S. Afr. J. Agric. Ext. Ndebele & Zenda
Vol. 51 No. 3, 2023: 135-160
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Climate Change Impact and Adaptation of Agro-Pastoral Farmers in Awerial County, Lakes State of South Sudan

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ABSTRACT

This study examined the impact of climate change and weather-related extremities on the livelihoods of agro-pastoral farmers to identify the climate change adaptation practices adopted by the climate-affected households in Awerial County of South Sudan. A mixed methods approach was utilised. 401 respondents were interviewed using individual questionnaires and focus group discussions. The study's results showed that agro-pastoralists perceive climate change as occurring in the study location, as evidenced by perceived increases in temperature, rainfall variability, and increased frequency of floods and droughts. Climate change also impacts livelihoods, as can be seen from livestock losses, increased food insecurity, loss of inputs, deforestation, and diminished water for livestock and domestic purposes. In the face of climate change, agro-pastoral farmers adapt by planting trees, crop/livestock diversification, mixed farming, soil and water conservation, reduction in livestock numbers, adjustment of planting dates, irrigation, and application of fertilisers. However, adaptation to climate change by agro-pastoral farmers is constrained by limited access to credit, lack of skills/information and access to agriculture inputs/technologies. The extension message includes strengthening local early warning systems, livelihood diversification and promotion of climate-sensitive agricultural practices for agro-pastoralists.

Keywords: Adaptation, Agro-Pastoral Farmers, Awerial County, Climate Change, South Sudan.

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1. INTRODUCTION

Empirical evidence from sub-Saharan Africa (SSA) indicates that climate change will continue to negatively impact agriculture and disproportionately affect poor and marginalised households who depend on agriculture as a major livelihood (Zougmoré *et al*., 2018). An increase in the intensity and frequency of weather extremities and climate variability has raised broader concerns over climate change as they tend to affect human livelihood activities and strategies (Thornton *et al.,* 2014; Godde *et al.,* 2021). Global warming due to greenhouse emissions caused by human-related activities has been cited as the primary cause of climate change (Fauta *et al.,* 2012; Adebisi-Adelani & Akeredolu, 2020). Rain and temperature are the most indispensable hydrological climate variables used to characterise climate change and variability (Marie *et al.*, 2020). The increasingly erratic and unpredictable weather patterns have impacted various economic sectors, including the agricultural industry, through their direct impact on food production (Enete & Amusa, 2010; Godde *et al.*, 2021).

The agricultural sector is susceptible to climate change because it depends on environmental conditions and biodiversity (USAID, 2019). Climate change poses a significant threat to smallholder farmers. It threatens to undermine global progress toward poverty alleviation, food security, and sustainable development (Harvey *et al.*, 2018). Smallholder farmers are highly vulnerable to climate change because most depend on rain-fed agriculture, cultivate marginal areas, and lack access to technical or financial support that could help them invest in more climate-resilient agriculture (Harvey *et al.,* 2018). Pastoralists and agro-pastoralists are classified as smallholder farming groups that are very vulnerable to climate change (Herrero *et al.,* 2016). Climate change is expected to affect the livelihoods of agro-pastoral communities through diminished crop production and a reduction of livestock numbers due to poor livestock performance and increased mortality (Debela *et al.,* 2019). Suleiman *et al*. (2018) state that 'agro-pastoral systems involve an integration of livestock and crop enterprises and grazing resources (rangelands, pastures) in time and space'.

South Sudan, a country within which a significant population depends on pastoralism/agro-pastoralism, has not been spared from the impacts of climate change. The study in question focused on South Sudan to understand the impacts of climate change on agro-pastoralist farmers. A case study approach focused on Awerial County (District), which is in Lakes State (Province) of South Sudan, was utilised to better understand the subject and contribute to the

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body of knowledge on climate change impacts and adaptation practices of agro-pastoralist farmers.

Agriculture extension support for smallholder farmers is critical, considering the variable climate of their production systems (Afful, 2016). Support through agricultural extension may help small-scale farmers to benefit from extension programmes and provide social support to individual member farmers.

The agricultural sector remains the primary source of livelihood in South Sudan, with about 80% of the population dependent on it (ACCORD, 2021). The agriculture sector in South Sudan continues to face challenges associated with extreme weather events and climate variability (FAO, 2020). Smallholder farmers are one of the groups most vulnerable to climate change, yet efforts to support farmer adaptation are hindered by a lack of information on how they are experiencing or responding to climate change (Harvey *et al.*, 2018). Although there are well-established concerns about climate change effects worldwide, there is little quantitative information concerning how serious these effects are on smallholder farmers in the context of South Sudan. Studies on the impacts of climate change on smallholder farmers and their adaptation/mitigation in the South Sudan context, including Awerial County, are also lacking. This is even though climate change adaptation has the potential to significantly contribute to a reduction in negative impacts on smallholder farmers that are due to climate variability (Tesfaye & Seifu, 2015). There is a lack of empirical studies on climate change and its impact in South Sudan. The lack of information negatively impacts the implementation of strategies by agriculture extension advisers to help agro-pastoralist farmers cope with climate change while maintaining and improving productivity.

2. RESEARCH METHODOLOGY

The study population was smallholder farmers drawn from seven (7) payams of Awerial County, South Sudan. In South Sudan, the payam (village) is the second lowest administrative division and has a minimum population of 25 000 individuals. The smallholder farmers comprised 94 men and 307 women engaged in smallholder agricultural production such as pastoralism, agro-pastoralism, and vegetable production. Key informants interviews (KIIs) from non-governmental organisation (NGO) representatives, County administrators, local leaders and government officials from the Ministry of Agriculture and Fisheries were also part of the target group.

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The study adopted a two-stage cluster sampling methodology to select the study participants. Cluster sampling is a sampling method that involves dividing an entire population of externally homogenous but internally heterogenous groups called clusters (Salkind, 2018:90). The advantage of this sampling method is that it requires fewer resources and reduces variability (Salkind, 2018:90). In South Sudan, the boma is the least demographic unit followed by a payam for any study to be conducted. Therefore, since this study targeted one county (Awerial County), a two-stage sampling technique was found to be convenient where the enumeration areas (EA) and the payams from Awerial County were divided into bomas according to the 2008 population and housing census. The second sampling stage involves the division of bomas into clusters using village names or blocks of the residential areas. With assistance from local leaders or authorities, the enumerators identified the centre of each selected residential area where the first households were randomly chosen for questionnaire administration. From the centre of the selected residential area, enumerators were involved in spinning a pen on a notebook, and the house to which the pen pointed became the first for questionnaire administration. After interviewing the first household, the enumerator moved to the next home on his right, and this became the second household to be interviewed. The enumerator would skip the next house from the second house based on a pre-determined sampling interval. This process continued until the required sample size or number of households interviewed was fully covered by the survey. The data for this study was collected using questionnaires, interview guides, focus group discussions and document analysis. Quantitative data was collected through the household questionnaires and analysed using descriptive statistics, while qualitative data was analysed using content analysis.

3. RESULTS AND DISCUSSION

3.1. Demographic Information

3.1.1. Gender of Respondents

401 respondents were sampled from seven payams (villages) in Awerial County of South Sudan. A considerable proportion (*n*=307, 77%) of the respondents who were sampled were female, while the remainder were male (*n*=94, 23%) (Table 1). Generally, women in South Sudan tend to spend a lot of their time on different roles (for example, cooking, fetching water, collecting firewood, grinding/pounding cereal/ground nuts, washing clothes, caring for children at home and sweeping the compound) which usually confines them to locations near their households (NPA, 2020).

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On the other hand, men engage in more productive roles (for example, herding cattle and market participation-related activities) that allow them to spend more time away from the homesteads during the daytime compared to their female counterparts. The gender roles and gender violence could explain why the enumerators interviewed more women during the day as more men were absent during the time of the interviews. In South Sudan, the combination of gender inequalities in agriculture, gender-based violence, climate change and variability make women vulnerable to climate shocks (UNEP, 2021).

TABLE 1: Summary Statistics of a Survey Carried Out in Sudan (n=401)

Gender distribution	**Percentage**
Male	23
Female	77
Age (Years)	
18-25	68
26-35	28
36-45	24
46-55	7
56-65	32
Above 65	3
Household residence status	**Percentage**
Host community	72
Internally displaced person (IDP)	24
Returnees	4
Education level	**Percentage**
Matriculated	1
Grade 9 to Grade 12	4
Tertiary qualification	3
Grade R to Grade 8	8
Never been to school	83
Major agriculture-based livelihoods practised by respondents	**Percentage**

Vegetable production	8
Pastoralists (livestock)	9
Crop production	17
Crop and livestock	65
Other	1
Land ownership size	**Percentage**
More than 1 Ha	46
0.6 Ha to 1 Ha	29
0 to 0.5 Ha	25

3.1.2. Age of Respondents

According to the UNFPA (2018, quoting the South Sudan Census (2008), South Sudan has one of the world's youngest populations, with about 73.7% of the population below the age of 30. The youthful demographic of the country tends to present challenges in terms of poverty, unemployment, and access to health. The census data correlates well with the results of the survey (refer to Table 1), as 68% (*n*=234) of the respondents were within the age range 18 to 35 years and can be classified as "youth". The remainder of the respondents were within the following age categories: 36- 45 years (*n*=95; 24%), 46 to 55 years (*n*=28; 7%) and above 65 years old (*n*=14; 3%). The low proportion of the population above 65 years could be linked to the low life expectancy in South Sudan, which, according to O'Neill (2021), was 56.35 years for men and 59.38 for women.

3.1.3. Household Residence Status

According to the NPA (2021), the IDPs in Awerial County were mostly from Bor, Duk and Twic East counties who fled floods that hit their area because of torrential rains and inter-communal conflict in September 2020. As indicated in Table 1, most of the sampled households were from the host community (*n*=288; 72%), with the remainder being internally displaced persons (*n*=96; 24%) and returnees (*n*=17; 4%).

3.1.4. Education Level of Respondents

As shown in Table 1, 83% (*n*=333) of the respondents have never been to school, while 8% have attended Grades R to Grade 8. The remaining respondents have the following educational

qualifications: Matric (*n*=4; 1%), Grade 9 to Grade 12 (*n*=18; 4%) and tertiary education (*n*=12; 3%). The findings agree with the study conducted in Kenya by Imana and Zenda (2023), who found that most pastoralists who participated in the survey did not have formal education. The education sector in South Sudan has been affected by years of conflict, poverty and limited educational structures, which have resulted in the bulk of the population not having been to school. According to UNICEF (2021), 70% of South Sudanese children are out of school, while 63% of the teachers have no formal education. Access to education is hindered by poverty, cultural and religious views and child marriages, which restrict the girl-child's access to education. In South Sudan, access to education tends to vary based on gender. For example, 87% of female-headed households have no access to formal education compared to male-headed households, which stands at 65.7% (De Coning *et al.,* 2021).

Most households (n=258; 65%), as shown in Table 1, are agro-pastoralists and engage in a combination of livestock and crop production. According to the WFP & FAO (2018), about 60% of the population in Awerial County engages in agriculture, which involves rearing cattle and goats while also growing rain-fed main-season groundnuts, maize, sorghum, beans, and pumpkins. The results of the survey also show that part of the population engages in crop production only (*n*=68; 17%), livestock only (*n*=38; 9%) and vegetable production (*n*= 31; 8%).

3.1.5. Land Ownership and Size

Land tenure is important to enhance sustainable livestock farming systems (Zenda & Malan, 2021). It determines the sustainability of livestock farming systems. When land ownership is mostly communal, there would be little incentive to practise sustainable land management effectively (Zenda & Malan, 2021). The land tenure system in Awerial County is traditionally under customary law, with the rights of use guaranteed to every member of the community (NPA, 2021). Table 1 indicates that the majority (*n*=391, 98%) of the sampled households own land with only a few (*n*=10, 2%) not owning land under the communal land tenure system. This indicates that land tenure was not an issue that extension advisers needed to address. A considerable number of households (*n*=190; 46%) own more than one hectare of land, while the remainder owns 0.6 to one hectare (*n*=114; 29%) and 0 to 0.5 hectares (*n*=97; 25%), respectively. The calculation of the size of land owned is complicated as some of the land

parcels are commonages of grazing land/pastures, jointly owned by their respective communities.

3.2. Agro-Pastoralist Farmers' Perceptions of Change in Climate Variables

3.2.1. Perceptions of Climate Changes

Perceptions tend to have an impact on how smallholder farmers deal with climate-induced risks. The chosen behavioural responses to this perception will ultimately have an impact on adaption options, processes, and outcomes (Debela *et al.,* 2015). Misconceptions about climate change may result in maladaptation or no action, hence contributing to an increase in the negative impacts of climate change. The results of the survey (Table 2) show that an overwhelming proportion (97%) of the agro-pastoralists have observed climate change for the last 20 years while a smaller proportion have not (3%). These results indicate that climate change is a serious challenge that needs to be addressed in the study area.

TABLE 2: Percentage of Respondents Experiencing Climate Change in the Last 20 Years

Percentage of respondents experiencing climate change in the last 20 years.	Percent
Yes	97
No	3

According to Murray (2016), as quoted in Quinn *et al.* (2019), smallholder farmers/agro-pastoralists in South Sudan have started noticing the change in climate patterns with indications of delays in rainfall onset and the emergence of longer drier spells at the beginning of rainy seasons, coupled with increased rainfall intensity and flooding. South Sudan has, in the last 20 years, been very vulnerable to climate change, which has been manifested in the form of droughts, flooding and, recently, infestation of locust pests (Quinn *et al.,* 2019). The signs that the climate is changing include the following: increased temperatures (82%), increased frequency of flooding (67%), increased pests and diseases (47%) and increased frequency of droughts (20%) respectively (Table 3).

TABLE 3: Summary of Agro-Pastoralist Perceptions of Climate Change

Indicators of climate change based on agro-pastoral farmers' perceptions	**Frequency**	**Percent**
Increase in temperatures	327	82%
Increased frequency of droughts	80	20%
Increased incidence of flooding	270	67%
Increase in pests and diseases	189	47%
Agro-pastoralist perceptions of temperature increases		
Not changed	6	1%
Decreased	110	27%
Increased	273	69%
Don't know	12	3%
Agro pastoralist perception of observed changes in rainfall in the last 20 years		
Not changed	8	2%
Increased	285	71%
Decreased	110	27%
Don't know	12	3%

3.2.2. Perceptions of Changes in Temperature

Table 3 illustrates that 69% (*n*=273) of the respondents were convinced that the temperatures have increased in the study location in the last ten years. However, 27% (*n*=110) of the smallholders indicated that there had been a decrease in the temperatures. A meagre 3% (*n*=12) were unsure if there was any temperature change while 1% (n=6) observed no temperature changes. The results align with the government of the Netherlands (2018), which notes that South Sudan is experiencing a warmer and drier climate accompanied by rapid increases in warming, which is two and half times greater than the global warming average. The increase in temperatures is associated with increased evapotranspiration from plants and reduced soil moisture, which inevitably results in reduced or failure of crop production.

3.2.3. Changes in Rainfall

The government of the Netherlands (2018) notes that there is evidence that South Sudan has been experiencing an increase in rainfall variability in timing and amount of rainfall received. While the amount of rain received has decreased, the distribution of the rain has been uneven, with large amounts received in brief bursts, contributing to flooding. Most of the smallholders indicated that the rainfall amounts have increased. As depicted in Table 3, the survey results suggest that most of the respondents (*n*=285; 71%) perceive that there has generally been an increase in the rainfall amounts in the study location. On a different note, 25% (*n*=101) of participants reported that there has been a decrease in overall rainfall received in the last ten years. On the lesser side, 2% (n=7) were unsure if there were any changes, while a similar number, 2% (n=8), felt no changes in the rainfall. Morton & Herrero (2013) also concur with the findings of this study by affirming that climate change is affecting rainfall distribution, amounts and intensity, which influence the duration and timing of crop growing seasons, which, in turn, has a net impact on plant growth and crop productivity.

3.2.4. Perceptions on Drought Occurrences

Drought is a major concern for the agro-pastoralists. As presented in Table 4, the survey results indicate that 70% of the respondents (*n*=280) agree that the frequency of droughts in Awerial County has increased in the last ten years. However, 24% (*n*=98) have a different view as they feel the frequency of droughts in the target location has reduced. The remainder, 4% (*n*=13), were uncertain, while 2% (*n*=10) indicated that there had been no change in the frequency or occurrence of droughts. This study's results align with USAID (2019), which notes that droughts have become more common in South Sudan since the 1960s and that in 2015, the country experienced a severe drought linked to the El Nino effect. This indicates that extension advisers should train farmers on how to respond to drought to prevent veld deterioration.

TABLE 4: Summary of Agro-Pastoralist Perceptions on Frequency of Droughts

Perceptions on the frequency of drought occurrence	**Frequency**	**Percentage**
Decreased	98	24%
I don't know	13	4%
Increased	280	70%

Not changed	10	2%
Total	**401**	**100%**

The early seasonal rains received in South Sudan since June 2021 have resulted in rivers flooding their banks and dykes, leading to flooding of large areas of land in Awerial County of Lakes State (UNOCHA, 2021). Some of the flooded communities have been forced to move to higher ground or to migrate as a coping or adaptation measure. It is estimated that about 426 000 people have been affected and displaced by floods in South Sudan since May 2021 (OCHA, 2021).

3.2.5. Agro-Pastoralists' Views on and Knowledge About the Causes of Climate Change

The views and perceptions about change causes tend to be a function of personality, pre-existing beliefs, cultural values or spiritual worldview, emotions and contextual, social and environmental factors (Kuivanen, 2015). As depicted in Figure 1, farmers within the same community may, therefore, perceive climate change differently due to their beliefs, previous experiences, values, and expectations. In this regard, about 42% (*n*=318) of the respondents feel that climate change results from natural processes, while 36% (*n*=272) perceive that climate change occurs because of human actions. These results indicate that beliefs and attitudes towards climate change are a function of contextual factors, including direct experiences, access to climate information, interaction with other people, and experiential learning. In addition, the results also correlate with those of Barnard *et al*. (2015), who concur with other scientists that man-made and natural factors cause climate change. The survey results also indicate that 19% (*n*=147) attributed climate change occurrences to acts of God. Debessa *et al.* (2015:3), quoting Nyanga *et al.* (2011), also note that indigenous people with limited access to climate information (as is the case in South Sudan) attribute changes to religious, ritual and/or cultural practices.

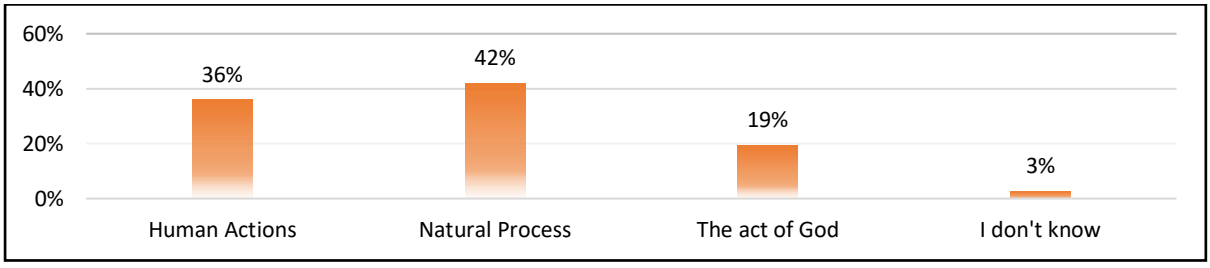

FIGURE 1: Agro-Pastoralist Perceptions of Causes of Climate Change

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4. AGRO-PASTORALIST FARMERS' PERCEPTIONS OF CLIMATE CHANGE IMPACTS

Pickson & He (2021), quoting Leiserowitz (2007), note that perceptions are important regarding how farmers perceive the associated risks and form the background against which policies are supported or disregarded. Farmers' perceptions of changes or impacts also form a pre-indicator in the process of adaptation and tend to be essential because how farmers perceive the associated risks of the climate forms the background of how they respond and adapt to changes in the climate (Adger *et al.,* 2009 as quoted in Pickson & He, 2021). For this reason, the respondents were asked how they perceived the impact of climate change on their agro-pastoral-based livelihoods. Table 5 indicates that agro-pastoralists experience a myriad of climate change impacts. Most sampled households (n=238, 59%) have experienced crop failure/reduced crop production. Some major climate change impacts included increased incidence of pests/diseases, loss of livestock, reduced water access and increased food insecurity. The findings of this study are like those of De Coning *et al.* (2021), who found that climate change impacts in South Sudan are exacerbating vulnerabilities and reducing the resilience and adaptive capacity of agro-pastoral farmers.

TABLE 5: Climate Change Impacts on Agro-Pastoralist Farmers

Climate Change Impacts	Frequency	Percentage
Reduced water for domestic and livestock purposes	205	51%
Reduced feed (graze and browse) for livestock	122	30%
Increased deforestation	78	19%
Increased incidence of pests and diseases	225	56%
Crop failure/reduced crop production	238	59%
Loss of agricultural inputs like seeds and tools	182	45%
Loss of livestock	210	52%
Escalation in conflict due to natural resource competition	54	13%
Increased hunger and food insecurity	175	44%

4.1. Climate Change Impacts

4.1.1. Crop Failure/Reduced Crop Production

The survey results indicate that a significant proportion of respondents (59%; *n*=238) have experienced reduced/failure of crop production due to the climate change impacts (Table 5). These results suggest that crop failure could be because of moisture stress associated with droughts and sporadic rainfall distribution. USAID (2019) notes that cereals and grains, the main staple diet in South Sudan, are very sensitive to changes in rainfall (frequency and distribution), with 70% variability in the production of the crops linked to variations in rainfall received in a particular location. This finding concurs with Jiri *et al.*'s (2017:27) studies conducted in South Africa (Limpopo Province), which found that droughts lead to low crop yield and high crop failure.

4.1.2. Increased Incidence of Pests and Diseases

The survey results indicate that 56% of the respondents (n=225) have experienced an increase in pests and diseases in livestock and crops due to climate change impacts (Table 5). South Sudan currently suffers from many endemic diseases, such as Fall Army Worm (FAO, 2020). Awerial Country (study site) has also experienced outbreaks of Desert Locusts, which have negatively impacted the crops' yields (FAO, 2021). The most common livestock diseases that have been due to changes in the climate in Awerial County are East Coast Fever (ECF), Foot and Mouth Disease (FMD), Contagious Bovine Pleuropneumonia (CBPP) and Contagious Caprine Pleuropneumonia (CCP) in cattle and goats (NPA, 2013). The incidence of livestock diseases tends to increase during the rainy season. These results indicate that extension advisers should train farmers to respond to pests and diseases.

4.1.3. Loss of Livestock

The survey results (Figure 2) indicate that 52% of the sampled households (*n*=210) have experienced livestock losses due to climate change impacts. Most of the livestock deaths (50%) are due to diseases, while the remainder of the reported losses are due to droughts (21%), floods (15%), conflicts (10%), slaughter (3%) and predation (1%) respectively (Figure 2). According to De Coning *et al.* (2021:2), climate-related livestock losses tend to increase the risk of cattle-raiding and ongoing rivalries, ultimately resulting in conflicts, retaliations and displacements.

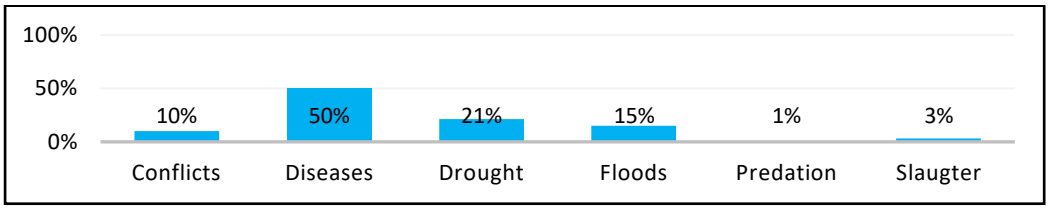

FIGURE 2: Major Causes of Livestock Deaths/Losses

According to Chol (2021), the livestock losses in South Sudan were due to starvation (inundated grasslands), drowning and diseases such as Foot and Mouth disease (FMD), Lumpy Skin disease (LSD), Haemorrhagic Septicaemia (HS), Black Quarter (BQ), Foot and Mouth disease (FMD), anthrax, *Peste des Petits Ruminants (PPR)*, East Cost Fever (ECF), diarrhoea due to infections, myiasis and foot rot (infectious pododermatitis) in sheep, goats and cattle. The advent of floods has also increased the worm burden and biting flies, ultimately resulting in increased pneumonia incidences, stress levels and abortions. FAO (2021) reports that 1 480 livestock (244 cattle, 415 sheep and 821 goats) died during the 2021 rainy season due to climate change-related impacts in Awerial County.

4.1.4 Reduced Water for Domestic Purposes

The survey results indicate that 51% of the respondents (n=205) have experienced reduced water availability for domestic and livestock purposes due to purported climate change impacts. FAO (2017) also concurs with the results of the survey by adding that climate change presents a challenge for rural people by causing water shortages and due to its impacts on both the demand and availability of water for agriculture and domestic consumption.

4.1.5. Increased Hunger and Food Insecurity

Increased hunger and food insecurity can be directly exacerbated by climate change. The survey results indicate that 44% of the households (n=175) have experienced increased hunger and food insecurity attributable to climate change impacts. The results are in line with the Integrated Phase Classification (IPC) report (2020), which states that 52.6% of the South Sudanese population (6.35 million people) are experiencing acute food insecurity due to a combination of climatic change-induced factors (droughts and floods), decline in the economy and escalation of sub-national conflict.

4.1.6. Loss of Agricultural Inputs (Seeds and Tools)

The survey results indicate that 45% of the respondents (*n*=182) have experienced a loss of inputs (seeds and tools) because of climate change impacts. Since most agro-pastoralist households depend on their own retained seeds, the flooding experienced in South Sudan has destroyed planted crops and the loss of valuable seed inputs. The loss of livestock due to climate change impacts has also contributed to reduced crop production due to the loss of livestock used as draught power for the ox-drawn plough. During FGDs, the participants noted that climate change had resulted in a loss of valuable seed inputs, particularly millet, long-season sorghum variety, pumpkins, and groundnuts.

4.1.7. Increased Deforestation

Agro-pastoralists who were interviewed (19%; *n*=78) believed that climate change was leading to increased deforestation in Awerial County. FGD sessions with community members revealed that more community members were cutting down trees for sale as firewood and charcoal as a livelihood diversification response to the impacts of climate change. The increased frequency of droughts and floods was also noted as impacting the growth of forest trees, resulting in reduced canopy cover and soil erosion. Similar findings were reported by Popoola, Monde and Yusuf (2019) in the Eastern Cape Province, a part of South Africa, in their study on perception and adaptation responses to climate change.

4.1.8. Escalation of Conflict Over Natural Resource Competition

According to the survey results, 13% of the respondents (n=54) indicated that climate change contributes to an escalation in conflict due to competition over natural resources. The UN Environment Programme (2018) concurs with the survey results by highlighting that competition over access to water, fuelwood, pasture and productive farmland between clans and communities intensifies conflicts and migration within the migration. In Awerial County, access to grazing land and water sources is usually at the root of intra and inter-communal conflicts (OCHA, 2019). Coning *et al.* (2021) also concur by noting that climate extremities like droughts and flooding are having an impact on agro-pastoralist routes and mobility patterns, which, in turn, result in tensions and conflict over land, grazing and water.

4.1.9. Reduced Feed (Graze and Browse) For Livestock

The study indicates climate change contributes to reduced feed (browse and graze) for livestock in Awerial County. About 30% of the respondents (*n*=122) believe climate change impacts livestock feed availability. According to FAO (2021), the herbaceous forage and shrubs providing the bulk of livestock (ruminants') diet in South Sudan are constantly threatened by climate change impacts. In the last few decades, climate variability has negatively impacted the rangeland ecosystem, resulting in fluctuations in water supply and forage.

4.2. How Agro-Pastoralist Farmers are Adapting to Climate Change

4.2.1. Climate Change Adaptation Strategies

The results of the survey show that the majority (*n*=378; 94%) of the sampled smallholder farmers have acted by implementing strategies to mitigate the impacts of climate change on their agricultural-based livelihoods.

TABLE 6: Climate Change Adaptation Strategies of Agro-Pastoralists

Adaptation Strategy	Frequency	Percentage
Using different varieties	192	48%
Adoption of drought-tolerant and early-maturing crop varieties	98	24%
Water harvesting technique	75	19%
Change livestock type	56	14%
Seek off-farm employment	31	8%
Changing planting dates	165	41%
Crop diversification	104	26%
Changing fertiliser application	76	19%
Mixed farming	261	65%
Reduce the number of livestock	90	22%
Agro-forestry/planting of trees	150	37%
Increase the use of soil and water conservation techniques	67	17%
Applying different feed techniques	126	31%
Temporary migration	104	26%

The measures employed include crop diversification, use of different varieties, adjustment of planting dates, application of fertiliser, livestock diversification, culling of livestock, planting trees, mixed farming, and soil and water conservation.

4.2.2. Diversification and Use of Different Varieties

The survey results indicate that the most dominant strategy used by 25% of the sampled smallholder farmers (*n*=394) involves the diversification of crop types and varieties. Multiple cropping systems act as insurance in case of crop failure (Menikea & Keeragala-Arachchib, 2016). According to Akinnagbe & Irohibe (2014), the advantage of mixing crops with different attributes relates to drought tolerance (for example, maize and sorghum), input requirements (for example, legumes and cereals) and maturity period (for example, maize and beans). According to the survey results, the farmers have resorted to using drought-tolerant varieties (n=98, 6%) to mitigate the impacts of droughts that have become frequent in the area due to climate change. The local short sorghum variety is one example of a -tolerant crop adopted by most farmers, as confirmed through the focus group discussions (FGDs). These findings resonate with Akinnagbe & Irohibe's (2014) argument that planting drought-tolerant crops helps reduce farmer's vulnerability to climate change. These authors further note that farmers in Senegal, Ghana, Nigeria, and Burkina Faso have also been practised using drought-tolerant crops as a climate change adaptation strategy. Other smallholder farmers (*n*=192, 12%) have resorted to using different varieties or changing crops grown to mitigate the impacts of climate change. From the FGDs, it was noted that smallholder farmers were, in some instances, forced to abandon some crops or switch to new ones as the impacts of climate change had eliminated some of the crop cultivars. An example of a crop which has been affected by climate change and has disappeared from the communities is millet, which has resulted in smallholder farmers resorting to other crops (FGD).

4.2.3. Changing Planting Dates and Fertiliser Application

The survey results indicate that due to the high incidence of rainfall variability in the area, 15% (*n*=241) of the sampled smallholders have adjusted their planting dates and fertiliser applications as a risk mitigation measure. Asfaw *et al.* (2018, as quoted in Akinnagbe & Irohibe, 2014) note that natural changes in climatic variables such as rainfall and temperature can cause smallholder farmers to change planting and harvesting dates as a coping mechanism. To minimise crop production risks, smallholder farmers practise staggered planting, for

example, by practising dry land planting before the onset of rain. In contrast, others plant immediately after the first adequate rains (Akinnagbe & Irohibe, 2014).

4.2.4. Livestock Diversification and Reduction in Numbers

The livestock owners also cull or reduce animals by selling or slaughtering when pasture and water sources are constrained due to droughts. Akinnagbe & Irohibe (2014) also note that agro-pastoralists and pastoralists in the Sahel adopted key strategies that involve culling weak livestock for food and adopting a multi-species composition of herds to survive climate change extremities. The survey results indicated that 10% (*n*=146) of the sampled households minimise over-dependence on one livestock class by practising livestock diversification as a climate change mitigation strategy. Danso-Abbeam *et al.* (2021) also concur that livestock diversification is another strategy used by households to address the economic risks associated with climate change impacts.

4.2.5. Soil/Water Conservation and Water Harvesting as Part of Adaptation

The survey results show that 19% (*n*=75) of the respondents have resorted to water harvesting as a climate change adaptation strategy. This helps improve water access during the dry season, when most water sources tend to dry up. Some of the water conservation techniques used by agro-pastoralists include *haffirs*, shallow wells and small dams (FGDs). The agro-pastoralists (17%, *n*=75) have also used soil and water conservation techniques as a climate change adaptation strategy. *Haffirs* are man-made groundwater storage structures that are used to store water for use by both livestock and humans. The results of the survey are also in tandem with Skambraks (2014), who notes that farmers in Ethiopia are also using soil moisture conservation techniques as part of climate change adaptation, which involves control of soil erosion and vegetative soil coverage through building terraces, planting trees and drainage channel optimisation.

4.2.6. Mixed Farming (Crop and Livestock)

Engaging in mixed farming is vital in climate change adaptation as it reduces the risk of over-reliance on a single farm production system. Most agro-pastoralist farmers (65%; *n*=261) have adopted mixed farming as a risk mitigation and climate change adaptation strategy. The residents of Awerial County keep cattle/goats and grow various crops, including maize, groundnuts, pumpkins and beans. Skambraks (2014) also notes that mixing livestock and crops

is an adaptation mechanism that diversifies the farm and contributes to an increase in the farmer's adaptive capacity.

4.2.7. Agro-Forestry and Planting of Trees

Skambraks (2014) defines agroforestry as integrating woody perennials with crops and livestock in the same land unit in a temporal or spatial arrangement. Growing more than one crop reduces the farmer's risk of failure since different climatic events affect different crops. The survey results indicate that 37% of the respondents (n=150) have resorted to planting trees/agroforestry as a climate change adaptation strategy. Akinnagbe and Irohibe (2014) state that rural farmers in Africa have, over time, been practising planting trees as part of climate change adaptation. The authors also note that tree planting involves transplanting seedlings for land reclamation, forestry and landscaping purposes.

4.2.8. Temporary Migration and Off-Farm Employment

According to SIPRI and NUPI (2021), climate change has interacted with migration and mobility through displacements caused by weather extremities and altered mobility patterns of agro-pastoral communities. Akinnagbe and Irohibe (2014) reported that migration is an important mechanism to deal with climate stress. Pastoralist communities have been known to migrate with their livestock in response to drought and as part of their usual mode of life. The survey results indicate that 26% (*n*=104) use temporary migration as a climate change adaptation strategy. In addition, the survey results also indicate that 8% of the respondents (*n*=31) resort to seeking off-farm employment as a climate change adaptation mechanism. In the West African Sahel region, temporary migration has been cited as an adaptive mechanism to climate change (Akinnagbe & Irohibe, 2014).

4.2.9. Use of Supplementary Feeding for Livestock

Agro-pastoralists use supplementary feed during the dry season consisting of purchased feed, preserved fodder and lobbed trees (FGD). According to the FAO (2021), crop residues contribute to the feed budget of livestock in the agro-pastoral areas of South Sudan. The major crops grown by agro-pastoral farmers that are used as crop residues for supplementation are groundnuts, sorghum, maize, cowpeas, rice, and horticultural crop species. The survey results indicate that 31% (*n*=126) of the livestock owners resort to supplementary feeding when the quality of the veld/browse is in poor condition.

4.3. Climate Change Adaptations Constraints Faced by Agro-Pastoralists

4.3.1. Financial Constraints

The survey results indicate that 39% (n=156) of the respondents lack the financial resources required to engage in their preferred or alternate adaptation strategies. The results concur with Harvey *et al.* (2018:1), who note that limited access to finance is one of the major constraints to smallholder farmers' climate change adaptations. Mugiya and Hofisi (2017) also note that the lack of finance to buy seeds and other inputs is a major constraint to climate change adaptation faced by smallholder farmers.

4.3.2. Lack of Agricultural Inputs/Technologies

Three percent (33%) of the respondents (n=134) faced challenges adapting due to limited or lack of access to agricultural inputs and technologies. Most of the communities in South Sudan lack resources such as irrigation and water infrastructure for them to be able to adapt to changes in the climate. There are also challenges in accessing inputs (crop seed types and varieties), for example, improved crop varieties that are unavailable in the location or not accessible due to the high price of inputs. The research findings concur with observations by Progressio, Zimbabwe (2009) and Rahim (2011), quoted from Mugiya and Hofisi (2017), who cite access to irrigation infrastructure and seed/inputs as severe constraints to climate change adaptation.

4.3.3. Lack of Skills and Information

The survey results show that 28% (n=111) faced challenges in adapting to climate changes linked to limited access to information and skills (Figure 9). Access to information and extension services is key to adaptation and coping responses. Smallholder farmers usually receive information from radios, television, the internet, input dealers, government extension services, the private sector, and other farmers. Access to information and the accompanying adaption of skills is hampered in South Sudan (in particular, Awerial County), thereby limiting the efficacy of their adaptive capacity and responses to climate change.

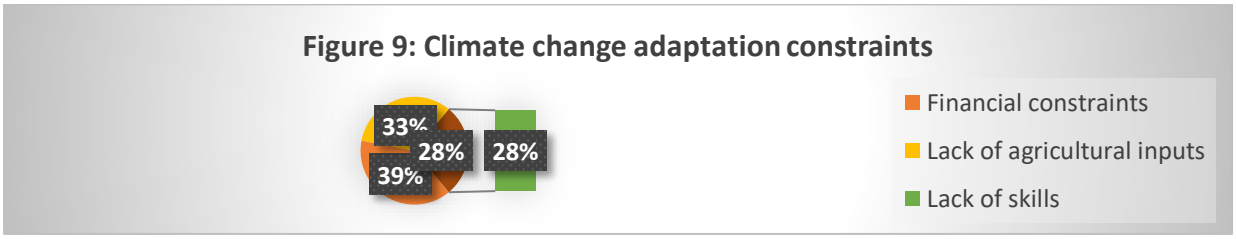

FIGURE 3: Constraints by Agro-Pastoral Farmers in Adapting to Climate Change

10.17159/2413-3221/2023/v51n3a14086

5. CONCLUSION AND RECOMMENDATIONS

South Sudan is experiencing the effects of long-term climate change, such as increased temperatures and precipitation and short-term changes characterised by more frequent flooding and droughts. Agro-pastoral farmers also tend to be highly vulnerable to the impacts of climate change due to their dependence on climate-sensitive rainfed crops, location in marginalised landscapes, low capacity to adapt to climate changes and over-reliance on ecosystem services and goods. Most of the agro-pastoral farmers in South Sudan are bearing the brunt of climate change, which has been manifested through loss of livestock, crop failure, displacements/migration, loss of inputs, destruction of infrastructure, increase in food insecurity and reduced water for livestock and domestic use. In response to climate change, agro-pastoralists are currently employing adaptation strategies, which include crop diversification, livestock diversification, reduction in animal numbers, planting of trees, adjustment of planting plans, application of fertilisers, mixed farming, and soil and water conservation. Support for agro-pastoralists through agriculture extension could include strengthening local early warning systems, diversifying livelihoods, and promoting climate-sensitive agricultural practices. Climate change tends to affect women and men differently. Future studies may need to assess the gendered dimension of climate change impact and adaptation strategies of agro-pastoralist farmers.

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