of Africa include the use of emergency fodder in times of droughts, multi-species composition of herds to survive climate extremes, and culling of weak livestock for food during periods of drought. During drought periods, pastoralists and agro-pastoralists change from cattle (Bos) to sheep (Capra) and goat (Capra) husbandry as the feed requirements of the later is less than the former (Oba 1997). Pastoralists' nomadic mobility reduces the pressure on low carrying capacity grazing areas through the circular movement from the dry northern areas to the wetter southern areas of the Sahel. This system of seasonal movement represents a local type of traditional ranching management system of range resources (Hoffmann, 2008).

Breeding strategies: Many local breeds are already adapted to harsh living conditions. However, developing countries are usually characterized by a lack of technology in livestock breeding and agricultural programmes that might otherwise help to speed adaptation. Adaptation strategies address not only the tolerance of livestock to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases (Hoffmann, 2008). Such measures could include: (i) identifying and strengthening local breeds that have adapted to local climatic stress and feed sources and (ii) improving local genetics through cross-breeding with heat and disease tolerant breeds. If climate change is faster than natural selection, the risk to the survival and adaptation of the new breed is greater (Hoffmann, 2008)

Livestock management systems: Efficient and affordable adaptation practices need to be developed for the rural poor who are unable to afford expensive adaptation technologies. These could include (i) provision of shade and water to reduce heat stress from increased temperature. Given current high energy prices providing natural (low cost) shade instead of high cost air conditioning is more suitable for rural poor producers; (ii) reduction of livestock numbers – a lower number of more productive animals leads to more efficient production and lower GHG emissions from livestock production (Batima, 2006); (iii) changes in livestock/herd composition (selection of large animals rather than small); (iv) improved management of water resources through the introduction of simple techniques for localized irrigation (e.g., drip and sprinkler irrigation), accompanied by infrastructure to harvest and store rainwater, such as tanks connected to the roofs of houses and small surface and underground dams.

Capacity building for livestock keepers: There is a need to improve the capacity of livestock producers and herders to understand and deal with climate change thereby increasing their awareness of global changes. 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 (Devereux, 2001).

2.5.2 Other adaptation strategies among agro-pastoral communities

Labour migration: Migration is a dominant mode of labour (seasonal migration), providing a critical livelihood source. The role of remittances derived from migration provides a key coping mechanism in drought and non-drought years but is one that can be dramatically affected by periods of climate shock, when adjustments to basic goods, such as food prices are impacted by food aid and other interventions (Maxwell, 2001). Migration is (and always has been) an important mechanism to deal with climate stress. Pastoralist societies have of course habitually migrated, with their animals, from water source to grazing lands in response to drought as well as part of their normal mode of life. But it is becoming apparent that migration as a response to environmental change is not limited to nomadic societies. In western Sudan, for example, studies have shown that one adaptive response to drought is to send an older male family member to Khartoum to try and find paid labour to tide the family over until after the drought (McLeman and Smit, 2004). Temporary migration as an adaptive response to climate stress is already apparent in many areas. But the picture is nuanced; the ability to migrate is a function of mobility and resources (both financial and social). In the West African Sahel, recent studies have cast light on the use of temporary migration as an adaptive mechanism to climate change.

Income diversification: A survey carried out by Mertz *et al.* (2010) indicated that in Southern Burkina Faso, farmers adapt to the effects of low yield by indulging in the dry season market gardening and non-farm income sources. This is corroborated by additional in-depth studies at local level in northern Burkina Faso, where local people focus on activities that are less dependent on climate (Nielsen and Reenberg 2010a, 2010b). An analysis of national household survey data in Burkina Faso between 1998 and 2007 showed that the average wealth increased for almost all major livelihood groups and the number of wealthy people steadily increased. These results highlight the importance of off-farm income which generates opportunities, especially in marginal rural areas, for long-term adaptation strategies to climate variability and change. Generally, Africa is already under pressure from climate stresses which increase vulnerability to further climate change and reduce adaptive capacity (Langill, 1998). The adverse effects of climate change have a particularly devastating effect on agriculture, which is the mainstay of most African economies. This has affected food production with its resultant effect on widespread poverty. Some African communities have developed traditional agricultural adaptation strategies to cope with climate variability and extreme events.

Therefore, experience with these strategies needs to be shared among communities. Techniques include: diversification of herds and incomes, use of forest products as a buffer against climate induced crop failure, soil fertility improvement techniques, soil moisture and water conservation practices, decentralization of governance of resources and the manipulation of land use leading to land use conversion, to name a few. However, some of these techniques may need to be adjusted to face additional climate risks associated with climate change.

The major constraints to applying agricultural adaptation strategies in Africa has been a general lack of knowledge, expertise and data on climate change issues; a lack of specific climate change institutions to take on climate change work and the need for a better institutional framework in which to implement adaptation. Actions to address these gaps include: training programmes for local government officials, dedicated research activities and post-graduate courses; and the initiation of specific institutional frameworks for climate change. Proactive adaptation can improve capacities to cope with climate change by taking climate change into account in long term decision-making, removing disincentives for changing behavior in response to climate change (removing subsidies for maladaptive activities), and introducing incentives to modify behavior in response to climate change (use of market-based mechanisms to promote adaptive responses). Furthermore, improving and strengthening human capital, through education, outreach, and extension services, improves decision-making capacity at every level and increases the collective capacity to adapt.

2.6 Community / Local Governance Early Warning Mechanisms / Policies of Actions to Mitigate the Impacts of Climate Change

According to Folke *et al.,* 2010, it is evident that increasing resilience to impacts of climate change can be realized by reducing vulnerabilities and increasing adaptive capacity. Resilience can be achieved for every specific risk by reducing sensitivity, exposure and increasing adaptive capacity. These measures can be achieved by intervening into all different dimensions namely: biophysical, economic and social. IPCC (2014) defines resilience as the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation. Miller *et al.* (2010) explains that there is a time

dimension to the resilience concept: a system is resilient when it is less vulnerable to shocks across time, and can recover from them. Adger (2000) argues that these external stress and disturbances can be due to environmental, political and social change.

Three aspects are critical to resilience thinking: resilience, adaptability and transformability (Folke, 2010). Transformability can be defined as the capacity to create a completely new system when ecological, economic, or social structures make the existing system unsustainable (Walker et al, 2004). It is evident that processes of social learning and communication across multiple institutional scales, community reorganization, and adaptive capacity are critical when building general resilience of marginal societies to climate change (Osbahr et al., 2008). The policies developed at national levels can be insensitive to local needs. At times they do not provide the rural poor with access to the assets and services they need to allow them to innovate and adapt to the ways that can increase resilience to climate variability and change. To facilitate climate adaptation actions to deliver resilience, local perspectives and knowledge need to be acknowledged and given due priority in formal planning systems (Adger 2000)).

Within the Horn of Africa, agro-pastoralist systems are known to be tightly coupled human-environment systems, in which human livelihoods are derived substantially or wholly from livestock keeping that forage on extensive rangeland as common resources (Ellis, 1998; Martin et al., 2014). This region is known as one of the world's most food insecure regions with increasing human populations that are highly dependent on the natural resource base for their livelihoods. According to Niamir-Fuller (1998) and McGahey, Davies and Barrow, (2008), agro-pastoralists make efficient use of flexible resource utilization strategies that enable them to cope with the high spatio-temporal resource variability typical of arid and semi-arid areas. In this

region, agro-pastoralists survive in "fragile ecosystems" that are perpetually affected by drought and are continually threatened by desertification. The diverse livelihood systems of these enable them to cope with and recover from stresses and shocks, maintain or enhance their capabilities and assets while not undermining natural resources ((DFID), 2004).

Studies by Rass (2006), Schilling, Opiyo, and Scheffran (2012) and Opiyo et al.,(2015a) show that the livelihoods of pastoralists depend on, first, the availability and access to assets (capital), such as water, pasture, animal health services, social networks, markets, credit and education; and second, the environment in which these assets are combined for production and consumption, specifically the political, organizational and institutional infrastructure; and third, the dynamic context of risks (drought, violent conflicts, human and animal disease outbreaks, and competition for natural resources) and seasonal trends that affect assets and the environment, and undermine livelihoods resilience. Scenario studies by Swift (2000) concluded that the agro-pastoral economy is likely to thrive in the region by the year 2020 as a result of favorable climatic conditions for livestock production in the dry lands (Hoffman MT, Voge C. 2008).

2.7 Factors contributing to vulnerability to climate Change in South Sudan

Notenbaert et al. (2013) noted that many factors contribute to vulnerability, and these factors undermine capacity for self-protection, block or diminish access to social protection, delay recovery or expose some households to greater or more frequent hazards than other households. In South Sudan, according to NAPA 2017 Publication, these factors include;

- **Reliance on rain-fed subsistence agriculture**

Traditional subsistence agriculture is the dominant economic activity in South Sudan with approximately 78% of households reliant upon crop farming and animal husbandry as their main source of livelihood. Typically, such farmers rely upon rain-fed agriculture and use traditional methods of farming. This combination renders them highly vulnerable to climate variability,

particularly erratic rainfall. Unfavorable weather conditions – such as persistent droughts and annual flooding – also result in crop and livestock losses. Droughts are also causing encroachment of the desert southwards, while floods have destroyed forests in low-lying areas, particularly in areas close to the Sudd Wetland and White Nile River.

- **Increased deforestation**

Since gaining independence, immigration and natural population growth in South Sudan have resulted in an increased demand for charcoal and fuel wood, as well as land for agricultural and residential purposes. The rate of deforestation has consequently accelerated. Recent maps on land cover changes indicate a dramatic shift from woodland and forest to cultivated land and bare soil. Deforestation and habitat degradation have decreased the ability of woodland and forest ecosystems to provide important goods (such as non-timber forest products) and services (such as water provision) to rural communities. This increases the vulnerability of rural communities to climate variability, as the goods and service provided by these ecosystems buffer communities against the crop failures associated with erratic rainfall, floods and droughts. Deforestation is also having a negative impact on biodiversity and wildlife conservation in South Sudan.

- **Increased soil erosion**

As a result of deforestation, overgrazing and bush fires, soil erosion in South Sudan is increasingly becoming a problem. Consequently rivers, lakes, dams and irrigation canals are silting up, reducing the supply of water for drinking and irrigation. Soil quality is also declining, which negatively affects agricultural productivity.

- **Reduced water quantity and quality**

Within the last two decades, a number of previously perennial rivers along the border with the Central African Republic have become seasonal. This has had significant ecological impacts, as well as adverse effects on livelihoods within South Sudan. The decreased water flow and associated siltation of rivers is causing congestion of irrigation channels and drops in the water table. Swamp areas are therefore decreasing and trees are dying due to a lack of water. There has also been a change in the water quality, which has had adverse impacts on fisheries. Water quality is being adversely affected by the increasing concentration of people in urban areas and the application of chemicals and toxic products, including fertilizers and pesticides, and increasing sewage and industrial effluents. Pollution from the oil industry is also a serious risk to wetlands, particularly in the Unity and Upper Nile states.

- **Limited technical capacity to understand and predict climate change**

The prolonged period of civil war in South Sudan caused, inter alia: i) insufficient investment in education, particularly at the tertiary level; and ii) skilled professionals to leave the country. These factors have contributed to a general lack of technical capacity within the country to understand and predict the effects of climate change. This situation is exacerbated by the limited availability of necessary technologies, such as weather stations and geographic information systems (GIS), to measure and monitor climate variability. The limited technical capacity to predict climate variability and change constrains efforts to reduce the vulnerability of poor communities.

- **Limited institutional capacity to cope with climate Change impacts**

There are several institutional capacity constraints in South Sudan that limit the ability of the government to reduce climate change vulnerability. Firstly, as a new country, many policies and strategies related to environmental management and agriculture are still emerging and do not

explicitly include climate variability and change. Secondly, there are inadequate institutional arrangements at the national, state and county levels for effective coordination, planning and implementation of climate change adaptation interventions. Finally, as a least developed country, South Sudan has limited financial resources available to implement programmes aimed at reducing vulnerability to climate change. These institutional capacity constraints limit the integration of climate change adaptation into national policies and development planning processes in South Sudan. This limits both short- and long-term planning for climate change adaptation (Tiitmamer, N. 2015; Assessment of Policy and Institutional Responses to Climate Change and Environmental Disaster Risks in South Sudan).

In Aweil East County, Northern Bahr el Gazal State, the consequences of climate change are potentially more significant for the poor agro-pastoralists who rely on rain fed agriculture and animal husbandry in an environment with unreliable rainfall. As theorized, vulnerability to the impacts of climate change is generally a function of exposure to climate variables, sensitivity to those variables, and the adaptive capacity of the affected community (Mendelssohn *et al*, 2000). For example, agriculture and forestry activities depend on local weather and climate conditions; change in those conditions could therefore directly impact productivity levels and diminish livelihoods. Farmers and pastoralists in Aweil East have to contend with other extreme natural resource challenges and constraints such as poor soil fertility, pests, crop diseases, and a lack of access to inputs and improved seeds. These challenges are usually aggravated by periods of prolonged droughts and/or floods and are often particularly severe during El Nino events (Mendelssohn *et al.*, 2000; Biggs *et al.*, 2004).

Identified Gaps

There have been attempts made to understand the impacts of climate change and how communities are adjusting their livelihoods strategies to cope with climate change in South Sudan (BRACED, 2017, SUDD special report. March 2015). Studies by Braced project (2017) in Northern Bahr el Gazal reported that high impacts of climate Change are linked to factors such as a high reliance on natural resources, rain-fed agriculture and livestock production, limited ability to adapt financially and institutionally, high poverty rates and a lack of safety nets. However, Eriksen and Linda (2009) on the other hand argued that people's adjustments to multiple shocks and changes, such as conflict, floods and drought are intrinsically political processes that have uneven outcomes. Both studies, (Braced report.2017, SUDD special report. March 2015) concluded that strengthening local adaptive capacity is a critical component of adapting to climate change. Research studies by Hassan and Nhemachenas (2008) reported that attention to determinants of households' vulnerability to climate change and adaptation can contribute to socially and environmentally sustainable responses to extreme climate events in various production systems.

Similarly, literature review of the (South Sudan NAPA Policy Framework 2011) revealed that a number of climate change impact studies have been conducted on specific sectors such as water resources, agriculture, health, and livestock production by using impact models and to a lesser extent socio-economic analyses (Smit and Wandel 2006; Eriksen and O"Brien 2007; Nassef et al. 2009). However, much of the scientific knowledge for climate change impacts on agro-pastoralist fail to provide critical insights on the interaction between the climate variable and human factors at the micro or household level. In addition, there is limited knowledge and awareness of factors that contributes to high vulnerability to climate change impacts among the local agro-pastoralist communities and, furthermore, the rural agro-pastoral communities in the

study area rely heavily on traditional mechanisms to adapt and cope with a changed climate, some of which may not be relevant for today (BRACED 2017).

As a result, this study provides evidence for policy decisions with regards to the impacts of climate change on agro-pastoral households' vulnerability and their possibilities to cope with – and recover from climate shocks as a pre-requisite for enhancing resilience among Agro-pastoral communities in Aweil East. Also, this study sets a stage for an understanding of local strategies used by the Rural Agro-pastoralist communities in Aweil East in coping and adapting to impacts of climate change. This study further contributes to already existing of efforts of the government of South Sudan and its development partners especially the United Nations Development Programme (UNDP) in South Sudan in strengthening the capacity of the local communities to understand actions that influence climate change, and facilitate a community level platform for collective actions towards mitigating impacts and vulnerability to climate change.

CHAPTER THREE
METHODOLOGY

3.0 Introduction

This chapter has six sub-sections. The first three sub-sections briefly provides overview on the scope of the study, it as well discussed how the research approach was designed and how the respondents were selected. The fourth section focused on how the data analysis was conducted. Issues concerning ethical evaluation and consideration are mentioned in the fifth section. The last section discusses the challenges faced during the entire research period and other limitations of the study.

3.1 Content of the study

The study focused on assessing the impact of climate change among rural Agro-pastoralist communities in Aweil East County, Northern Bahr-el Gazal state of South Sudan. It looked into getting perceptions / understanding of the local communities on the patterns of climate change in their areas, the impacts as well understanding their vulnerabilities and the local adaptation strategies adopted by them at household levels. It also examined the capacity of the local authorities in enhancing the resilience of the communities to adopt and mitigate the impacts of climate change.

3.2 Research Design

The study adopted both descriptive and explanatory research designs. As the former allows for description of a given phenomenon, the latter will allow test of relationships. Together with that, an explanatory study enabled the study to formally seek answers to problems by answering the question “why” as opposed to questions such as “what”, “where”, “when” which are answered by a descriptive approach (Yamane, 1967 cited in in Mesfin, 2006) Finally, this combination of designs enabled the study to describe relationship(s) among variables (Singleton and Strants,

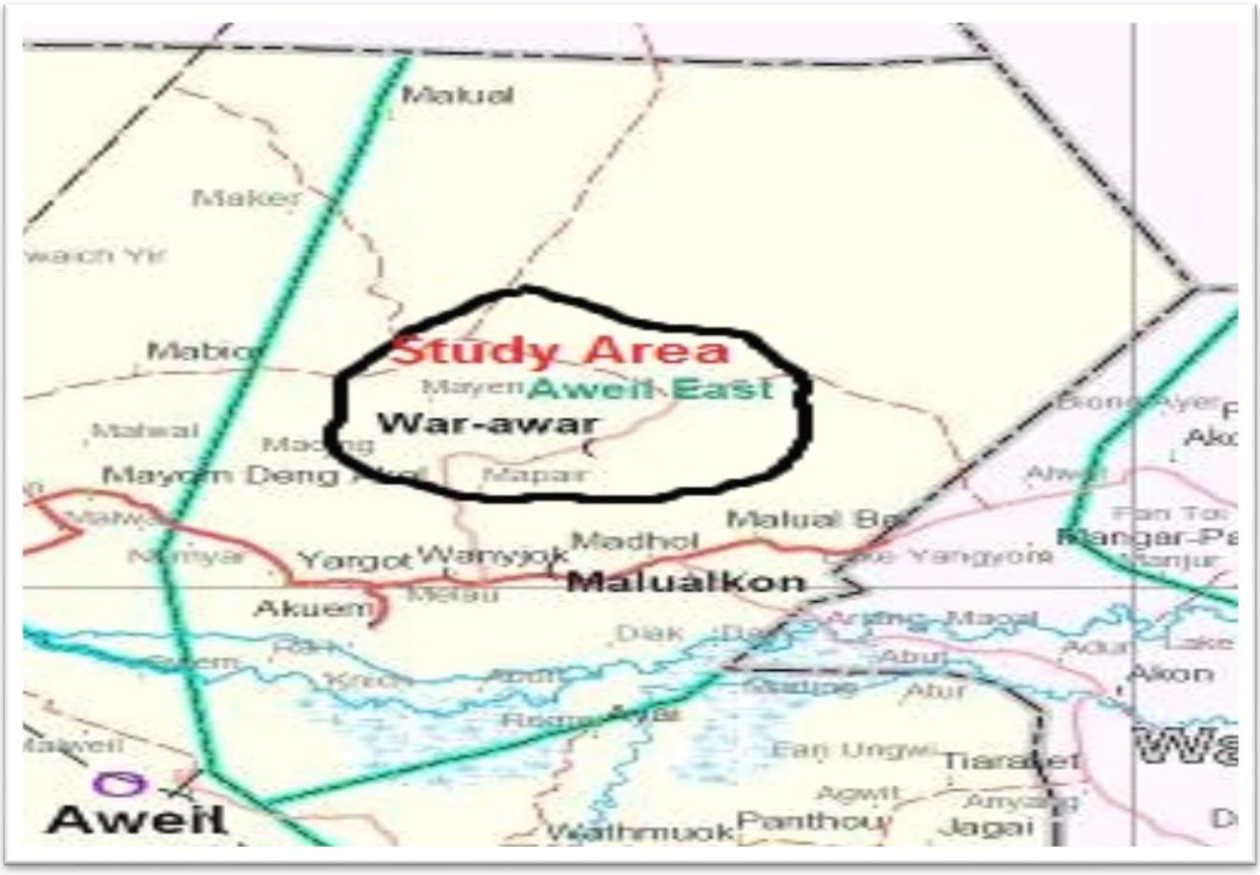
2005; Babbie, 2010). Further, the study incorporated both quantitative and qualitative research by collecting data for both.

3.3 Geographical Scope

The study was administered Aweil East County, Northern Bahr-el Gazal state (Map 1). Administratively, South Sudan has adopted a decentralized system of government with 10 states; Northern Bahr-el Gazal is among the states situated in drought and flood prone area in northern part of the country bordering Sudan. The study area, Aweil East County, borders Gogrial West County to the east, Southern Kordofan to the north-east, Southern Darfur to the north, and Aweil South County to the south. The county consists of the seven administrative payams: Malualbai, Baac, Madhol, Mangartong, Mangok, Yargot and Wunlang running parallel from north to south. The current population of Aweil East County is estimated at 180,948 individuals. The large numbers of the population are Internally Displaced Persons (IDPs) and returnees that has flown into the county from both North Sudan and from within South Sudan as result of the long civil war between the Sudan Population Liberation Movement (SPLM) and the Khartoum Government. Approximately half of the returnee's populations have settled in the areas that were previously depopulated due to the war in the north of the county (highlands), as well as along the railway in the west of the county.

The study area, Yargot as similar to other payams in Aweil East County suffers frequent climate induced disasters such as floods, droughts and disease outbreaks. The study area lies on the western flood plains agro-ecological zone of South Sudan. It has fertile black clay soil in the lowlands and less fertile sandier soil in the highlands. Rivers within the county are merely seasonal and low land areas are usually cut off from the main road for a couple of months due to river flooding or stagnant rain water. During the rainy season (April-September), seasonal

flooding in the low-lying areas (toics) from tributaries of the Nile allow for the predominant production system of agro-pastoralism, as well as small fishing activities.



Map 1: showing the study area (Map Source: Adapted from USAID and USGS. 2011)

3.4 Study Population

Yargot payam is among the seven payams, in Aweil East County whose populations are predominately agro-pastoralists and where they are frequent occurrence of climate change events such as floods, droughts and disease outbreak. The study focused on five bomas and ensured equal representation of the members of the communities, women and men, elderly people as well as the youths. Yargot payam has total population of 29,807 individuals according to latest 2013 publication by the South Sudan National Bureau of Statistics. The researcher ensured that local authorities such as payam administrator, village chiefs and other community leaders are consulted and their participation was enhanced.

3.4.1 Sample size

The sampling unit used for the study was the household of the agro-pastoral communities. Due to time, financial, personnel, and access constraints, the researcher used a 95 percent confidence interval with a level of precision of 0.05 margin of error in order to satisfy the requirements of the research. As such, the researcher used the South Sudan National Bureau of Statistics 2013 dataset for total population of Yargot Payam in Aweil East County. Against these total population figures of 29,807 individuals (4,968 households), A sample size of 370 was pre-determined using scientific formula (Yamane, 1967 cited in Mesfin, 2006); Sample size for participatory data collection was determined by the nature of stakeholders related to the study.

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

$n = 4968/1+4968(0.05)$

$n = 4968/+1+12.42$

$n = 370$

Where n= the required sample size, N= is the total number of households, and e=level of precision

3.5 Sampling Techniques

This study used a multistage sampling technique. First, Aweil East County was purposively sampled based on the geographical location, dominant livelihood activity and proneness to droughts and floods events. Afterward, the dissections within the county was listed and categorized on the basis of their various livelihood zones, land-use systems activities, accessibility and the extent to which they were perceived to be prone to extreme climate events. The study used both probability and non-probability sampling techniques.

3.5.1 Probability Sampling

On the one hand, the defining property of probability sampling according Singleton and Strans, (2005) is that "every possible combination of cases has an equal chance of being included in the sample. Following acquisitions of the village population from local community leaders (Chiefs), simple random sampling was used to identify sample for household survey. The number of the households in the target five bomas where equally divided, and each Boma was allocated 74 samples.

3.5.2 Non-Probability Sampling

On the other hand, purposive sampling was used to determine participants for the in depth key informant interviews, which include the county Relief and Rehabilitation Commission, Payam Administrators, Boma and Village Chiefs. Furthermore, the study also employed and focus group discussions (FGD) with five groups in the five Bomas (one FGD each) comprising of eight (8) participants, which was diversely represented with women, youth, men and the elder members of the community. This non-probability sampling technique allowed the investigator to rely on his/her expert judgment to determine representative units (ibid.).

3.6 Data Collection techniques

A number of tools were used for data collection and these include; self-administered questionnaires, interview guides, observation checklist and document review checklist.

3.6.1 Structured Survey Questionnaire

The researcher used the questionnaire tool for collecting data that was constructed with open ended and close ended questions (appendix I). The researcher used the questionnaire because it collects large amounts of information from a large number of people in a short period of time, and it was relatively cost effective, quick and easily quantifiable by the researcher that enabled

analysis of the data and compared the findings for clarity (Yamane, 1967 cited in Mesfin, 2006). Households were conducted to gather information on socio- economic condition, climatic phenomena, impacts on their livelihoods and their adaptation practices to cope with the negative effect of climate change. A total of 370 households (sample of 4,698 households) from the study area participated in the survey.

3.6.2 Interview Guide

The researcher set questions (appendix ii) that guided the oral interactions between the researcher and the respondents. The tool was good to use since the researcher was in the field himself and asked the respondents in order to get more information that was necessary for the research thus yielding more informative data from the field. The target research participants are heads of the households, mainly agro-pastoral. The interview guide provides a more flexible version of the structured interview as "it allows depth to be achieved by providing the opportunity on the part of the interviewer to probe and expand the interviewee's responses" (Rubin and Rubin, 2005: 88). The researcher used a basic checklist (see Berg, 2007) that helped in covering all relevant areas (i.e. research questions). The advantage of such a checklist, as Berg considers, is that it "allows for in-depth probing while permitting the interviewer to keep the interview within the parameters traced out by the aim of the study" (ibid,p. 39)..

3.6.3 Observation Checklist

The researcher used an observation checklist (appendix iii) or list of things that an observer used for observing subjects of study. This list was prepared by the researcher and was integrated with other data collection techniques such as focus group discussions, and household survey. This observation checklist was used by both the researcher and the research assistants who were physical in the field, including relevant photos for the research purpose were taken. Using this

approach the researcher systematically observed the state of the ecological system pertaining to the grazing lands, crops and water sources amongst other things. Photographs were taken as part of the observation process.

3.6.4 Focus Group Discussion

Five (5) focused group discussions comprising eight (8) participants in mixed gender and age groups were done in the study area. These Focus Group Discussions clarified the subjective issues and benefited the group interactions in getting further insight on the impacts of climate change, household's vulnerability level and available local adaptation strategies among the rural agro-pastoralist communities in the study area. These focus group discussions were held in the six villages, in which different categories of the community members were involved, where women, men, youth and elderly were consulted and their views were captured.

In addition, a total of three of key informant interviews were conducted with specific members of the government bodies such as county commissioners, payam administrators, local chiefs, village elders, County Relief and Rehabilitation Commission and local community committees. A check-list of questions was used to guide and narrow the discussions to relevant issues around the main research questions. These individual interviews took an in-depth approach in which the respondents freely discussed the impacts of climate change on their community, households / individuals vulnerability level and what local adaptation strategies. This was in order to solicit more information and knowledge on climatic change impacts and adaptation strategies in Aweil East County.

3.6.5 Review of Documents

Secondary data that are of very relevance to this study were obtained for a basic understanding about climate change, impacts as well local adaptation strategies of the local communities and government institutional capacities to mitigate the impacts of climate change and enhance resiliency in Aweil East County. In this study, relevant documents were collected from both the governmental and non-governmental sectors. As Bryman (2012) argues, documents reveal something about an underlying social reality, so that the documents that an organization generates (such as assessment reports, UN humanitarian bulletin) were viewed as representations of the reality of that organization. Moreover, secondary sources describe past phenomena based on primary sources. The data obtained from secondary sources was used by organizing and linking it to the primary sources. Working exclusively with secondary sources was not advisable as the researcher may merely repeat the mistakes contained in those sources and fail to provide a new, independent perspective on past events (Rubin and Babbie, 2010).

3.7 Questionnaire pre-testing

A pilot test-run was conducted with local enumerators prior to the main survey, and the final questions were amended accordingly. The pre-test questionnaire was used on 32 households around Aweil east. The questionnaires used for pre-test were excluded from the final data entry and analysis. The piloting was done to check the suitability of the tools and also whether the field assistants could pose the question without difficulty.

3.8 Data Analysis

Analysis of data combined both qualitative and quantitative approaches. General, descriptive model was used to ascertain various aspects of household characteristics, production systems, income sources, impacts of climate change and adaptation strategies at household level. The Quantitative data analysis was done using SPSS software. In addition to data triangulation from

evidence collated during this study, the findings have been cross-referenced with the relevant literature to search for areas of convergence and divergence.

3.9 Data Presentation

The results obtained are represented in the form of tables, graphs, and charts. The rainfall and temperature data related to South Sudan and the study area obtained from the Global Climate Change portal were analyzed using the Ms-Excel in the form of rainfall and temperature curves. The report was disseminated through meetings with the local authorities, few community members through an organized 3 hours community workshop.

3.10 Logistical and Ethical Considerations

As with any research, it was important to ensure that those providing the information are doing so voluntarily and knowingly. According to Rubin and Babbie (2010), a major tenet of research ethics is that participation must be voluntary. All participants were made aware why they are participating in the study; participants were informed about the purpose of the study, and consent to participate in it. Hence, all interviews were conducted anonymously, and this was made clear to the interviewees. In addition, the researcher made clearly the nature of the study and his neutrality from the start. The researcher also considered that the universal ethical precepts are never broken (Bryman, 2012). According to Kirby et al. (2006), ethical procedures are generally understood as protections for participants, but they are also protections for researchers and others involved in the research. Ethical principles revolve especially around four main areas (Bryman, 2012);

- Whether there is harm to participants
- Whether there is a lack of informed consent
- Whether there is an invasion of privacy
- Whether deception is involved

The researcher ensured that the focus group discussions, the participant observation and the interview techniques were held in a way that could not harm the participant. Besides, confidentiality of the respondents was respected. Moreover, the researcher made contact with the responsible local government organs in order to get the required research permission prior to the research process.

3.11 Study limitations

Due to lack of properly functioning meteorological stations in the study area, it was not be possible to get consistent and quantitative updated climate data regarding the study area. However the information were collected from documentary review such as Global Climate Change Portal information on South Sudan provided basic scientific understanding of the climate change situation in the study areas.

Conclusion

This chapter presented the research design and methodology that was followed to get responses from the field. The chapter showed that a qualitative design was chosen in order to allow for in depth probing of the respondents. The section that dealt with research methodology explained, among the others; the study area; the population; sample size and selection method; data collection method and data analysis.

CHAPTER FOUR

PRESENTATION AND INTERPRETATION OF FINDINGS

4.0 Introduction

This section presents both the quantitative and qualitative research findings. First, the findings from the household survey are presented, which are presented under the headings of perception about climate change, household livelihoods and vulnerability to climate change impacts as well local adaptation strategies. The qualitative findings from the focus group discussions and key informants interviews offered a contextual basis from which to consider the quantitative data and will follow this section.

4.1 Gender distribution of the respondents

For the general household survey, a uniform number of households (74 randomly selected sample sizes) were interviewed across each of the five villages in Yargot Payam of Aweil East County, totaling to 370 pre-defined study samples. As shown below, the ratios of males and females were 64:36 with 237 male respondents (64 percent) and 133 female respondents (36 percent) as shown in Figure 2.

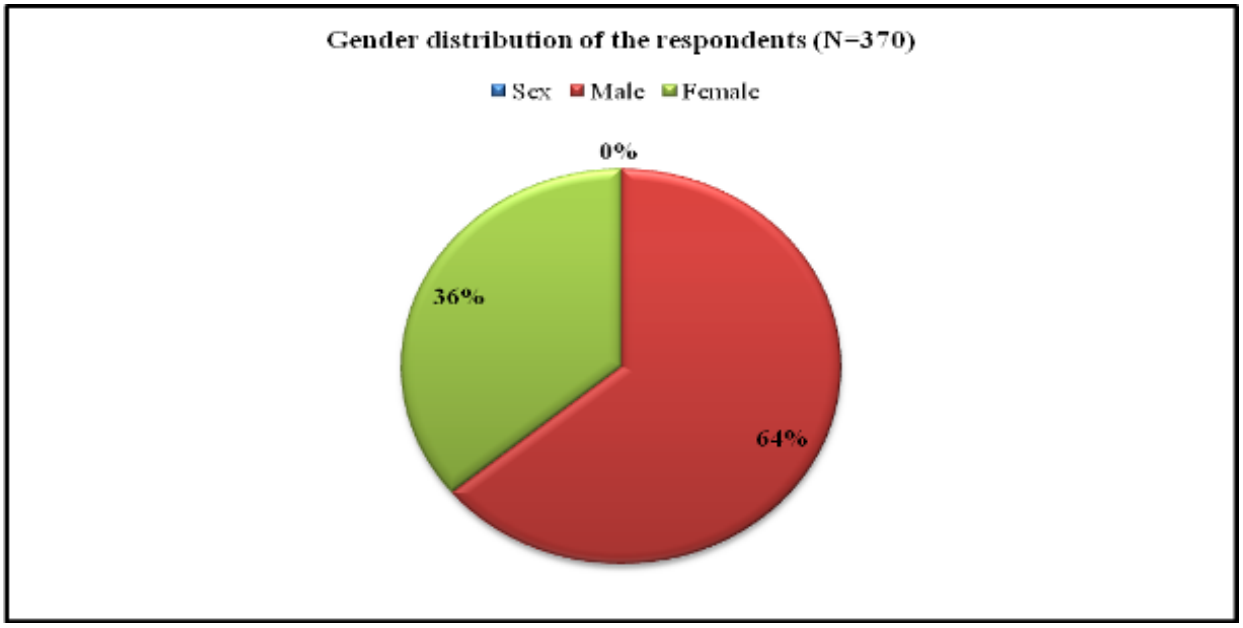


Figure 2: Gender distribution of the Respondents

During the survey, most respondents 30.3percent had an age range of 30-39 years for males and females as shown in Table 1.

Table 1: Age distribution of respondents

Age group	Percent
16-19 years	21.2
20-29 years	25.2
30-39 years	30.3
40-49 years	16.9
50-59 years	4.3
60-69 years	1.3

4.2 Respondents' level of Education

Most respondents stated that they have not attended formal education (43.4 percent) and 40.5 percent stated that they have completed up to a primary education. Meanwhile 15.3 percent has completed either secondary school or post-secondary school education as shown in Table 2.

Table 2: Respondents' level of Literacy

	Percent
Did not attend formal education	43.8
Attended basic primary education	40.8
Attended secondary/post-secondary school education	15.4

As shown in table 3 below, of the interviewed population, (22 percent) of the respondents have stayed in the study area for less than five years (<5 years) as some were in the neighboring Sudan during the long civil war, and (42 percent) have either stayed in the area between (5-10) years meanwhile (36 percent) have stayed longer than ten years in surveyed villages. However according to the key informant interview with the local authorities, there are reportedly decrease in the population figures in the last 4 years (2013-2018). This is due to the major movement of the local population to neighboring countries like Sudan as result of persistent food crisis and declined access to livelihood.

Table 3: How long have you lived in this community?

Years		Percent
Valid	<5 years	22.2
	5-10 years	41.9
	> 10 years	35.9

4.3 Livelihoods of the study population

As shown in Figure 2 below, half of the respondents (51 percent) are agro-pastoral households i.e. practicing both livestock (cattle, goats and sheep) keeping and farming, with another (32 percent) stating that they are only dependent on farming to make living. Meanwhile household only relying on livestock keeping made up a total of (17 percent) of all respondents. Majority of focused group participants practiced livestock keeping and farming, meanwhile other sources of livelihood as stated by the participants in the focused group discussions and key informants interviews including small scale business such as restaurant and tea making especially for women. Youths in the study area also lay bricks for income generation. Meanwhile other categories of the people are government civil servants.

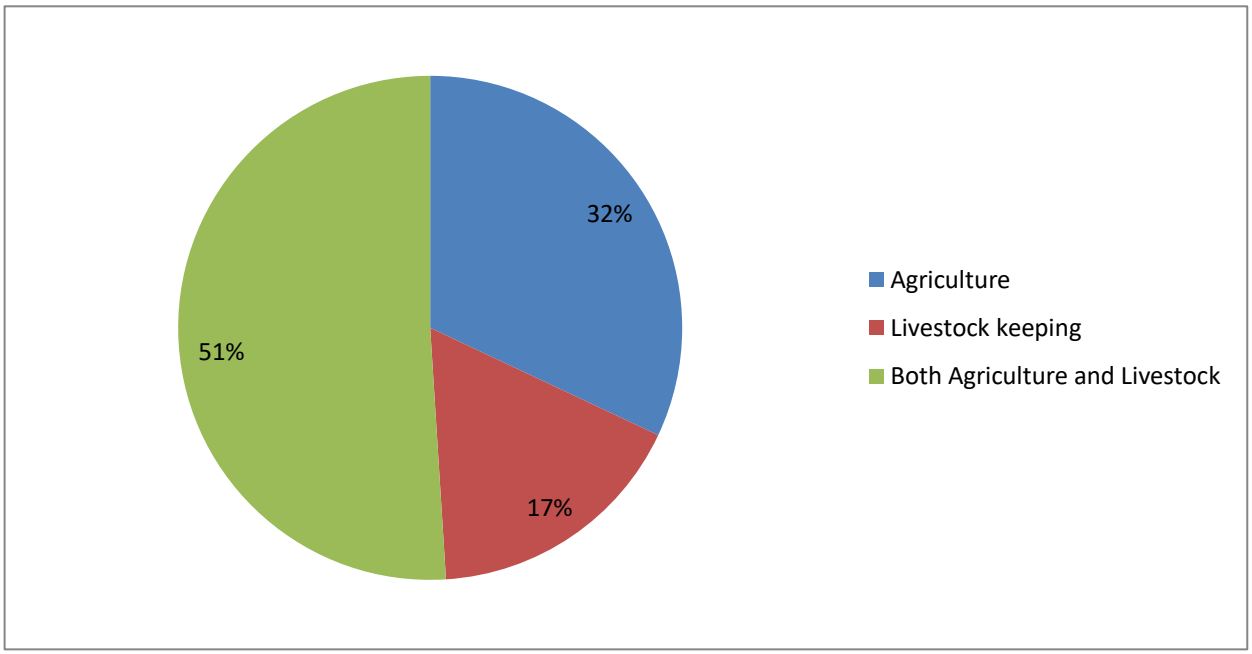


Figure 3: Respondents Main Source of Livelihood (N=370)

Of the respondents who are practicing farming (N=301), 79 percent are practicing subsistence farming only meanwhile 11 percent are both practicing subsistence and cash crop farming such as growing tobacco for sale. Another 10 percent of the respondent practicing either agro-pastoralism are growing cash crop only as an alternative means to raise income from the local market through sale of tobacco, these portion of respondents rely on livestock keeping and mainly uses the income from cash crop farming to purchase food items for consumption from the nearby market.

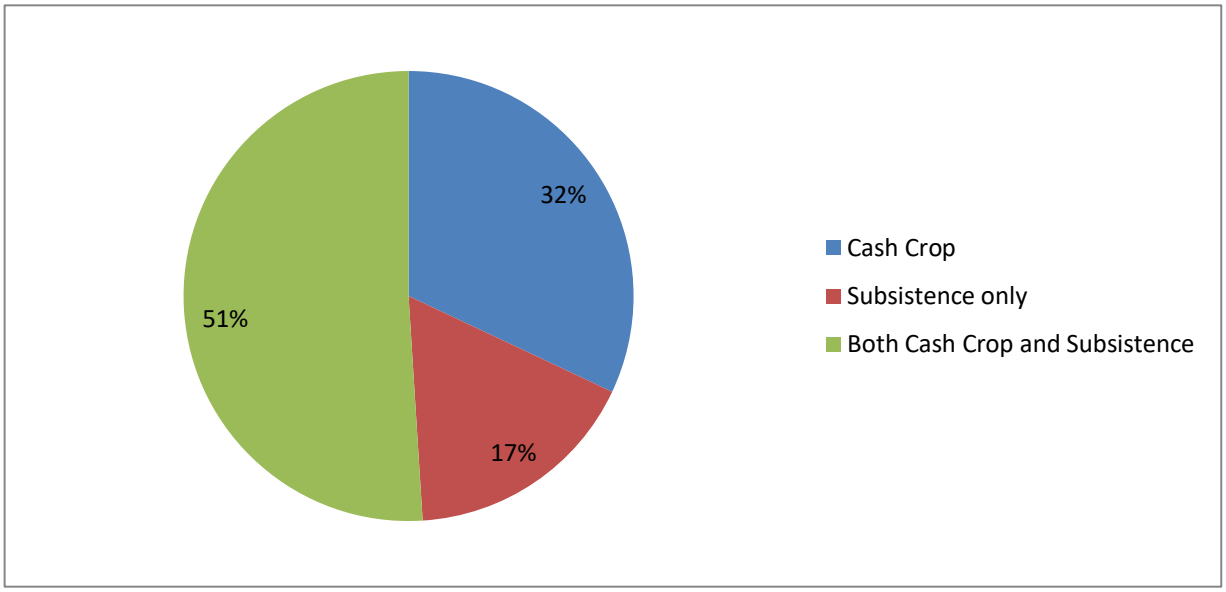


Figure 4: Respondents' Agriculture Practices

4.4 People perception on climatic variables and climatic hazards

Respondents in the five surveyed villages were asked if they had heard about climate change before this study's interviews. The figure 4 below shows the distribution of responses to the question;

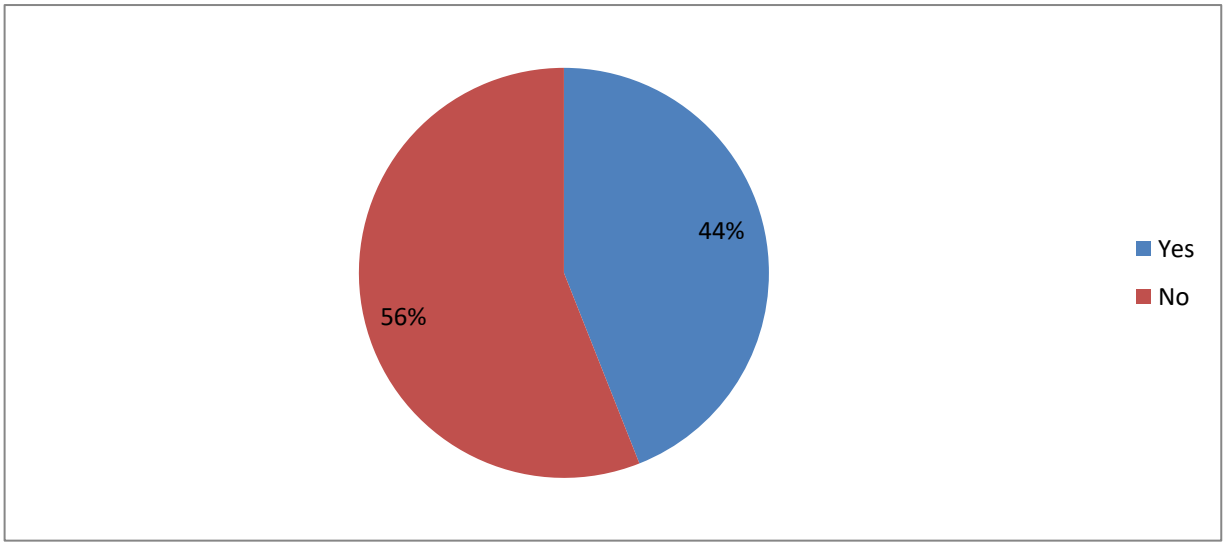


Figure 5: Respondents perception on Climatic Variables and climatic hazards

As seen in figure 4 above, 54 percent of total respondents have heard about climate change though they could not explain what causes it while 46 percent had not heard about climate change. Agro-pastoral households in the study area testified that they have observed several changes in recent years. The community members who did not know the phrase climate change, but the older people (in their 50s and older) interviewed on what was the weather like when they were young and what has changed attested that there is a shift in when the rainy season starts. The rain when it comes, it is interspersed with dry spells. Most crops grown by agro-pastoral, like local varieties of sorghum mature late and are affected by heavy rains and drought. The second question asked concerned whether climate change is happening. Respondents were asked whether they thing the climate is changing as from 2011 to 2018. The table 4 below shows the distribution of responses to the question:

Table 4: Showing respondents' responses on whether Climate is changing in their villages

Do you think the climate is changing compared to last eight years (2010-2018)		Percent
	Yes	69
	No	10
	Don't know	21

Of the interviewed population, 69 percent agree climate change is a reality while 10 percent disagree while 21 percent are unsure. This finding is in line with findings by other researchers including the recent BRACED publications in 2017, which stated that one of the greatest limitations to climate change adaptation is lack of climate change information. However, it is important to quickly note that vast majority believe climate change is happening as they did observe that there were changes in their local climate. As far as respondents are concerned the concept of climate change remains a technical subject.

4.5 Climate Change situation of the study area

This section deals with the analysis of climate data mainly, temperature and rainfall. Review of climatic literature from the Global Climate Change portal sponsored by World Bank was done, specifically looking at climate information relating to South Sudan from 1901-2015. Furthermore, relevant publications on climate change information relating to the study area from 2010-2018 were reviewed, this include the BRACED report, 2017, the South Sudan National Adaptation Programme of Actions policy framework 2011 and SUDD special report of March 2015. In order to complement this secondary information, a survey questionnaire was administered among households to find out their knowledge about local climatic variations during the last eight years (2010-2018).

4.6 Rainfall pattern

A rainfall pattern in the study area is one of the most important determining factor shaping agro-pastoral production systems and livelihoods in the study area. Agro pastoralists interviewed believe that rainfall has highly varied over the years, both temporally and spatially. The study area has experienced a highly variable climate and with shifts in rainfall patterns in terms of quantity and frequency over the past eight years with dire consequences on livelihoods. Respondents in all areas visited reported change in rainfall patterns characterized by decrease in its quantity and frequency. Occurrence of a periodic droughts and seasonal flash floods experienced between July-September annually. Of particular mention are two recent events in 2008 and 2017 whereby droughts and flash floods caused destruction in many of the surveyed villages, causing disruption of livelihoods and extensive loss of property as well as livestock. Besides, in the all surveyed villages/communities, 93% of the household farming is rain-fed Agriculture, this highly exposes their vulnerability to unpredictable rainfall pattern. Figure 5 below illustrates the average monthly rainfall for Northern Bahr el Gazal in 2018 compared with recorded rainfall in 2010 [source: Climate Management Information System (CLiMIS)- South Sudan National Bureau of Statistics and Ministry of Agriculture and Food Security].

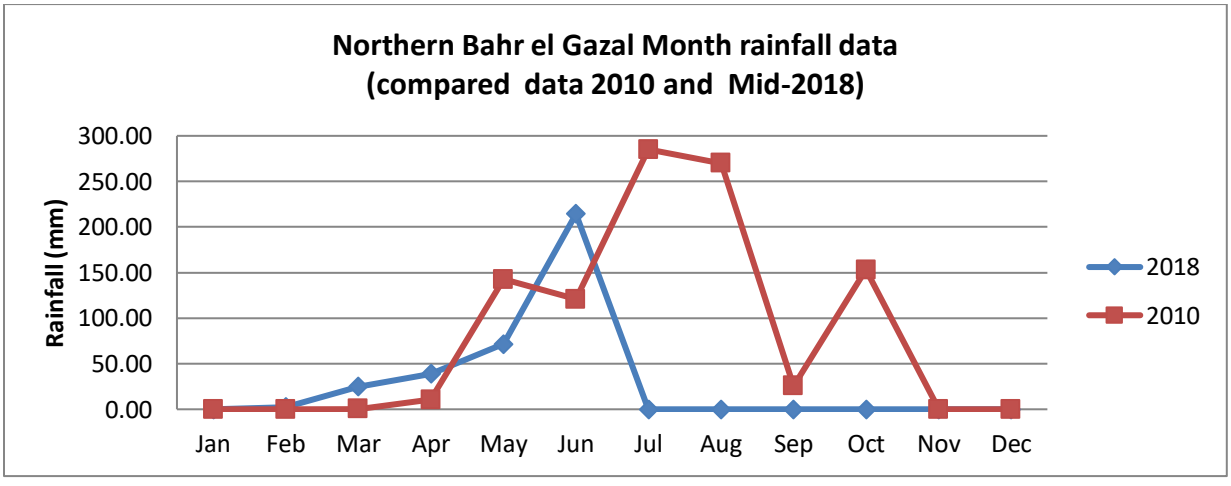


Figure 5: Average monthly rainfall for Northern Bahr el Gazal in 2018 compared with recorded rainfall in 2010.

4.7 Impacts of Climate Change among the Rural Agro-Pastoral Communities in Aweil East

Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change (Chapter 17; Füssel and Klein, 2006). The term 'vulnerability' may therefore refer to the vulnerable system itself, e.g., low-lying islands or coastal cities; the impact to this system, e.g., flooding of coastal cities and agricultural lands or forced migration; or the mechanism causing these impacts, e.g., disintegration of the West Antarctic ice sheet. The respondents were asked to rank the major impacts of climate change on their livelihood and their responses are shown in figure 6 below.

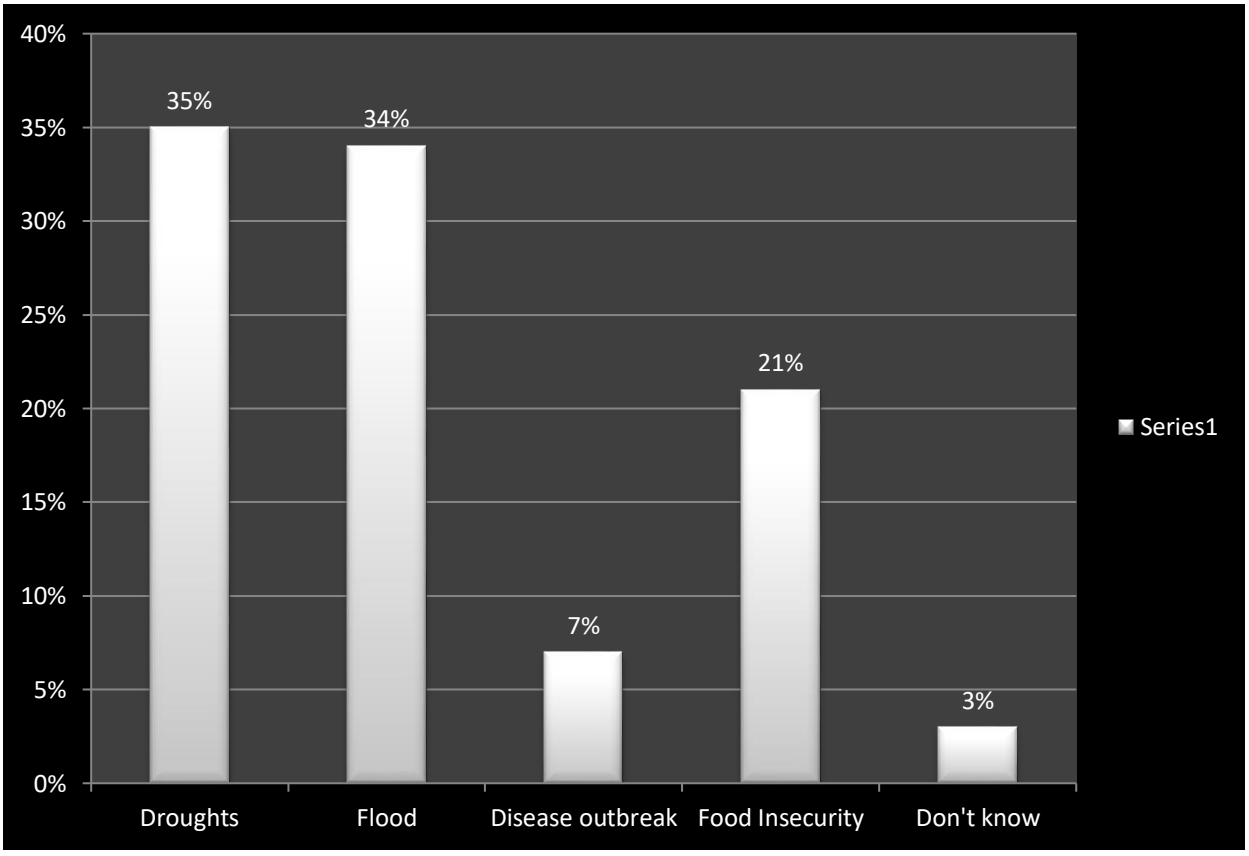


Figure 6: The major impacts of Climate Change on livelihoods of the Agro-pastoralist in Aweil East

4.7.1 Drought impacts

Drought is a recurrent feature of most semi-arid regions of south Sudan, and Aweil East is no exception. Though diversely defined (Wilhite and Glantz, 1985), droughts are all characterized by inadequate amounts of moisture around which systems have stabilized. Agro-pastoral drought is thus due to limited soil moisture which cannot support arable agriculture and/or natural pastures for grazing for livestock coupled with persistent water stress for human and animal consumption. Agro-pastoral communities in the study area, who are heavily dependent on rain-fed agriculture for subsistence, are exposed to droughts at increased frequencies than in the past (BRACED, 2017). The respondents were asked to rank the major impacts of droughts as attributed by climate change on their livelihood and their responses are summarized in Figure 8 below.

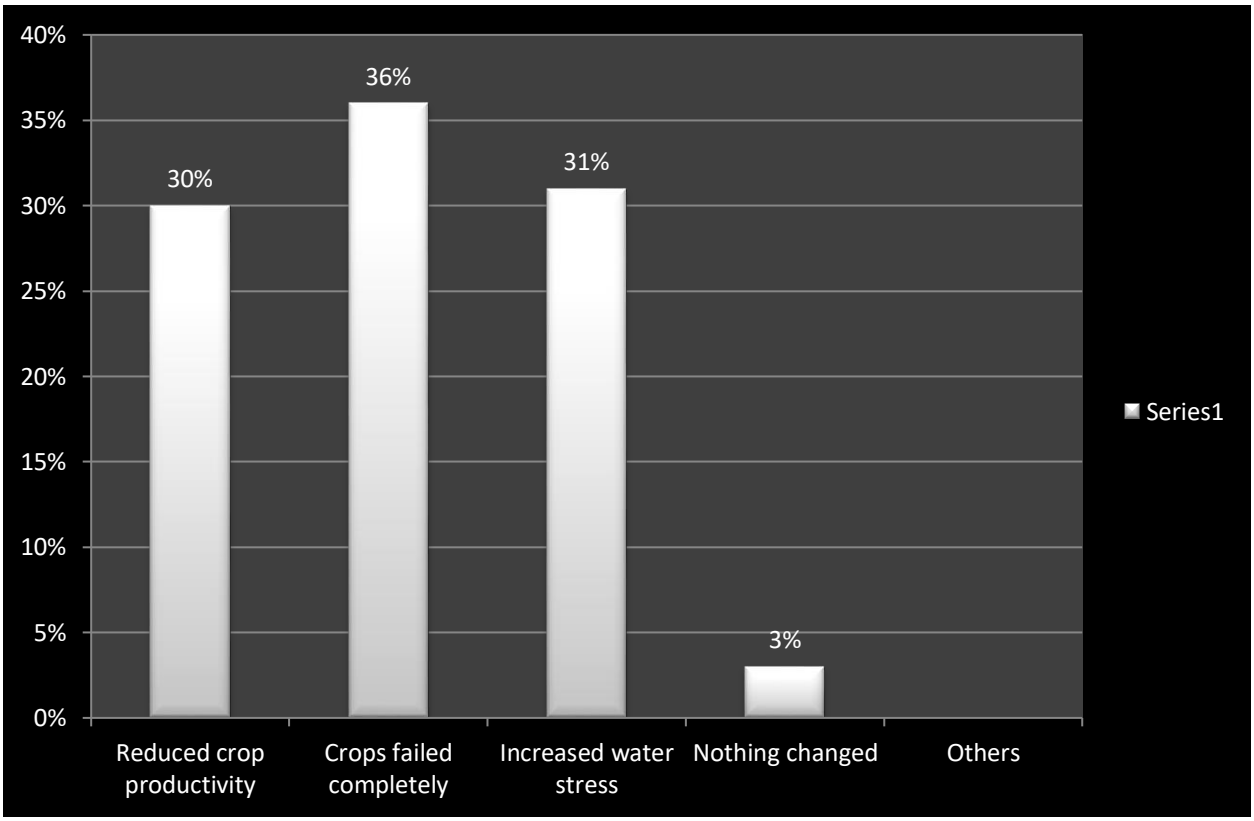


Figure 7: Effect of Droughts on the livelihood of the Agro-pastoralist Community in the last eight years (2010-2017: N=370):

As reflected Figure 7 above, 31 percent of the respondents reported climate change impacts resulted to reduced crop production due to limited or no rainfall. Also 40 percent of the respondent reported complete crop failure due to limited rainfall. Furthermore, it was reported that due to drought as attributed to impacts of climate change, there has been an increased water stress in some of the surveyed villages with about 24 percent of respondents testified, implying insufficient access to water for domestic usages. In relation, respondents were asked to relate the impact of climate change on the soil structures; the figure shows the distribution of responses to the question.

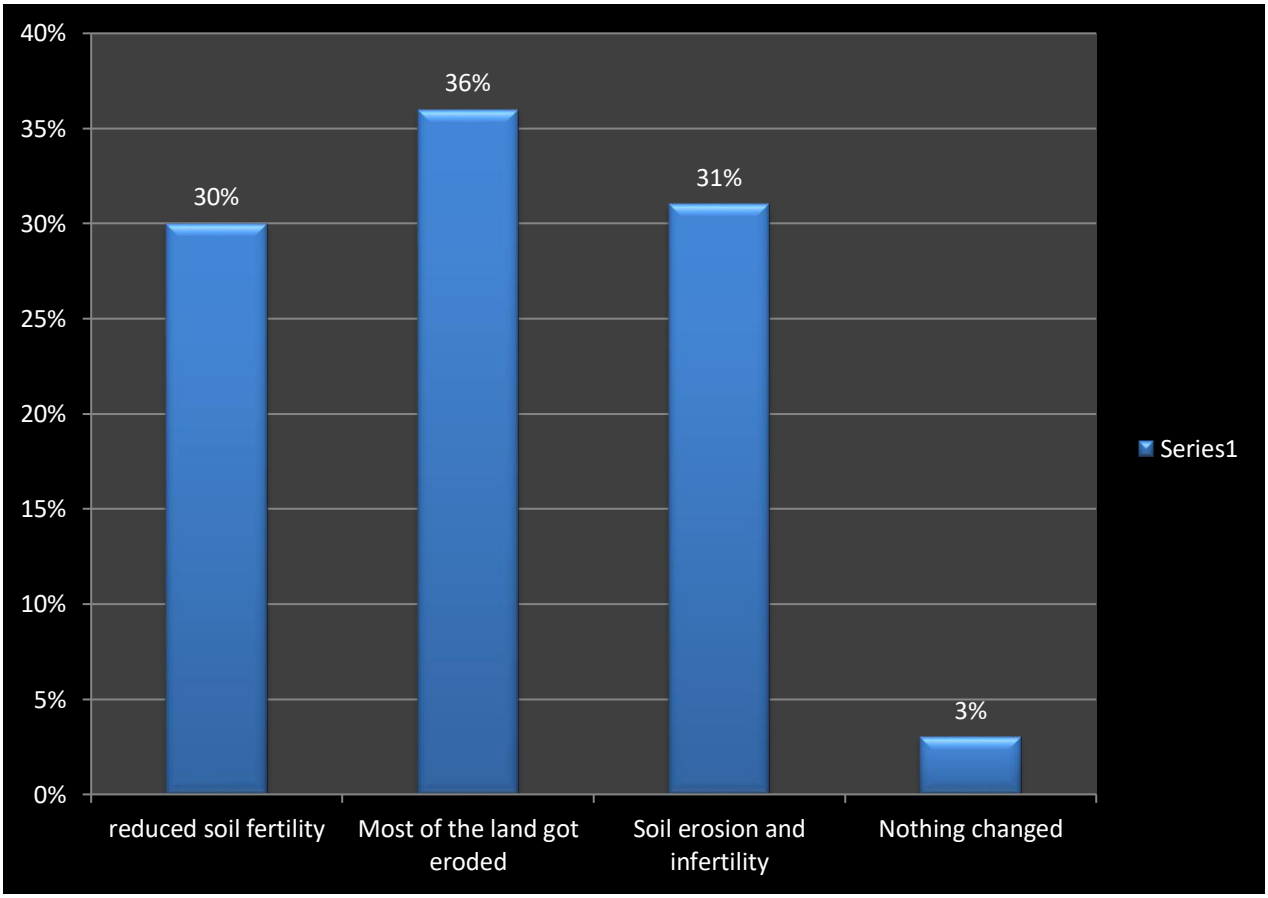


Figure 8: Effects of droughts on the soil or landscape of Aweil East in the last eight years (2010-2017: N=370

As shown in Figure 8 above, about 30 percent of the respondents reportedly stated due to effects of droughts, most of the soil has reduced fertility while 36 percent of the respondents agreed that climate change effects such as floods and droughts has also resulted to soil erosion, meanwhile 31 percent of the respondents agreed to combination of both loss in soil fertility and continued soil erosion as consequences of floods and droughts triggered by climate change. Respondents use soil infertility indicators such as the soil allows water sits for a long time, evaporates more than drains, always very wet ground, some areas are seen with large gullies over 2 inches deep joined to others, thin or color of soil. This is illustrated in the plate 1 below;

Plate 1: Showing the effects of drought on the landscape in Mangok Village of Aweil East

4.7.2 Effects of drought on Rural Agriculture in Aweil East County

Rural livelihoods in South Sudan, as in most other Sub-Saharan countries, mostly revolve around farming and pastoral activities. Similarly, farming in Aweil East is as well largely dependent on rainfall patterns and any negative changes in the rainfall patterns negatively impact on crop production. The reduction of precipitation resulted in inadequate soil moisture for crops leading to wilting as shown in overlay 2 below. As previously mentioned 36 percent of the respondents noted that unpredictable rainfall patterns have led to some villagers not planting at all in some seasons because they would have waited for the right rains until it was too late to plant.

Plate 2: Showing the effects droughts on crop production in Mangok Village in Aweil East- July 2017 (Source: Field Data)

In addition, participants of focused group discussion also mentioned that in order to adapt to frequent droughts, they use traditional methods to store and preserve seeds for planting in the next season. However, during severe drought that is followed by a famine, people run out of seeds to use for planting as these seeds are being consumed.

4.8 Impacts of floods on livelihoods of the Agro-pastoralists Community

With a detailed analysis of historic flood data from the ministry of humanitarian affairs documentation on flood hazard risk mapping and analysis, and the assessment of long-term weather patterns and climate change literature, the research specifically targeted to understand how individual agro-pastoral households and communities experience flooding and its impacts, and what people do as households and as communities to mitigate the effects. 55 percent of the respondents in the surveyed areas attested that the rain starts later than it did in the last eight years ago. The late arrivals of rains are reportedly harder and more damaging than they used to be. Respondents spoke frequently of "rain floods," (flash floods) which have occurred frequently and have a major impact on crops. This finding is further supported by literature review of the recent BRACED (2017) publication related to the study region which stated that crop damage and destruction is the most critical negative impact of flooding in most parts of Northern Bahr-el Gazal. In addition, respondents also reported that Flooding mainly occurs between July and September, when heavy rains fall leading to the flashy flooding. During the flooding season, many of the surveyed villages are left under water, leading to extensive damage to water infrastructures, house structures, destruction of crops and displacement of families. Crop damage and destruction is the most critical negative impact of flooding as ranked higher by 55 percent of the respondents. This is followed by shelter damage and destruction, and disruptions of social amenities including road accessibility, access to healthcare and education facilities as illustrated in Figure 9 below;

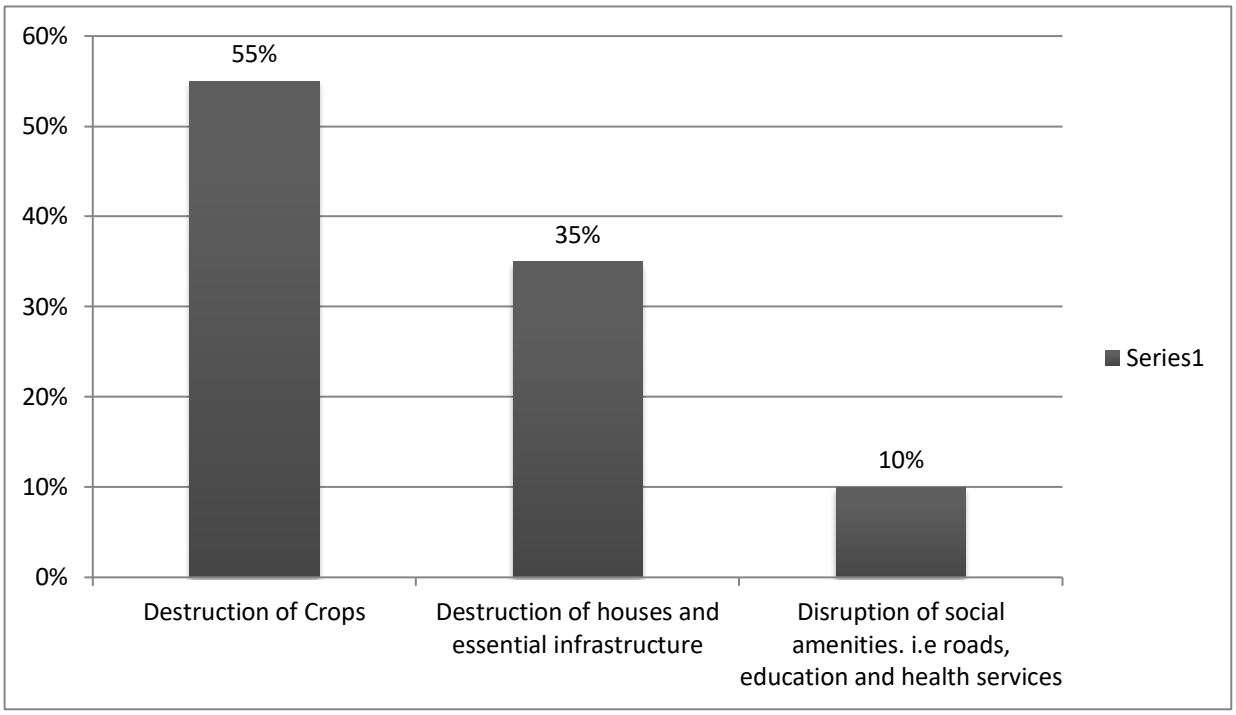


Figure 9: The impacts of floods on the households in study area (rank the highest impact: N=370)

As shown in figure 9 above, crop damage and destruction are undoubtedly the most important impacts of flooding to the assessed population resulting to persistent hunger, causing illness, disruption to education and employment, and starvation as reported by the respondent. This finding is validated by the literature review of Integrated Food Security Phase Classification Projections for South Sudan (February–April 2018; May–July 2018), which indicated acute food insecurity has reached to extreme Critical levels (IPC Phase 5) due to livelihood limitations eroded by climatic shocks, such as prolonged dry spells and flooding, and pest infestations (e.g. Fall Armyworm). In addition, members in the assessed households also mentioned that they had been affected by water source pollution, livelihood changes, and the damage and destruction of latrine infrastructure. In addition, it was reported by one of the participants in the focused group discussions that during flood events, Women and Children are displaced and their living conditions deteriorates due to poor shelter infrastructure.

Plate 3: Showing flooding in one of the surveyed village Akeum in June 2018 (Source: Field Data)

4.8.1 Impacts of floods on housing

As seen in the overlay 4 below, floods in the study are very destructive to houses and these damages are more visible and prominent. According to the household interview findings, 78 percent of the respondent mentioned that the extent of damage to the houses depends on the roofing and wall structures. It was observed that unlike roofs with sheets, straw roofs exhibited water leakage after continuous rain. Further, mud walls that soak water were reported to collapse easily. The respondents mentioned that the sustainability of water protection capability is very low for this mad-made house. Therefore, during the monsoon period continuous rain water makes the house wall softer and loos. The thatched houses are severely damaged after flooding whereas houses with cemented pillar, brick wall and concrete houses are partially damaged from the flood.

Plate 4: Showing flooded village in Yargot payam-June 2018 (Source: Field Data)

4.8.2 Impacts of floods on livestock

Of the interviewed respondents, 56 percent stated that flood also caused losses of the livestock like goat/sheep, chicken and cow/oxen. As stated by 89 percent of the respondents, animal husbandry is their first largest livelihood followed by agriculture, however some of the livestock are swept away by flood and others dies during flooding from unidentified diseases. 45 percent of the respondents also mentioned that, during flooding, there is limited pasture for their animals and therefore most these animals die from inadequate access to green pasture.

4.8.3 Impacts of flood on road and transport

Of the interviewed households, 61 percent reported that the road situation during monsoon is very poor due to continuous flooding, erosion and sedimentation. FGD participants also mentioned that almost in every year, during the monsoon period, heavy rainfall enhances a massive damage in all local roads and drainage system in the study area. Therefore, the rain

water could not flow from the locality to the outside. From the individual household interview it was found out that during the flood period all of the roads were overflow by the flood water. Boat was the only vehicle to maintain social communication as well as to go to any place from house.

4.8.4 Impacts of flood on health

In the study area, 72 percent of respondents mentioned that during the flood period, health facilities were most commonly affected. Most of these health centers are affected as flood water go inside those centers. During this period, different water- borne diseases like diarrhea, cholera, jaundice and skin related health problems are most commonly seen. Especially, children and aged people are most commonly suffered from these types of health related problems. Respondents of the focused group discussion as mentioned that during floods, primary treatment sometime are not possible due to lack of accessibility of basic health facilities. They also complained that the flood water is entire all over the area and the water is contaminated by different bacteria and poisonous substances, so that by the contact of this water could be harmful for human health but they are bound to use this water in different daily activities because of the lacking of safe water.

4.9 Adaptation Strategies

Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. The IPCC (2007) defines adaptation as adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. The climate change impacts discussed above paint a fairly negative outlook on the livelihoods of agro-pastoral communities. Current and projected impacts of climate change are as pointed out include increase risks of floods and droughts, exacerbated risks of pests, disease

outbreaks, displacement and destruction of houses due to floods as well as inter-communal conflicts around natural resource access and control (BRACED 2017). These impacts can be lessened through strengthened agro-pastoral resilience through adoption of viable adaptation strategies and risk management measures, which could eventually enable them to overcome the current and projected impacts of the climate change. During the study, the adaptation strategies were discussed under crop and livestock adaptation strategies, water stress adaptation strategies and human settlement and re-settlement adaptation strategies.

4.9.1 Flood adaptation strategies

Respondents in the five surveyed bomas were asked what measures they put in place in order to respond to effects of flood that include before occurrence, during flooding and post-flood. This is illustrated in figure 13 below;

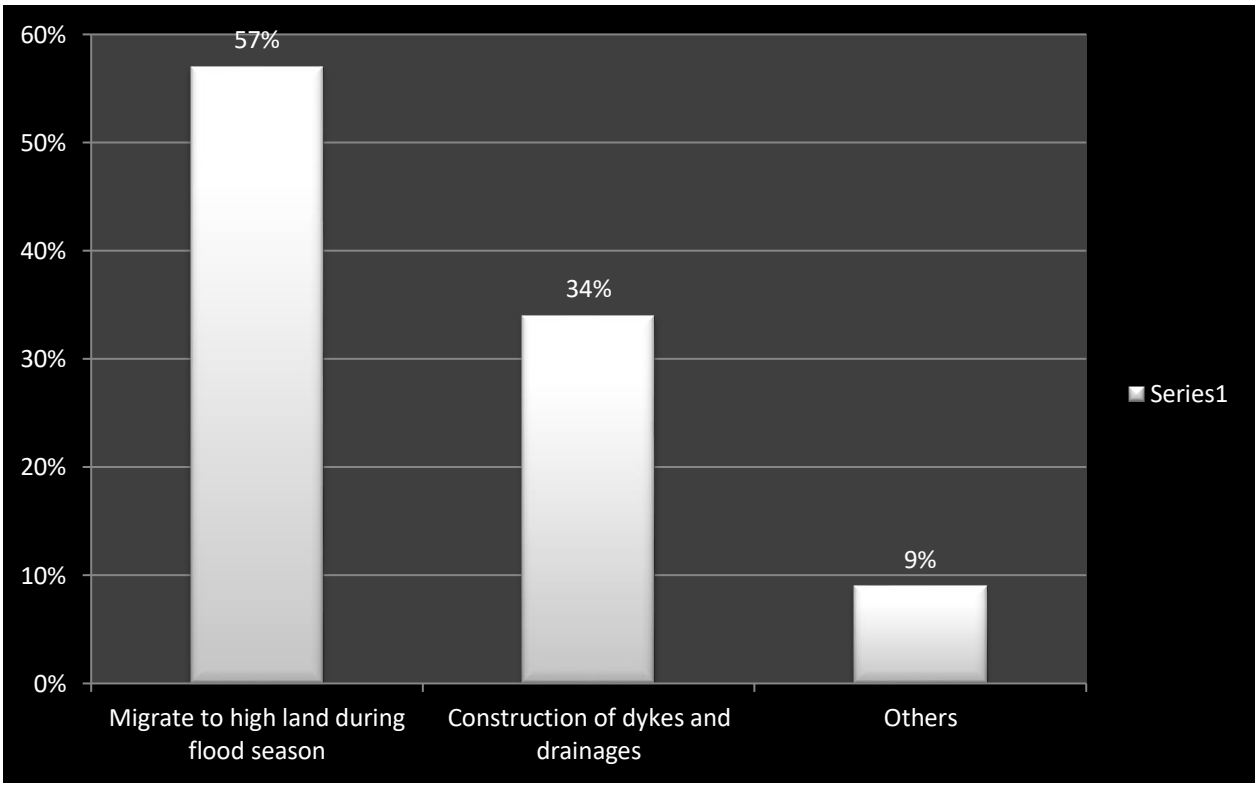


Figure 10: Measures put in place to respond to effects of floods in Study Area (N=370)

As reflected in Figure 13 above. 57 percent of respondents said they migrate to high land especially during flood periods. Meanwhile 34 percent generally reported that they constructs dyke structures in order to control the flow of water, and another 9 percent reported using other strategies such as digging ditches and drainages to control the effects of floods on crops. Majority (79 percent) of the participants of the Focused Group Discussion (FGD) mentioned that in order to mitigate effect of flood on houses, they ensure that the level of floor local houses is raised. Despite the measures in place, most respondents (84 percent) reported that these dykes do not successfully control the floods, the reason behind this being lack of tools and strength to build big dykes, and because the floods are more intense than in the past. In addition, findings from Focused Group Discussion demonstrate that in the study area, women and children are more vulnerable to reported climate shocks; this extremely related their level of exposure. In addition during flood events, the wood women collect (or have collected) to cook gets wet and unsuitable for cooking. Women are forced to walk long distances and spend a lot of energy to go to dry areas to source and collect firewood, which they carry on their heads with children tied on their backs.

4.9.2 Drought adaptation strategies

Respondents in the five surveyed bomas were asked about the measures they put in place in order to respond to effects of droughts. As shown in figure 14 below, majority (74 percent) of the respondents have no coping mechanism to droughts rather than relying on humanitarian aid and support from families living in the urban areas or abroad. While (22 percent) of the respondents resorted to resort to irrigation of vegetables crops, especially putting up vegetable gardens near water sources such as boreholes. Meanwhile, (4 percent) of the respondents have alternative coping mechanisms that include migrating to urban areas in search of alternative livelihoods.

Key informants and focused group discussions participants also reported that migration is one of the most common coping strategies practiced by pastoral and agro-pastoral communities during the period of feed and water caused by shortages limited rainfall. When such resources are critical, agro-pastoralists in the study areas migrate with their livestock, particularly cattle towards parts of Western Bahr el Gazal where there are green pasture and access to water as reported by the respondents.

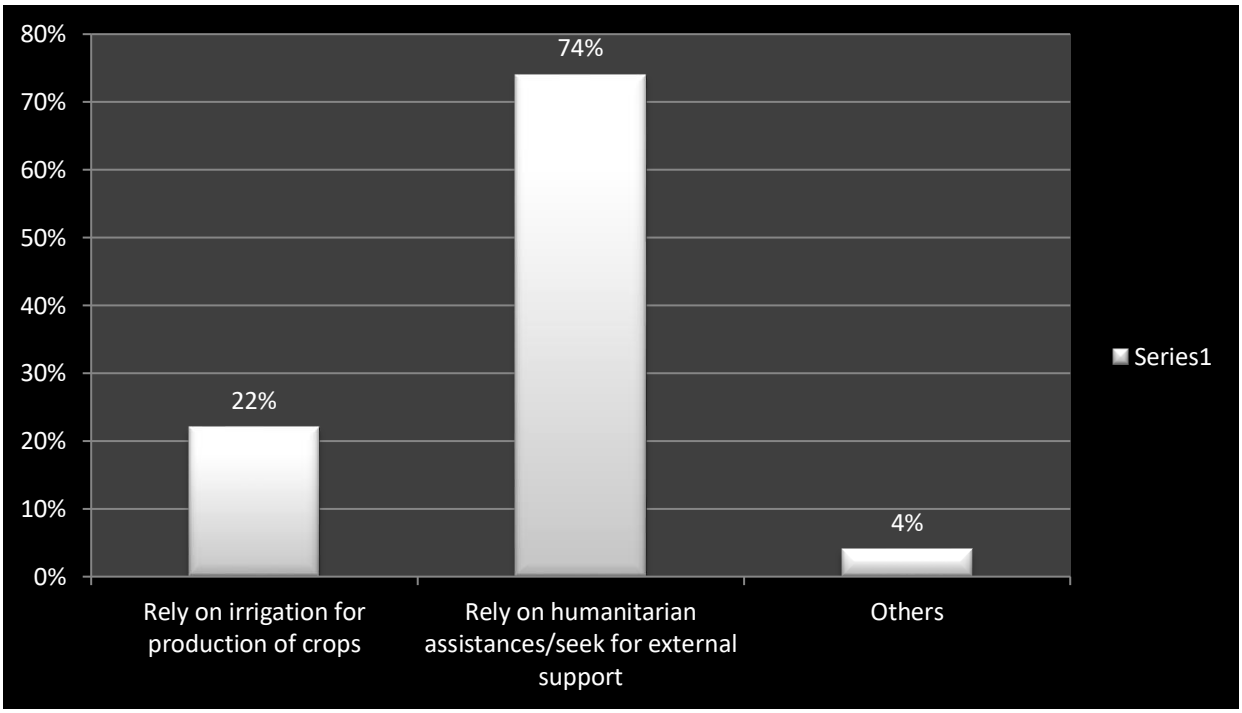


Figure 11: What measures do you have in place to respond to effects of droughts in your village (N=370)

4.9.3 Livelihood adaptation strategies

Overall, (74 percent) of respondents stated that fishing was their alternative source of livelihood especially during times of flooding. This was evident in the surveyed five bomas, given that the arrival of fish provides a major source of food, effectively marking the end of the hunger season. The same respondents (74 percent) reported that they can sell any fish they catch, and that there is demand for even more fish in the urban area, especially the state capital Aweil town. In addition, participants in the focused group discussion stated that, in order to adapt to changing

soil fertility structure, the utilize strategies such as crop rotation, mixed cropping and changing planting fields in order ensure that the soil fertility is promoted. In addition, in the key informants' interview, it was mentioned that in the event of drought or floods, elders negotiate with elders from communities not affected to have access to pastures, water and other means of livelihoods. Some clans control territories on the banks of rivers and streams, which provide better pastures and access to water during the drought. As an adaptation means, a clan would migrate to this territory during the dry season and migrate back to highlands during the rainy season. These practices enable livestock to have access to green pastures and water during the dry season, hence continued milk production. The study also found out that Pastoralist community' burn dry pastures to generate the growth of green pastures

4.9.4 Community level early warning mechanisms/policies of actions to mitigate the impacts of Climate Change

This section aimed to provide answer to the fourth specific objectives of the study, and deals with the analysis of local early warning system/community based climate change risk preparedness mechanisms, the role played by local government structures and responsibility on creating awareness on climate change impacts and adaptation among the local communities. Climate Change impacts and adaptation policies were reviewed from the South Sudan National Adaptation Plan of Action on Climate Change 2011. Survey questionnaires were administered among households to find out their knowledge about local early warning system/community based climate change risk preparedness mechanisms as well their involvement and consultation by the local government in creating awareness on Climate Change impacts, mitigation and adaptation strategies and policy of actions.

4.10 Early Warning System/Climate Change Risk Preparedness

The study investigated the efforts in place on risk management for community resilience to climate change impacts such as floods, droughts and disease outbreaks. We wanted to find out if there are comprehensive systems at community level for climate change risk reduction as well as preparedness and rapid response to natural disasters. Therefore respondents were asked whether they received early warning information. "Do you have any community early warning system in place to respond to natural disasters such as floods, droughts or disease outbreak?"

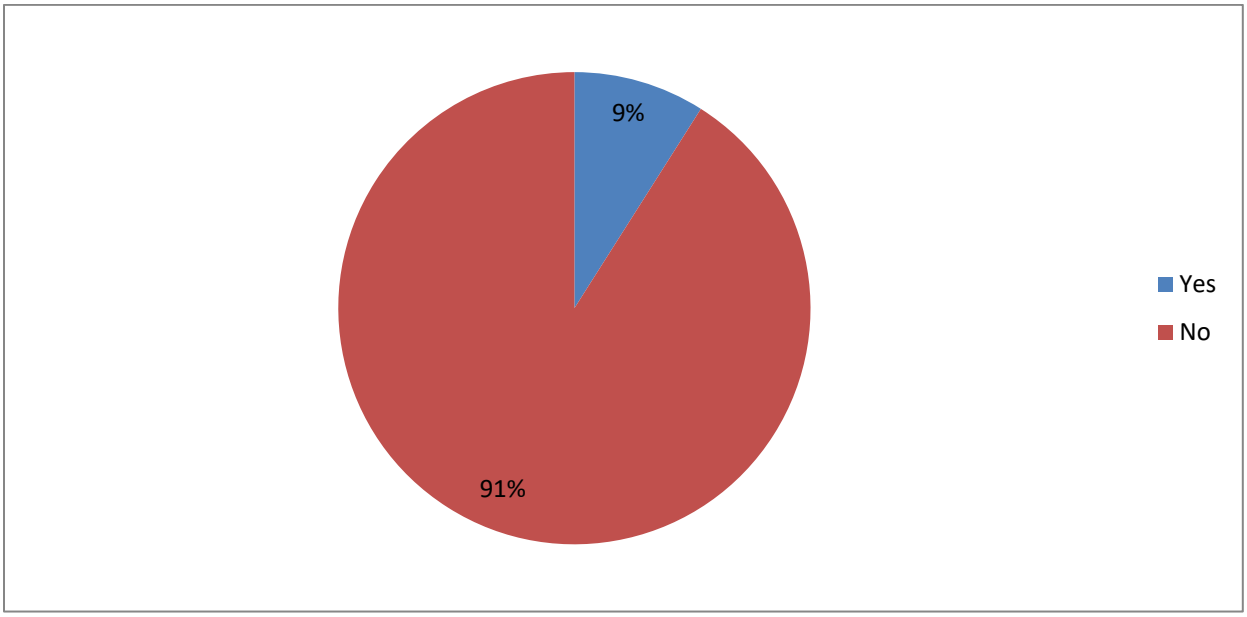


Figure 12: Community early warning system in place to respond to natural disasters such as floods, droughts and disease outbreaks

As shown earlier in figure below, the vast majority of respondents (91 percent) had never received early warning information and was not aware if there is local disaster management plan in their location. Of this vast majority of (91 percent), they mentioned that they simply wait for the disaster to occur without any preparedness. The FGDs respondents argued that most often weather forecasts are wrong therefore people take any warnings unserious. Meanwhile, The 9 percent of respondents use indigenous knowledge to predict disasters and confirmed that they normally get radio as well telephone messages especially about weather predictions.

4.11 Role of local government in disseminating knowledge on climate change

This study section investigated communities' level of understanding to hold government accountable on creating awareness on climate change impacts and adaptation knowledge. The respondents were asked whether the local authority/NGO ever discussed with them the effect of climate change or likely changes in metrological situation. Respondents were expected to choose Yes/No. Table below shows distribution of responses;

Table 5: Respondents reaction to role of local government in dissemination of Climate Change Knowledge

	Percent
Yes	4
No	96
Total	100

As reflected in Table 16 above, it's clearly indicated that majority (96 percent) disagreed with the view that the local government and humanitarian actors are providing awareness on climate change impacts and extending adaptation services locally to the communities. The 4% who agreed that government was doing its role of helping people to adapt as well received basic knowledge on climate change either from Non-Governmental Organizations working in the area. The key informants' interviews however reflected the role of local government especially the county Relief and Rehabilitation Commission in creating awareness to the local communities on climate change knowledge and extending adaptation strategies, though currently, the government has limited capacity to respond. In addition, the findings also indicated that many institutions are creating climate related data; however, they are not coordinating. Thus, key information is not reaching end users especially to the pastoralists and farmers. Literature review of the publication made by the BRACED project (2017) indicated that there are institutions currently generating climate related information in South Sudan and for the East Africa region. These include: the

South Sudan Meteorology Department (SSMD), FEWSNET, the UN system, ICPAC and some NGO's. Each of these organizations has different reasons]why they produce this information. For example, WFP and FAO, integrate weather information into assessments on food security in the country. SSMD produces information that supports the aviation sector daily and a seasonal forecast for various users in the country. Few producers of such information or those that utilize such information have been systematically helping people to integrate climate information into decision- making at the local level.

Also participants of the focused group discussions expressed the significance of the climate information they received, which means if climate information is available – it will change people's behavior. In addition the surveyed community members prefer to receive climate information through the radio and community meetings, which means oral communication is a key channel for delivering climate information services. However, generally there is huge gap in disseminating climate change information to the local population, thus climate change awareness among the agro-pastoral communities remain very low as per the findings, despite that traditional rainmakers are still influential (ethno-meteorology) and Traditional Ecological Knowledge (TEK) is strong and being widely utilized by the local agro-pastoral households/communities.

Conclusion

In conclusion, understanding the impacts and vulnerability to extreme climate events is necessary for a community that entirely depends on climate sensitive livelihood activities. It is also necessary for policy makers to develop mitigation and adaptation programmes for long-term resilience. Vulnerability analyses contribute to the knowledge on climate-sensitive socio-economic or ecological systems, enabling policy to be targeted on the most vulnerable places, sectors or people and adaptation options to be defined. This study focused on the micro-level to

assess the variability of vulnerability across a community, however in the future, studies assessing household-level vulnerability to climate-induced stresses should explore level of vulnerability on individual household basis, and this is because vulnerability varies based on the gender roles as well level of exposure within a household. Women, men and children are differently affected by climate change impacts; this is similar to disability status of a person. Similarly, future resilience interventions should target individual households within a community because major decisions about adaptation to climate induced stresses and livelihood processes are taken at the micro-level.

CHAPTER FIVE

DISCUSSION OF THE FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Agro-pastoralist perceptions about Climate Change

The respondents' perception shows that the inclination of agro-ecology is gearing toward hotter and less humid environment. However, the gradual climate change in the study shows a differential impact depending on the annual agro-ecological situation where the increase in temperature results to decreased amount of precipitations resulting to droughts, which impacts both on crop production, access to water as well pasture for livestock. And as climate change is more likely to obstruct agricultural activities and consequently reduce the societies coping range to the future likely climate changes. The challenge can also be evident from the fact that water became the first most stressor for the majority of the agro-pastoral communities in the study area. This is consistent with (Collier *et al.* 2008) who have shown that climate change increases the heat stress on livestock and plants, decreases land suitable for agriculture and consequently, lowers the yield of production.

5.2 Impacts of Climate Change on the Agro-Rural Pastoralist Community

Fundamentally, this study demonstrated the impact of climate change on the rural Agro-pastoral communities and this is evident with increasing climatic variations both in terms of extreme weather frequency and gradual changes, and consequently aggravating the impact to crop production and livestock rearing as well disease outbreaks. However, there are local coping mechanisms that are used to reduce the climate change impacts such as migrating to high land, constructing dykes or drainages or through livelihood diversification options. There are also institutional coping strategies such as humanitarian aid, safety net, food and water distribution, awareness rising on flood risks and use of technology. With increasing landlessness caused by flood displacement and unemployment, water scarcity, unaffordability and unavailability of

agricultural inputs and other stressors, climate change is more likely to continue to risk the socio-economic activities and exacerbate the vulnerability of the Agro-pastoral communities.

5.3 Impacts of Climate Change Related Hazards (Droughts and Floods)

On the other hand, the increased frequency of heavy rain and unreliable seasonal rainfall, coupled with delay in the onset of rain and prolonged drought and the impact on livelihood observed in Aweil East are also the predominant in most of developing Countries, particularly where agriculture is subsistent and crops are gathered by traditional means, e.g. in Bangladesh (F.A, A. (1988). The land preparation obstruction during prolonged drought or rain delay worsens due to the traditional way of farming, land dry up and increased mortality and weakness of oxen to plow the land. The seed cultivation and germination is also hindered due to the absence of irrigation technology. According to O'Brien et al., (2004) districts with higher irrigation rates are expected to have a higher capacity to adapt to climate challenges and other economic shocks. Similarly, a survey of farmers performed in 11 African countries has shown that the dry farm lands are particularly sensitive to climate change and have less resource to respond, but the irrigated farms have a positive immediate response to warming (Kurukulasuriya and Mendelsohn, 2007). The heavy rain destroys ripened crop was also exacerbated by the inefficiency of traditional methods to save the harvest (Harun-ur-Rashid and Islam, 2007).

Drought was considered by the respondents as one of the most frequent hazards in Aweil East, in addition to other hazards such as flooding, and disease outbreaks. The agro-pastoralist respondents maintained that frequent, prolonged drought events have increased in severity over the past decade or so. This perception validate BRACED report (2017) assertion about drought events in northern Bahr el Gazal, with rainfall being at least 50% to 75% below normal in almost half of the drought-stricken region in South Sudan and horn of Africa. It is argued that due to the

frequency of shocks in the study area, some of the coping capacity used by vulnerable households could well have equal or larger ranges to that of exposure and sensitivity to hazards. As discussed earlier on vulnerability, the interaction of environmental (biophysical) forces determines exposures and sensitivities, and various social, cultural, political and economic forces shape adaptive capacity (Yohe and Tol 2002; Turner *et al.* 2003; Skjeflo 2013).

5.4 Vulnerability to Climate Change among Agro-pastoralist households

Furthermore, Climate change related shocks (flood and drought) affects the lives of men and women, often differently. Women are more likely to be affected by climate change shocks as they depend more heavily on natural resources – water, firewood, etc. However, this study also proves that the occurrence of climate induced hazards such as floods does not only impact negatively but also provides the local agro-pastoral communities with livelihood opportunities, for example during the flood, local communities take advantage of fishing opportunities when fish numbers increase. This study has also shown that limited access to extension services and early warning information, in particular, are among the factors contributing to the vulnerability of the agro-pastoral households in the study area. These findings make a strong case for continuous targeting of pastoralist households in resilience-building interventions in South Sudan.

5.5 Adaptation and Resilience strategies among the rural Agro-pastoralist households

Nevertheless, the investigation of the existing local coping mechanism showed that even the disadvantaged households were found using one or more strategies to enhance their resistance against the effects of droughts and floods. Selling of livestock, migration to highland, raising of beds around house structures, digging of drainages as well raising road beds in special response to floods have been dominant and it is more likely to continue to play significant role to cope

with flood crisis. Though, it is currently challenged by land use change, frequent droughts and floods, mobility is very common practice in East-Africa and Asia (Ahmed *et al.* 2002). Furthermore, the significance of social interconnectedness seen in the study area is also prevalent and provides key social assets for the agro-pastoralists where they are able to widely integrate with each other in the different communities. This study finding is validated by SUDD Institute special report of March 2015.

However, the currently available coping mechanisms are not sufficient, particularly for the rural-agro-pastoral communities who are vulnerable due to different socio-economic status and challenges. Of interest are the traditional adaptation and mitigations mechanisms to respond to effects of climate change such as droughts and floods. In an event of floods, traditional councils of elders mobilize people to build dykes to prevent floods. The dykes are built using traditional tools. This method has been passed down from generation to generation since time immemorial. The dykes are often ineffective because they get overwhelmed by floods, a situation that can be avoided with an improved modern technology such as construction of flood brick that could replace sandbags to defend homes and infrastructure from flooding.

5.6 Conclusions

Understanding the impacts, vulnerability and adaptation to extreme climate events is necessary for scholars as well policy makers to develop mitigation and adaptation programmes for long-term resilience. Vulnerability analyses contribute to the knowledge on climate-sensitive socio-economic or ecological systems, enabling policy to be targeted on the most vulnerable places, sectors or people and adaptation options to be defined. The results of this study from Aweil East that portray social and biophysical vulnerability indices which are useful to local development programming for long-term resilience. However, as a prerequisite for building households‟

resilience to climatic extremes, in-depth understanding is necessary of the adaptive capacity, exposure and sensitivity.

This study focused on the micro-level to assess the impacts, vulnerability and adaptation strategies across different agro-pastoralist households. In the future, studies assessing household-level vulnerability to climate-induced stresses should explore the vulnerability levels at individual levels, as categories of people who are more vulnerable to climate induced hazards. Similarly, future resilience interventions should target individual households within a community because major decisions about adaptation to climate induced stresses and livelihood processes are taken at the micro-level.

5.7 Recommendations

Drawn from the findings, this study makes the following key recommendations;

- The first recommended action is that the government and humanitarian actors operating in the study area should consider to strengthen agro-pastoral resilience to effectively tackle and eventually overcome the impacts of climate change through creating awareness aimed at changing individual attitude towards the use of land resources and ensuring that decisive actions are collectively taken and repeatedly practiced at local levels by the communities themselves. This will help to cultivate communal dialogue around natural resource management at local levels. However a significant amount of time needs to be allocated to understanding this process.

- Secondly, there is a need for the local government authority, humanitarian organization to support establishment of a strong and organized community early warning system, this is crucial for the agro-pastoralists to get information about the upcoming weather shocks and take actions accordingly in order to minimize the disaster as early as possible. This should be

supported by proper weather forecast and quantitative data from meteorological stations. Thus, it is indispensable to strengthen the meteorological station in Aweil East County so as to provide reliable and timely weather information on a daily basis, through investment in climate services, especially in areas.

- Thirdly, there is need for the local government authority through the department of county Relief and Rehabilitation Commission (RRC) to conduct community level climate risk mappings in order to identify hazards, mitigate risks and establish disaster information sharing and improve coping strategies. Form Disaster Management Committees preparing Disaster Preparedness Plans and locally adapted early warning systems for coping with disasters.

- Fifthly, there is need for the government and humanitarian actors on ground to support the local agro-pastoral communities in building communal assets (e.g dykes) that prevent the flood/drought/migration. This can be through interventions such as cash for work/assets, Food for Work/Assets. Such intervention should be inclusive and encourages participation of the local communities for sustainability.

5.8 Consideration for future research

Further research is required to strengthen the basis of decision-making and generate more information to guide programming and enhance understanding on climate change in the arid and semi-arid environments. The future research areas include but not limited to the following; to ascertain the underlying factors influencing the climate of individual vulnerability to climate induced events in the study area as well the relationship between agro-pastoralist activities and climatic factors need to be determined.

REFERENCES

A research conducted by Mendelsohn *et al.* (2000) on analyzing adaptations made in Africa.

Arnell, N. W. (2002). The consequences of carbon dioxide for stabilisation of Climate Change Impact .

Assessment, N. C. (2015). Climate Change Profile: South Sudan.

Bare, M. (2011). The Future of Pastoralism in the Sahel Zone of West Africa: Exploring the Causes and Consequences'. Information, Society and Justice, 163-184.

Bationo, A. a. ((2001)). 'Soil Organic Carbon Management for Sustainable Land Use in Sudano-Sahelian . In N. C. Agroecosystems. West Africa', ,.

Boko, M. N. (2007). Impacts, Adaptation and Vulnerability. Contrbution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge. Africa; in Climate Change.

BRACED. (2017). Flood Impact Assessment Greater Bahr el Ghazal.

C.H.D, M. (2000). Climate change impacts and human settlements in Africa: prospects for adaptation. Environmental Monitoring and Assessment, 193-205.

CCDARE; Strategy and Draft Report, 2008)

CGIAR. ((2008)). CGIAR Alliance of CGIAR Center Best Bets to Boost Crop Yields in Sub-Saharan Africa: Rome, Italy:: Current Products of the Alliance of CGIAR Centers,.

Collier, P., Conway, G. and Venables, T., 2008. Climate Change and Africa. Oxford.

Collins, J. M. 2011. Temperature variability over Africa. Journal of Climate 24: 3649-3666

Conway, D., Allison, E., Felstead, R. and Goulden, M. 2005. Rainfall variability in East Africa: Implications for natural resources management and livelihoods. Philosophical Transactions of the Royal Society: Mathematical, Physical and Engineering Science. 363: 49-54.

Department For International Development, D. f. (2004). Adaptation to climate change: The right information can help the poor to cope. United Kingdom (UK): Global and local environment team, policy divison.

Devereux S, S. M. (2001). Food Security in Sub-Saharan Africa. ITDG . Publishing London.

Edger, W. H. (n.d.). Adaptation to Climate Change in developing world. In D. Studies, Programme Development (pp. 3(3):179-195).

F.A, A. (1988). Developing stable Agroforestry systems, an example of local agroforestry techniques from south western Nigeria-Disscussion paper in Geography 37, Department of Geography and University of Salford United Kingdom Pp.27.

Folke *et al.,* 2010 Mechanism for increasing the resilience of agro-pastoralists to climate change in the horn of Africa.

Frankenberger, T., Langworthy, M., Spangler, T., Nelson, S., Campbell, J., and Njoka, J. 2012. Enhancing Resilience to Food Security Shocks. TANGO International, Tucson.

Frankenberger, T., Langworthy, M., Spangler, T., Nelson, S., Campbell, J., and Njoka, J. 2012. Enhancing Resilience to Food Security Shocks. TANGO International, Tucson.

Gallopıng, G.C. 2006 Linkages between vulnerability, resilience, and adaptive capacity. Global Environmental Change 16: 293–303

Hoffman, T., and Vogel. C. 2008. Climate change impacts on African rangelands. Rangelands 30:12–17.

Hulme, M. et al., 2000. African climate change: 1900-2100. *Climate Research*, 17(2).

Hulme, M., Doherty, R. M., Ngara, T., New, M. G. and Lister, D. 2001. African climate change: 1900–2100. Climate Research 17(2):145–168

I, H. (2008). Livestock genetic diversity and climate change adaptation. Livestock and Global Change Conference proceeding. Tunisia.

Intergovernmental Panel on Climate Change IPCC. 2001. Climate Change 2001: Impacts, Adaptations and Vulnerability. Report of working group II. Synthesis report. Cambridge University Press. Cambridge.

Intergovernmental Panel on Climate Change, I. P. (2007). Climate Change Impacts, Adaptation and Vulnerability-Summary for policymakers. IPCC.

Intergovernmental Panel on Climate Change, I.-g. P. (1998). The regional impacts of climate change: An assessment of vulnerability. Special report of IPCC Working Group.

International Fund for Agricultural Development. (2009). Livestock and Climate Change.

IPPC. 2001a. Climate change 2001, The Scientific Basis. Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

Langill, S. a. (1998). Contribution of Working Group II to the fourth Assessment report of the IPCC.

Lema, M. a. (2009). Impacts of Climate Change, variability and adaptation strategies in semi-arid areas of Tanzania. A case of Manyoni District in Singida Region, Tanzania. Journal of Environmental Sciences and Technology , 3(8): Pp. 206-215.

Macmillian, P. (2007). Fighting Climate Change: Human Solidarity in a Divided World. Human Development Report.

Magadza, C.H.D. 2000. Climate change impacts and human settlements in Africa: prospects for adaptation. Environmental Monitoring and Assessment 61: 193 – 205.

Ministry of Humanitarian Affairs and Disaster Management, (2016-19). National Adaption Programmes of Action (NAPA) to Climate Change policy document. Juba: The Government of South Sudan.

Ministry of Environment, M. o. (2011). National Adaptation Programme of Actions on Climate Change Draft policy paper, South Sudan.

Ministry of Humanitarian Affairs and Disaster Management, G. o. (2016). National Adaptatio Programme of Actions on Climate Change. Juba: MHADM.

N., T. (2015). Assessment of Policy and Institutional Responses to Climate Change and Environmental Disaster Risks in South Sudan.

NET-2011, F. (2011). Famine Early Warning Systems Network-Informing Climate Change Adaptation.

Network, F. E. (2011). Informing Climate Change Adaptation Series, FEWS NET.

Niang, I. R. (2014). Impacts, Vulnerability and Adaptation to Climate Change in Africa.

Nielsen and Reenberg 2010a, 2010b). An analysis of national household survey data in Burkina Faso between 1998 and 2007

O‟Brien, K.L., Eriksen, S., Sygna, L., and Naess, L.O., 2006. Questioning complacency: climate change impacts, vulnerability, and adaptation in Norway. Ambio 35 (2), 50-56.

O'Brien, K., L. Sygna, and J. E. Haugen. 2004. Resilient or vulnerable? A multi-scale assessment of climate impacts and vulnerability in Norway. Climate Change 64:193-225.

P, B. (2008). Climate change vulnerability and adaptation in the livestock sector of Mongolia. Assessments of impacts and adaptations to climate change. International START Secretariat, Washington DC, US.

Paavola, J. 2008. Livelihoods, vulnerability and adaptation to climate change in Morogoro, Tanzania. Environmental Science and Policy 11(7): 642–654. Review of Economic Policy.

Schilling, J., Opiyo, F. and Juergen, S. 2012. Raiding Pastoral Livelihoods: Motives and Effects of Violent Conflict in North-western Kenya. Pastoralism, Policy, Research 2(25): 1-16.

Strategy, C. G., and Draft Report, C. C. (2008). Adapting by Reducing Vulnerability Programme,. Nairobi, Kenya and New York, NY: United Nations Environment Programme and United Nations Development.

Sudan, B. C. (2017). Building Climate Resilience in Fragile Context Assessment. Northern Bahr el Gazal.

Sudan, G. o. (2015). Intended Nationally Determined Contribution. Submission to the UNFCCC. MHADM.

Sudan, M. o.-G. (2011). National Adaptation Programme of Actions on Climate Change.

The Global Assessment Report (GAR 2011)

The SUDD Institute, U. (2007). Sudan-post conflict environmental assessment.

Tiitmamer. (2015). Assessment of Policy and Institutional Responses to Climate Change and Environmental Disaster Risks in South Sudan.

UNDP. (2011). The impacts of Climate Change on Sustainable Development .

United Nations Development Programme (UNDP), M. o. (2011). Environmental Impacts, Risks and Opportunities Assessment.

United Nations Environmental Programme. (2011). The implications of Drier, Hotter and more crowded future. Global Environment Alert.

United States Government Situational report (USGS), U. a. (2011). Climate Trend Analysis of Sudan.

USGS., U. a. (2011). Climate trend analysis of Sudan.

Women, U. (2017). Gender analysis of vulnerability to climate changer. Gender and Climate Change.

World Food Programme., U. N. (2014). Crop and Food Security Assessment Mission in South Sudan.

APPENDIX: I
HOUSEHOLD SURVEY QUESTIONNAIRE

STRUCTURED QUESTIONNAIRE

Informed Consent and Cover Page

Hello. I am Mr. Mbira Alex a student of Nkumba University doing an academic research on the impacts of Climate Change in your location. I would like to ask you some questions related your knowledge on climate change impacts on your household livelihoods and health.

The information you provide will be useful solely for my research and your participation in this study is voluntary. All the information you give will be confidential. The information will be used to prepare my research report, but will not include any specific names. There will be no way to identify that you are the one who gave this information.

If you have any questions about this study, you can ask me. At this time do you have any questions about the study?

Signature of Interviewer: _____

Date: _____

Respondent Agreed to be Interviewed YES / NO

Name of the Interviewer:_____ Village:_____ Date of interview:_____

Sex	Age	Education
1=Male	1=<18 Years	1=Did not attend formal education
2=Female	2=18-35 Years	2=.Primary School
	3=>35 Years	3=Secondary/Tertiary level of education

1 Basic Information:

			Response
1.01	Since when have you been living in this village?	1=<5 Years 2=5-10 years 3=> 10 years	
1.02	Do you own land (land size) and livestock (type/variety)?	1=Yes 2=No	
1.03	How many members are there in your family?	1=1-5 2=6 and above	
1.04	Are you growing cash crop or for self-consumption or both?	1=Cash crop 2=Subsistence 3=Both	
1.05	Is your farming entirely dependent on rain water, surface water or ground water?	1=Rain water only 2=Ground Water, especially irrigation 3=All the above	
1.06	Are you dependant only on agriculture for your income or are you also engaged in any non-farm activities? (What are the sources of your income?)	1=Agriculture 2=Livestock keeping 3=Both 4=Others/_____	

2. Climate change experiences:

			Respondent answer
2.01	Before this interview, had you heard about climate change? *(Interviewer explain in case the terms are unfamiliar)*	1=Yes 2=No 3=don't know	
2.02	What have you ALREADY heard about the possible FUTURE effects of climate change in your area?	1=Flood 2=drought 3=disease outbreak 4= unpredictable seasons 5= conflict 6=I don't know 7=others	
2.03	Have you noticed any rise or fall in the temperature or no change?	1=Yes 2=No 3=I don't know	
2.04	How do you perceive climate change/what do you think about climate change?	1=Climate change is real happening in my village 2=Climate Change is just theoretical and not happening 3= I don't know	
2.05	Do you feel that climate is changing when you compare the last five years to what you experienced 15-20 years ago?	1=Yes, the Climate has changed significantly 2= No, I see the climate the same as previous years 3=I don't know	
2.06	If you feel that climate is changing what are the signs (indicators) you have been observing?	1=Hotter temperature 2=Unreliable rainfall resulting to flashy floods 3=Drier land resulting to drought 4=disease outbreak	

2.07	Have you experienced dry spells more or hot loo winds blowing during the recent years?	1=Yes 2=No 3=I don't know	

3. Effects of climate change on livelihoods and agriculture:

3.01	How did the climate change affect the crops you grow? Current year (2011) Last year (2010) Year before last year (2009)	1=Crop yield has reduced significantly 2= Crop failed completely 3=Nothing changed in productivity 4=I don't know	
3.02	How did it affect the soil and do you see change in the fertility status of the soil?	1=Soil fertility has reduced 2=Most of land got eroded 3=No significant changes 4=I don't know	
3.03	How did it affect the livestock?	1=Livestock productivity has reduced 2=Limited pasture due to drier land 3=Livestock regular attack by diseases 4= All the above 5=I don't know	
3.04	Have you been experiencing increased water stress for irrigation over the last five years?	1=Yes, there is shortage of water 2=No, No water stress 3=I don't know	
3.05	Are the water sources available at surface level in your area or getting dried up year after year or	1=Yes, there are rivers that dried up 2=No 3=I don't know	

	increasing?		
3.06	Have you experienced droughts or floods in the last five years?	1=Limitedly 2=Yes and heavily 3=Not at all	
3.07	Has climate change affected your health or your family (wife and children)?	1=Yes, especially outbreak of diseases 2=Somehow, especially when its hotter 3=No, it does not affect 4=I don't know	
3.08	Have the kinds of pests affecting the crops increased during the last five years?	1=Yes 2=No 3=I don't know	
3.09	Have you found new types of pests on your farm?	1=Yes 2=No 3=I don't know	
3.10	Did you find more weeds growing in the farm?	1=Yes 2=No 3=I don't know	
3.11	Did you migrate in search of work, if so alone or with family? Current year (2011) Last year (2010) Year before last year (2009)	1=Yes 2=No 3=I don't know	

3.12	Was the migration of your family taking place in the last few years a planned one or was it sudden and unplanned due to unexpected loss in agriculture as a result of failure of monsoon?	1=Sudden and unplanned due to failure of crops and lack of green pasture for grassing 2=Planned 3=My family did not migrate	

4. Climate change related hazards:

4.01	Has your village been affected by floods or droughts or heavy rains?	1=Yes, combination of both 2=No 3=I don't know	
4.02	What are the Climate related problems your community has faced?	1=Floods 2=Droughts 3=Disease outbreak 4=Crop failure 5= loss of productivity	
4.03	What are the impacts of any of these on your family?	1=displacement/destruction of houses 2=Hunger/famine 3=Crop failure/loss of livestock	

5. Awareness/Level of understanding of Climate Change:

5.01	Have you been made aware of the effects of Climate Change by the NGO or Local government?	1=Yes 2=Never been informed 3=I don't know	
5.02	Have you been informed of the correct weather patterns or changes taking place in the weather (late or early arrival of rains or heavy rains) in time through radio / television by the Meteorological Department?	1=Yes 2=No	

6. Adaptive measures:

6.01	Have you changed any agricultural practices that you have been following to overcome the effects of climate change?	1=Yes 2=No	
6.02	Have you sold any assets such as livestock, jewelry due to loss of yields and to make both ends meet	1=Yes 2=No	
6.03	Does your community have the capacity to respond to the impacts of floods, droughts or heavy rains?	1=Yes, constructed flood dykes/raised HH level 2=No	
6.04	Have you and other farmers in your villages lost the crops/yields due to heavy floods or droughts or persistent rains?	1=Yes 2=No 3=I don't know	

7. Local Governance:

7.01	Has the local authority (RRC) ever discussed the issues that are affected by climate change and the adoptive measures that are required to counter them as far as the village and the community is concerned?	1=Never discussed climate change issues 2=Yes, but not so often 3=I don't know	
7.02	Have the local village heads discussed with the community on the changing weather events and their impact on agriculture?	1=Yes 2=Never discussed 3=I don't know	

APPENDIX: II

CHECKLIST

FOCUS GROUP DISCUSSIONS AND KEY INFORMANT INTERVEWS

Theme 1: Climate History and Adaptation

Conception

During your lifetime, have you noticed any changes in climate?

What do they understand by 'climate change (Climate Change)', examples or occurrences of climate change they experienced Occurrences of annual flood or storms do you think those are signs of climate change?

Has the frequency of storms, floods, droughts, heavy rains increased over time?

Have you heard stories of any such big natural disasters from your parents?

Are natural disasters or shocks any different now than what you had heard from your earlier generation? If so, how?

Adaptation

How does this change in climate affect you and your community? What kinds of problems do you have to face because of impacts of Climate Change? Is there any benefit or advantage of Climate Change as well? If so, what are those?

What do you do to cope or adapt to the impacts of Climate Change?

Do you think that these coping measures will be effective in future? Or, will they have to be changed?

To adapt to the impacts of Climate Change, do you take separate short-term and long-term measures?

Do you face any obstacle, challenge or constraints when undertaking the adaptive strategies or coping mechanisms to deal with the effects of Climate Change?

What tools, resources, information, interventions are needed to adapt to the impacts of Climate Change or overcome the barriers you mentioned?

Do women have to face more obstacles?

Is it harder for women to have access to resources needed for coping with the impacts of Climate Change or overcoming the obstacles you mentioned? If so, please explain how.

Are the impacts of Climate Change comparatively more for people engaged in a particular profession, livelihood practices or group? If so, how?

<u>Information</u>

Where do you get your information about these changes in climate?

How reliable are these sources of information?

Do you get informed of imminent natural disasters? Who informs you, or where do you get that information from

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