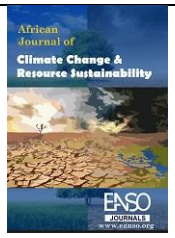
Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328



African Journal of Climate Change and Resource Sustainability
ajccrs.eanso.org
Volume 4, Issue 2, 2025
Print ISSN: 790-962X | Online ISSN: 790-9638
Title DOI: https://doi.org/10.37284/2790-9638

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

People's Perception of Climate change, climate variability, and Coping Strategies in South Sudan: The Case of Sudd Wetland

Andu Zakaria Lukwasa[1], Kassahun Ture[1], Tadesse Terefe Zekeke[2] & Fikru Abiko Anose Ture[3]

[1] Addis Ababa University, P. O. Box 1176, Addis Ababa, Ethiopia.
[2] Alliance Bioversity and the International Center for Tropical Agriculture (CIAT), Addis Ababa, Ethiopia.
[3] Wolkite University, P. O. Box 07, Wolkite, Ethiopia.
[*] Author for Correspondence ORCID ID; https://orcid.org/0009-0006-4926-1879; Email: zakarialukwasa2020@gmail.com

Article DOI: https://doi.org/10.37284/ajccrs.4.2.3328

Date Published: *16 July 2025*

Keywords:

Climate Change, Climate Variability, People's Perception, Coping Strategies, Sudd Wetland.

ABSTRACT

In this study, coping mechanisms and instrumental records were used to examine people's perceptions of climate change and variability. Data from 387 individuals were gathered by questionnaire. Furthermore, six focus group discussions were organised. Gridded data on temperature and precipitation were gathered from four stations between 1979 and 2014. The metrological parameters, including temperature and Sun heat periods, were measured and compared with the perception of the residents during the settlement in the 1920s. The perception result showed that both the minimum and the maximum temperatures were changing and rising. .99.5% of respondents reported an increase in solar heat and variability in the onset and cessation of rains, while 51% of respondents said the climate was unpleasant. As a result, we accept the alternative hypothesis, H0 = 0, which states that the residents of the research area were aware of climate variability and change, and reject the null hypothesis, H0 = 0. The Standard Precipitation Index showed that there were more dry spells than wet ones. The results of the Chi-square test showed a strong correlation between coping mechanisms and perceptions of variability and climate change. According to the study's findings, humans have primary and supplementary coping mechanisms for dealing with climate fluctuation and change. In addition to planned adaptation based on current local coping techniques, the study advises policymakers and development partners to establish climate-smart Agriculture solutions that are suitable at the Payam level.

APA CITATION

Lukwasa, A. Z., Ture, K., Zekeke, T. T. & Ture, F. A. A. T. (2025). People's Perception of Climate change, climate variability, and Coping Strategies in South Sudan: The Case of Sudd Wetland. *African Journal of Climate Change and Resource Sustainability*, *4*(2), 25-45. https://doi.org/10.37284/ajccrs.4.2.3328.

CHICAGO CITATION

Lukwasa, Andu Zakaria, Kassahun Ture, Tadesse Terefe Zekeke and Fikru Abiko Anose Ture. 2025. "People's Perception of Climate change, climate variability, and Coping Strategies in South Sudan: The Case of Sudd Wetland", *African Journal of Climate Change and Resource Sustainability* 4 (2), 25-45. https://doi.org/10.37284/ajccrs.4.2.3328

HARVARD CITATION

Lukwasa, A. Z., Ture, K., Zekeke, T. T. & Ture, F. A. A. T. (2025) "People's Perception of Climate change, climate variability, and Coping Strategies in South Sudan: The Case of Sudd Wetland", *African Journal of Climate Change and Resource Sustainability*, 4(2), pp. 25-45. Doi: 10.37284/ajccrs.4.2.3328.

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

IEEE CITATION

A. Z. Lukwasa, K. Ture, T. T. Zekeke & F. A. A. T. Ture "People's Perception of Climate change, climate variability, and Coping Strategies in South Sudan: The Case of Sudd Wetland", AJCCRS, vol. 4, no. 2, pp. 25-45, Jul.

MLA CITATION

Lukwasa, Andu Zakaria, Kassahun Ture, Tadesse Terefe Zekeke & Fikru Abiko Anose Ture. "People's Perception of Climate change, climate variability, and Coping Strategies in South Sudan: The Case of Sudd Wetland". *African Journal of Climate Change and Resource Sustainability*, Vol. 4, no. 2, Jul. 2025, pp. 25-45, doi:10.37284/ajccrs.4.2.3328.

INTRODUCTION

East Africa's agriculture, hydrology, ecology, and socioeconomics are all greatly impacted by fluctuations in precipitation (Zeleke & Damtie, 2016; Zeleke et al., 2023). Increased unpredictability in precipitation may have an impact on agricultural productivity, which is correlated with extremely dry and wet events, floods, and droughts—all of which are dangerous for the local economy, society, and environment.

The increasingly changing climate has a big influence on rural households, especially in sub-Saharan Africa (IPCC, 2007). According to Chen et al. (2013), South Sudan has a tropical climate with distinct wet and dry seasons. The rainy season begins in early April. As stated by Omoj et al. (2016), June, July, and August are the primary wet seasons. The northern region of South Sudan experiences unimodal rainfall, while the western and central regions get bimodal rainfall, according to Lukwasa et al. (2022). Extreme precipitation events that cause drought and flood incidents are prevalent in southern Sudan (Lukwasa et al., 2022). Coping mechanisms included spontaneous, involuntary, and hasty reactions to sudden danger. Thus, the behaviours and activities that occur within the production system are referred to as coping strategies (Eriksen et al., 2005).

The bulk of the population depends on agriculture for a living; hence, the unpredictable distribution of rainfall also had a negative impact on this industry.

Floods, droughts, and rising temperatures between 0.5 and 1.3 degrees Celsius between 1960 and 2039 were all signs of climate change (FEWSNET, 2013b; UNEP, 2018). Due to this, South Sudan ranks fifth in the world and is more susceptible to the effects of rising temperatures as well as more variability in rainfall (Bodegom et al., 2015; UNEP, 2018). Ninety percent of households in South Sudan rely on climate-sensitive livelihoods like farming, raising livestock, fishing, gathering, and trading wild foods (Bodegom et al., 2015). On the other hand, 81% of households cultivate land, 74% raise livestock, and 22% engage in fishing, according to UNEP (2018).

Sudd Wetland is extremely vulnerable to temperature and precipitation fluctuations. Warm temperatures and an erratic precipitation distribution pattern were seen in the Sudd Wetland (Sutcliffe& Parks, 1987; Rebelo et al., 2012). Between 1900 and 2000, the minimum and maximum temperatures rose by 1.5 and 0.6 ^{0}C, respectively, according to Mohamed and Savenije (2014). During the same time period, precipitation varies substantially from year to year and decreases slightly from southwest to northeast.

Mohamed et al. (2006), for instance, estimated the yearly evaporation rate in 1995, 1999, and 2000 to be 1460, 1935, and 1636 mm, respectively. This indicates exceptionally high evapotranspiration on a monthly and annual basis. The maximum temperature increased by 0.6 ^{0}C in 100 years, while the minimum temperature increased by 1.5 ^{0}C between 1900 and 2000 (Savenije, H & Mohamed, 2014). According to John et al. (2013), there are typically weeks of dry weather after a false start to the rainy season.

Families in the Sudd area have many means of subsistence: 89% work in agriculture, 80% care for livestock, and 24% fish (Quinn et al., 2019). The coping mechanisms described by John et al. (2013) involve farmers planting a variety of crop varieties and eating leaves and wild fruits. Seldom have the perception and adaptation methods of people living in the Sudd Wetland been thoroughly investigated concerning climate change and variability. According to Alam, G.M.M.; Nile et al., 2015; Gandure et al., 2013,

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

adaptation methods are essential for assisting local communities in coping with harsh weather conditions and related climatic variation.

In this article, the perception of people regarding climate change and fluctuation in the Sudd wetland is examined. The primary focus is on (i) people's understanding of climate change and variability; (ii) how households perceive these issues; and (iii) identifying the coping mechanisms they adopt. The remainder section of this article provides a comprehensive description of the methodology (Section 2), and Section 3 presents the findings and a discussion of the research. Section 4 concludes, and Section 5 offers recommendations.

METHODOLOGY

Both qualitative and quantitative research methods were applied in this study. In order to complement one another, the study used both qualitative and quantitative methodologies (Cohen et al., 2007). As a result, for triangulation, we used qualitative and quantitative approaches (Campbell & Fiske, 1959). Therefore, data for the study were collected from primary and secondary data sources.

Next, we employed Hypothesis. A hypothesis, according to Cohen et al. (2007), is a claim that suggests a connection between two or more selected elements. It is expressed in a manner that suggests testing. In order to determine whether the residents of the Sudd Wetland are aware of climate change and fluctuation, we used it in our research. The hypothesis is written as follows: alternative hypothesis H1 = 0, null hypothesis H0 = 0. We hypothesised that the Sudd Wetland's inhabitants are unaware of climate variability and change. When put to the test, results may indicate acceptance or rejection. The sections below provide the research methodology in depth.

Description of the Study Area

According to Rzoska (1974), the Sudd Wetland is located between 6′ and 9′ 8′ N and 30′ 10′ and 31′ 8′ E as seen in **Figure 1b**. It passes through Jonglei State (from South East), Upper Nile State (North East), Lakes State (South West), Unity State (North West), and Central Equatorial State (South) as it travels across South Sudan from south to north see **Figure 1a**). It is one of the biggest freshwater ecosystems in the world, with an estimated extent of 57,000 km2 (UNESCO, 2020).

The enormous Sudd wetland is formed when the White Nile empties into a shallow dip from Lake Victoria (UNESCO, 2020). The Sudd Wetland has an average annual temperature of 36 °C and receives 910 mm of precipitation in the summer, fall, and spring, according to Zeleke et al. (2024). For instance, Bor in Jonglei state has the lowest annual mean temperature (18–40 °C) and the least quantity of precipitation (500–700 mm). Wau in Western Bahr el Ghazal State has the greatest temperature (22–40°C) and receives the maximum precipitation (1,100–1,300 mm), according to Zeleke et al. (2024).

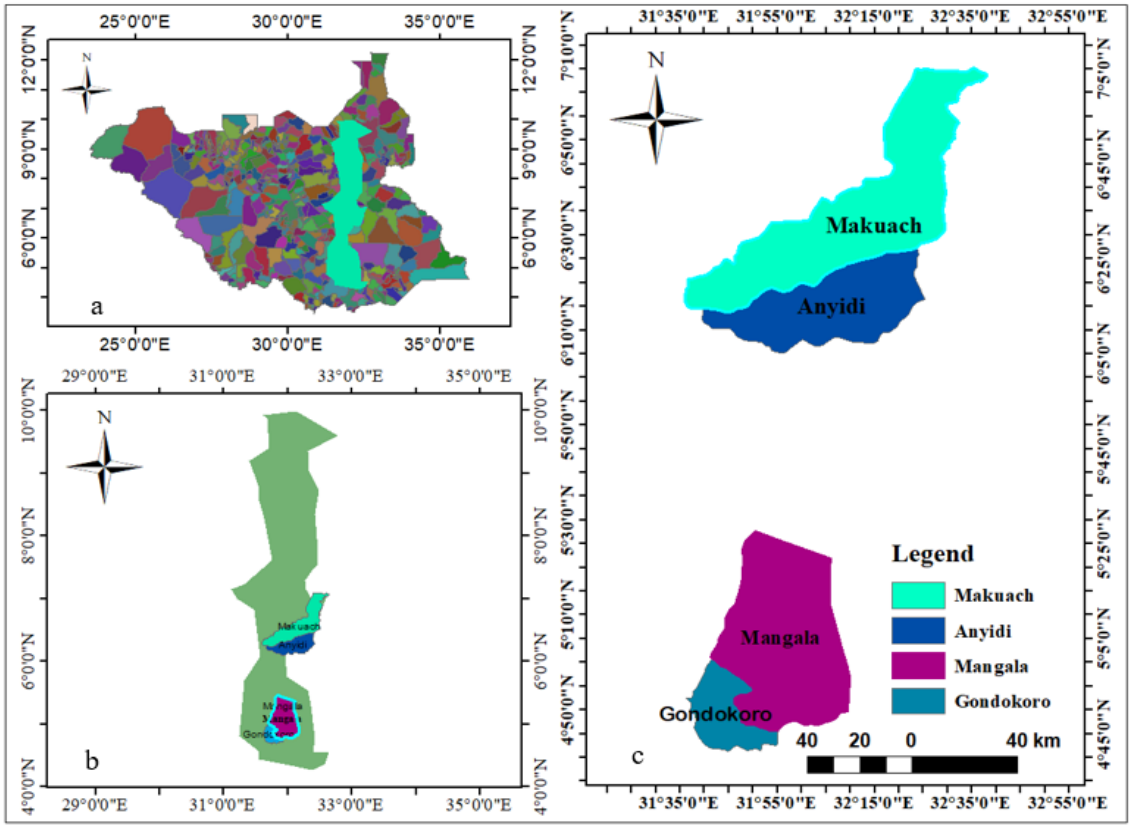
According to Shukla et al. (2019), Sudd Wetland's geographic location, like that of other tropical places, results in substantial climate variance. The primary rainy season of the Sudd-wetland, with geographical diversity in the south, north, and centre regions, is JJA. According to Zeleke et al. (2024), the majority of wet years in the Sudd wetland's south were 2001, 2011, and 2012, while the majority of dry years were 1984, 1997, 2008, and 2009. The north Sudd-wetland was dry in 1984, 1997, 2008, and 2009, and wet in 2001 and 2012. In the wetland's central region, 2011 and 2013 were wet years, while 1984, 1997, 2008, and 2009 were dry. The only significant difference between the wet and dry years occurred during the summer, and they occurred in all three of the main variance zones.

This study was conducted in four payams—Gondokoro, Mangala South, Anyidi, and Makuach, selected from the Sudd Wetland **Figure 1c**. The four payams were chosen on purpose because of their various locations within the Sudd Wetland and their experiences with climate fluctuation and change. Furthermore, according to FEWSNET (2013b), the population share a common livelihood in farming, fishing, and the raising of cattle. Anecdotal evidence suggests that

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

climate fluctuation and change represent a serious hazard to the local population, as well as field research.

Figure 1: South Sudan (a) Sudd Wetland (b) and the Study Area Sites (c)



The inter-tropical convergence zone's movement influenced the Sudd's climate, namely the distribution of rainfall, which varied annually and showed an uneven decline from southwest to northeast (Rebelo et al., 2012). The southwestern region received 1500 mm of rain annually, the plains received about 900 mm, and the northern region received 600 mm.

April through November is when the rainy season occurs, peaking in July and August (Soliman & Soussa, 2011). December through January has the lowest average temperature of 30°C, with a maximum of approximately 42°C in February. The Sudd topography is extremely flat, with slopes of less than 0.01%, and the soil is primarily clay (Savenije, H, & Mohamed, Y., 2014).

Winter was the season when the temperature peaked. In the Sudd Wetland, the amount of precipitation decreases from the southwest to the northeast. On the other hand, the Sudd Wetland's southwest to northeast region has milder temperatures.

For instance, there is a lot of variation in the amount of precipitation throughout the summer and spring. In their investigation, Tedesse et al. (2024) verified that flood and drought events have an impact on the Sudd wetland. A protracted drought followed by another extended flood could have a major negative influence on pastoralists' means of subsistence in the studied areas.

Large-scale climate variability patterns (changes in sea surface temperatures (SSTs) across the Indian, Atlantic, and Pacific Oceans) that affect macro-scale pressure systems and atmospheric dynamics throughout the Horn of Africa are the main cause of the complex spatial-temporal variability of rainfall over the Sudd Wetland. The intermittent occurrence of these two diametrically opposed hydro-meteorological dangers may progressively reduce the carrying capacity of the

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

wetland ecosystem and reduce pastoralists' ability to adjust to a changing climate. Tedesse et al. (2024) reported considerable spatiotemporal variance in the Sudd Wetland's mean annual temperature of 36 ◦C. From the southwest to the northeast of the Sudd Wetland, the temperature peaks during the winter.

The research area's household count (HHs) was obtained from the Southern Sudan Statistical Year Book (2010) for the sample size. Since South Sudan hasn't conducted a new census since 2010, we have been using the 2010 data. 11,733 households in all were spread among the three payams (SSCCSE, 2010). The sample size where the degree of confidence is 95% and P.5 was determined using the Yamane formula (Israel, G.D, 1992).

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

Where N is the size of the population, e is the level of precision at.5, and n = sample size.

There were 387 HHs in all, with a sample size of ±.5% and a 95% confidence level.

$$N\,[\text{Payam}] = N\,[\text{Household Payam}] \times \frac{n_0\,[\text{all Payams}]}{N\,[\text{Total Payams Household}]}$$

The number of houses chosen from Anyidi, Makuach, Mangala South, and Gondokoro was 137, 153, 49, and 48, according to the calculation above. A total of 387 persons made up the sample.

The study included two sample strategies: purposeful sampling and basic random sampling techniques. According to Cohen et al. (2007), every individual inside the research region has an equal probability of being chosen through simple random selection. Only informed individuals participate in the purposive sample, and the researcher builds the literature from their experiences.

The homes in the research area make up the sampling frame. Because households make up the majority of social and economic units that contain resources for production, distribution, and consumption, they provide an ideal sample frame. In line with previous research, we therefore used the household as our unit of analysis (Deressa et al., 2011; Shrestha et al., 2017). The head of the household, as an individual, served as the main sample unit. While we used selective sampling for the Focus Group Discussion and Key Informants, we nevertheless used a random selection of individuals from the House.

The data collection was from October to December 2022, and household questionnaires, focus groups, and key informant interviews were used to collect data. To guarantee that every family head had an equal chance of being chosen for the study, the houses were chosen at random. Voluntarily, the heads of household who eventually became the people were permitted to reply to the structured questionnaire. The questionnaire's items were centred on coping mechanisms, climate variability, climate change, and variability of the climate.

To complement each other, the study used a mixed methodology that included both qualitative and quantitative methods (Cohen et al., 2007). The research included quantitative and qualitative triangulation techniques (Campbell & Fiske, 1959). As a result, primary and secondary data sources provided the study's data. The section below has the details.

The historical data set for the baseline period, which was obtained from (http://globalweather.tamu.edu) gridded data, covered the years 1979 to 2014. The South Sudan Meteorological Service (SSMS) has a short history of data collection because of protracted instability and conflict in the nation. Even the data sets that are currently available are incomplete.

We gathered primary data from the field by having them complete the HHs survey form. The questionnaire consists of both closed- and open-ended questions. A total of 387 persons in the research region received questionnaires at random, making them our respondents.

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

Participants in the focus group included elderly people 45 years of age and older. Elderly individuals in the research area have a custom of telling family members stories about their culture, weather, and climate. The locals were able to preserve information and recount past experiences regarding the variability and climatic change of the research area in this way. Six to ten participants participated in the focus group discussion as interviewees to share their experiences (Deliens et al., 2014; Moretti et al., 2011).

In the Sudd Wetland, fourteen focus group discussions (FGDs) were held with a total of six participants in each. The questions mostly addressed perspectives of climate change, coping mechanisms in agriculture and livestock, and climate variable difficulties. The majority of participants were pastoralists and farmers. Understanding how people perceive the variability, impacts, and coping mechanisms of climate change was one of the key goals of these focus group discussions.

The FGD results were used to gain a general understanding of the effects, changes in climate, and coping mechanisms for triangulation. Triangulation, according to Cohen et al. (2007), is used to look into the perspectives of many actors. Focus groups were held in each Payam to confirm the data from the surveys, such as the start and end of the rainy season and climate extremes. After explaining the purpose of the study to the participants, those who volunteered were selected in front of the assistant chief of the community. Fluent Dinka language research aid made translation easier in Anyidi and Makuach. Here, a group's focus group discussion lasted for two hours. Four focus group discussions were held in Anyidi, and six focus group meetings were held in Makuach.

On the other hand, the members of Gondokoro Payam and Mangalla Payam speak the same language, which is Bari. There was no language barrier in this instance. The researcher and the assistant recorded the information from the FGD interviewees during the sessions on a generic sheet of paper, which was later transcribed into a single FGD interview guide. This focus group discussion lasted for an hour, and we conducted two FGDs in each Payam.

Key informant interviews were also used to perform a field investigation in the Sudd Wetland. The purpose of key informant interviews was to gather qualitative data on people's perceptions of temperature, climate change, rainfall variability, and their experiences with unpredictable rainfall, floods, and droughts. Apart from the coping mechanisms employed by farmers and livestock caretakers, four chiefs provided important information: Anyidi, Gondokoro, and Mangala South. These key informants were specifically chosen for the sample due to their extensive understanding of the Sudd wetland's climate.

Data Analysis

To identify climate change and variability, we looked at the minimum, maximum, and rainfall data for the climate. Here, we examine critically the trends and variability in the yearly mean and R^2 values of the climate variables. In the second phase, we used questionnaire counts and descriptive statistics to analyse how households perceived climate change and variability, as well as their coping mechanisms. Numerous papers have undergone this kind of analysis in the literature (Sawe et al., 2018).

To describe the trend of drought, the Standardised Precipitation Index (SPI) was used for the baseline period of 1979–2010. It serves as an index for early warning systems and drought monitoring (WMO, 2010). The SPI has a low data requirement, is computed over a variety of periods, and is easy to understand (El agib & El haj, 2011).

To analyse the fluctuation in the lowest and highest temperatures, we employed linear regression trend analysis. Trend analysis, according to Bamuhangi et al. (2016), shows the overall movement of the temperature and rainfall patterns. Additionally, it might help to clarify and improve understanding of the variability in the meteorological data. The line chart shows the

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

trend pattern using equation (1). The following equation, y=mx+c, has y as the temperature change factor (≲C), x as the series' year (end year– first year), m as the trend's slope, which indicates the detected change, and C as the regression coefficient.

$$y = mx + c \quad (1)$$

The dataset for the Short-wave radiation represented the Sun's heat. The unit is watts per square meter (Wm^{-2}) and is downloaded from the climate engine Website link. https: app.climateengine.org/climate Engine. It was at an altitude of 700 hPa pressure level above 600 meters above sea level. 700 hpa is used based on the latitudinal classification of the Sudd Wetland (Rebelo, 2012). We have used 700 hpa because the average altitude of the Sud wetland is about 500 m.

The completed surveys were examined, and those that included no missing data were coded and subjected to statistical analysis using the Statistical Package for Social Science (SPSS V.23). The following are the quantitative results of the qualitative data responses as determined by the descriptive statistics methods (Boru & Koske, 2014; Elum et al.,2017; Grant, 2010; Sawe et al.,2018). To verify the quantitative results, content analysis (Cohen et al., 2007) was performed on the open-ended questions.

According to Hatch (2002), typologies are collections of phenomena that represent subsets of a category. In order to compare the observed frequencies of the typologies with a binary value of Yes or No variable to the frequencies predicted under a binomial distribution with a given probability parameter of 0.01 for the hypothesis testing in the four Payams, we built typologies. Given that the premise was that households were ignorant of climate variability and change.

The first typology included people's perceptions of yearly temperature fluctuation, while the second dealt with people's perceptions of yearly rainfall changes. The test association and test strength between two or more groups are provided by the Chi-squared statistics (Ott, R. & Longnecker,2010). The focus group discussion data were subjected to content analysis, which involved a methodical classification process to uncover interviewee themes within categories that encapsulated the research's content (Cohen et al., 2007).

For accurate interpretation of study findings, statistical tests have proven to be a valuable tool (Turhan, 2015). We employed the Pearson Chi-square test and the Binomial test in our investigation. The dichotomous variable of the typologies in the Yes/No question about climate change is examined using the binomial test of significance. On the other hand, the goodness of fit is tested using the Pearson Chi-Square test of significance. Chi-square compares a particular cell for statistical significance, per Sharpe, D. (2015). The study employs the chi-square to examine the relationship between people's reactions' variability and their coping mechanisms for climate change.

RESULT AND DISCUSSION

In Anyidi, Makuach, Gondokoro, and Mangala South Payam in the Sudd Wetland, people's perceptions of climate change, variability, and coping mechanisms were the main topics of this empirical study's findings. The primary sources of information were fieldwork, people's experiences and perceptions of rainfall, and temperature comparisons with meteorological data.

Demographic Characteristics of Respondents

Gender, age, and occupation were the three demographic factors taken into consideration for the respondents from Anyidi, Makuach, Gondokoro, and Mangalla South Payam.

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

Table 1: Demographic Characteristics of Household Respondents

	Anyidi Payam (%)	Makuach Payam (%)	Gondokoro Payam (%)	Mangalla Payam (%)
Gender	Female 0.7	Female	Female	Female 8.2
	Male 99.3	Male 100	Male 100	Male 91.8
Age	45-48 8	45-48 27.8		45-48 20
	49-52 14.6	49-52 26.8	49-52 56.3	49-52 18.4
	53 and above 77.4	53 and above 45.8	53 and above 43.8	53 and above 79.6
Occupation	Farmers 63.5	Farmers 92.2	Farmers 100	Farmers 98.0
	Not Farmers 36.5	Not Farmers 7.8		Not Farmers 2.0

Source: *Field Work 2022*

Because the population followed a patriarchal system, male respondents dominated in all Payams, as shown in **Table 1**. Male respondents' rates in Anyidi were 93.3%, while female rates were 0.7%. After that, 14.6% of respondents were between the ages of 49 and 52, while 77.4% of respondents were older than 53. In a similar vein, in Makuach Payam, 41.6% of respondents were older than 53, 26.7 were between 49 and 52, and only 31.7% were between 45 and 48. Between 1979 and 2014, this age group's experiences and understanding of the climate throughout their period of settlement were greater. In Anyidi, 63.5% of the population worked as farmers, while the remaining 36.5% were employed in other industries.

These include those in the health, military, law enforcement, religious, and non-governmental organisations. The 100% male respondent rate in Makuach indicates a significant gender gap. 53-year-old respondents made up 45.8% of the sample, followed by 45-48 years (27.2%) and 49-52 years (26.7%). In Makuach, 92.2% of the population were farmers, while just 7.8% did not farm. They held positions in the government, the military, the police, the church, and non-governmental organisations, among other fields.

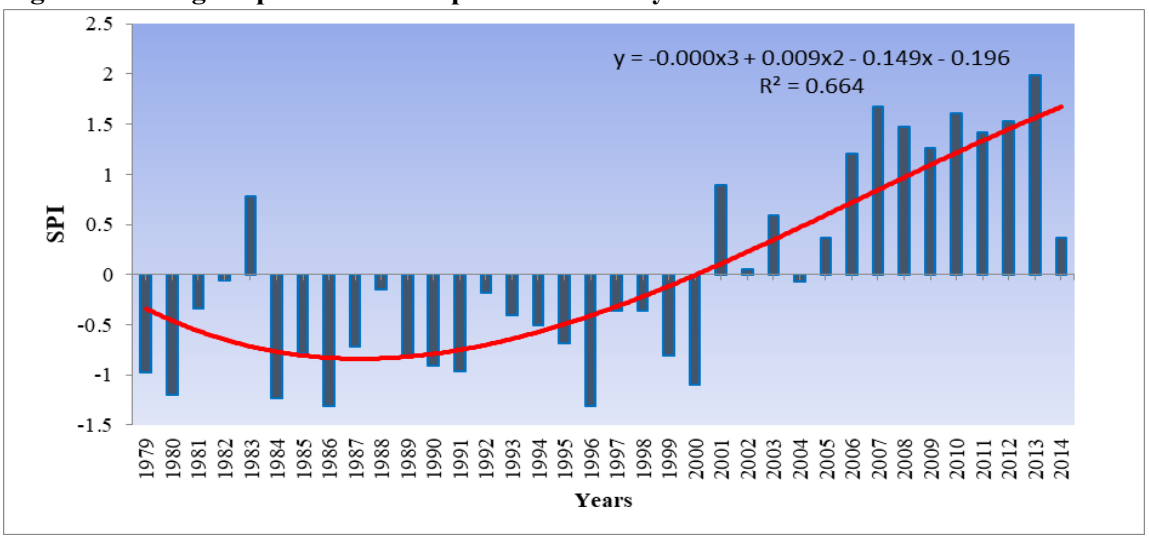
There were only male responders in Gondokoro Payam. See **Table 1**. 56.4% of respondents were between the ages of 49 and 53, while 43.5% were older than 53. Farmers make up the whole workforce in Gondokoro because it is the primary source of income. Nonetheless, a few family members work in Juba City's government, military, and health sectors. 8.2% of respondents in Mangala South Payam were female, compared to 91.8% of male respondents. 79.6% of respondents were above 53, 20% were between 45 and 48, and 18.4% were between 49 and 52 years old. In Mangala South Payam, 98.0% of workers were employed as farmers, and 2.0% worked in other industries, including government officials, the army, police, and county office security guards.

Climate Data

The climatic data from 1979 to 2014 included rainfall and temperature. It was displayed using a chart, regression trend analysis, and frequency analysis.\

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

Figure 2: Drought Spells and Wet Spells in the Study Area 1979-2014.

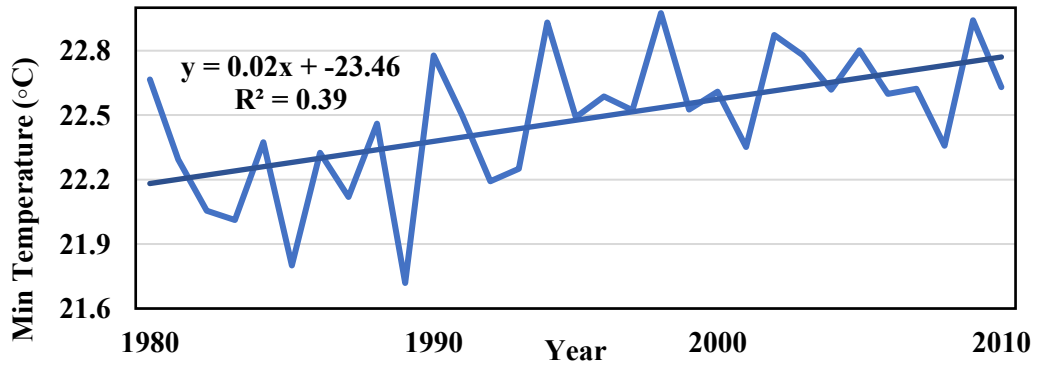


During the rainy season, from 1979 to 1999, the polynomial showed minimal annual precipitation; however, from 2007, precipitation increased. 28 years of dry spells with 78% and 8 years of wet spells with 22% were shown by the Standard Precipitation Index (SPI) result. (Figure 2). The outcome confirmed what most households felt, which was that the frequency of droughts had increased in their respective Payams. According to Yagoub et al. (2017), the SPI indicated a high frequency of droughts in 1984–1985, 1986, 1991–1992, 2000–2003, 2005–2006, 2007–2010, and so on. Furthermore, a study by Zelke et al. (2024) provided more specific data that were comparable. The years 1984, 1997, and 2008 saw the North Sudd wetland dry out. The years 1984, 1997, 2008, and 2009 were the most notable dry years in the Sudd Wetland's southern region.

All of the research sites (Anyidi, Makuach, Mangala, and Gondokoro Payam) saw similar dry and rainy years. Only in the summertime may there be a noticeable change. During the focus group discussion, a member brought up a few dry years that they had experienced in their lifetime. For instance, FGD participants in Anyidi and Makuach recalled certain years of drought that happened in 1983, 1987, 1992, 2000, 2002, 2005, and 2011. Likewise, the years were 1987, 1997, 1983, 1985, 2002, and 2010 in Gondokoro and Mangala South. The SPI result about drought and floods from 1979 to 2014 accurately captures these years.

Respondents mentioned that their payams, particularly the Boma near the White Nile River, had flooded. The worst flood, which killed animals, damaged houses, and ruined crops, occurred in 2013. The outcomes matched the report of Zelke et al. (2024), WMO (2015), and UNEP (2018).

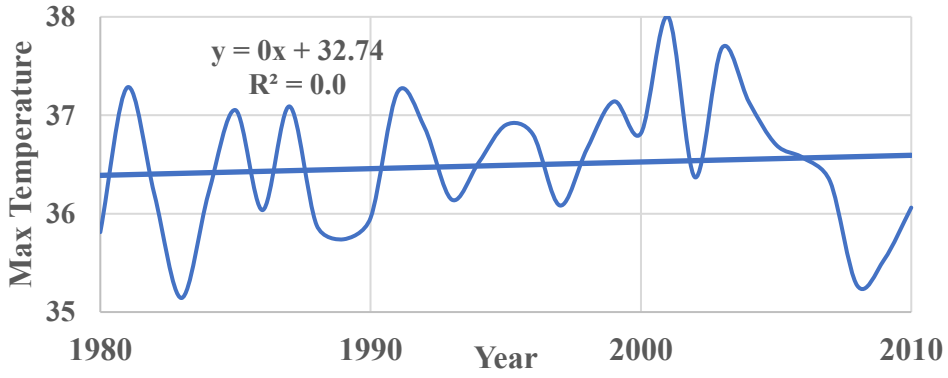
Figure 3: Minimum Temperature Trends and Variability in the Sudd Wetland 1981-2010



Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

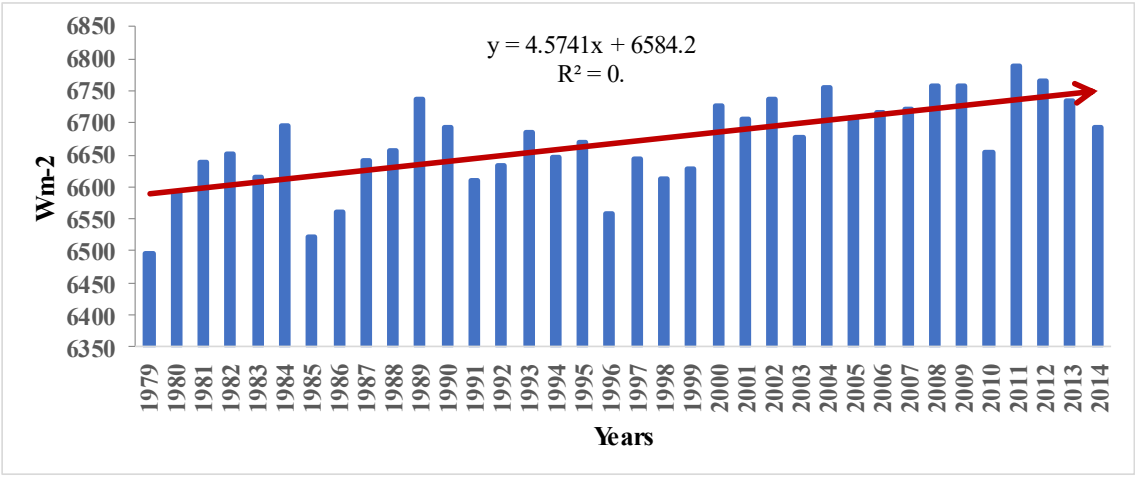
The minimum temperature computation took into account 30 years, from 1981 to 2010, as shown in **Figure 3**. 22.5°C was the long-term mean. The four coldest years with fluctuations below the long mean were 1988, 1995, 2001, and 2008. The La Niña Cycle years of these years accord with the data from (Null, J, 2017). Every other year was above the long mean, suggesting a high degree of variability in the research field. Nonetheless, every year exceeded the historical mean, suggesting a warming of the climate. The regression line shows an increase of 0.23◦C every decade and 0.023◦C annually. The data indicates a 1◦C increase between 1981 and 2010, which is comparable to the warming observed in South Sudan, as reported by Bodegom et al. (2015).

Figure 4: Maximum Temperature Trends and Variability in the Sudd Wetland 1981-2010



The maximum temperature computation took into account 30 years, from 1981 to 2010, as shown in **Figure 4**. At 36.5°C, the long mean was the years with the fluctuations above the long mean that were the hottest were 1990, 1998, and 2003. The El Niño cycles throughout these years align with the data from (Null, 2017). Every other year, both above and below the long mean showed variations in the research area. The maximum temperature rises more gradually than the minimum temperature. The regression line shows an increase of 0.01◦C every decade and 0.001◦C annually. It indicated a 0.03◦C increase from 1981 to 2010. The findings indicated that both the Sudd Region's maximum and lowest temperatures are rising. The outcome is comparable to that of Savenije and Mohamed (2014).

Figure 5: Short-wave Radiation Trends in the Sudd Wetland 1979-2014



We employed shortwave solar radiation to calculate solar heat, and as **Figure 5** showed, the trend of solar heat over the Suddwetland was rising. From 1979 until 2014, the sun's heat increased. However, there were several years when it fluctuated. A rise of 4.574 watts per square meter (Wm-2) per year and 45.74 Wm-2 per decade was shown by the regression line. The data

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

set result agreed with the Sudd Wetland people's sense of the sun's rising heat in the entire payams. **Figure 5** shows the results, which show that the highest solar radiation in 2011 was 6788 Wm2, and the long-term mean was 6669 Wm2 from 1979 to 2014.

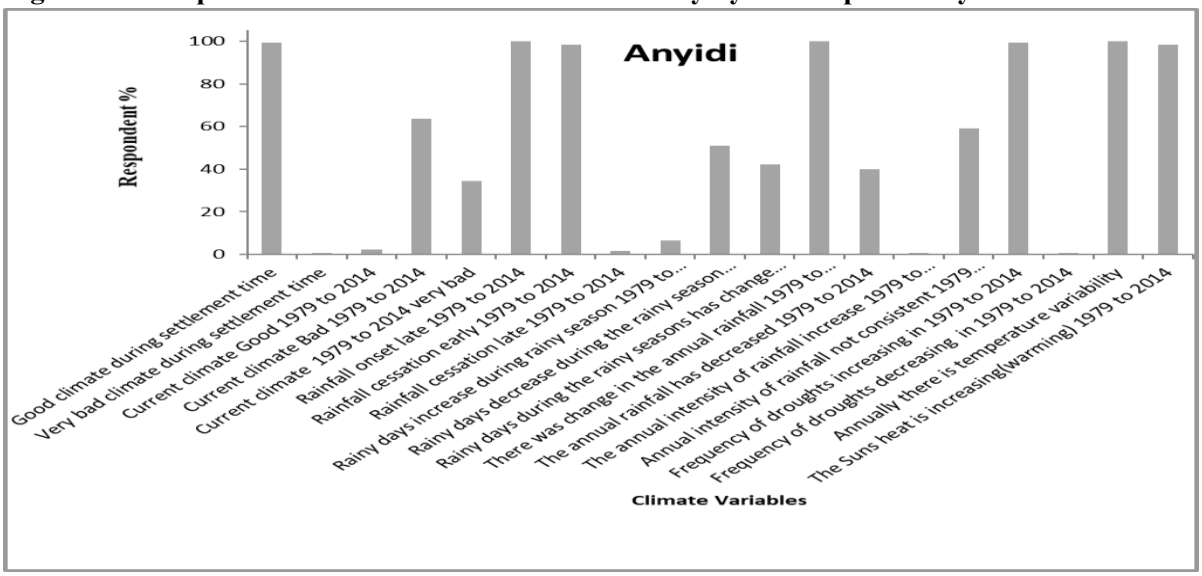
People's Perception of Climate Change, Climate Variability, and Impacts in Bor

Bor is a relatively large county in the Sudd wetland; nevertheless, for our study, we only looked at Anyidi and Makuach Payam.

People's Perception of Climate Change and Climate Variability in Anyidi

The questionnaire's questions, which first examined the climate during colonisation and then the years 1979 to 2014, formed the basis of the respondents' perceptions.

Figure 6: Perception of Climate and Climate Variability by the People of Anyidi



The seventy-year-old Head Chief of Anyidi Payam described the weather during the time of settlement as told to him by his father. Since the 1920s, people have lived in Anyidi for a very long time. Anyidi was fine when my father was a child; it rained early in March, and farmers there produced and gathered enough sorghum to feed the family for the entire year. There was plenty of grass, so our livestock produced ample milk. Based on information from his ancestors, his account of the weather throughout the period of settlement was good.

According to the interviewees, 99.3% of them rated the climate during the Settlement (1920s) as good, see the **Figure. 6**. In Anyidi, 100% of respondents agreed that the rainy season began later than expected, and the FGD discussant also agreed that the rainy season began later than expected—that is, in April or May rather than March. "The rainy season onset is a very late start in May or June instead of March," stated 75-year-old Reverend Michael. Beginning of the rainy season, as one of the locals explained: "In Anyidi, during the settlement period, the rainy season begins in March and lasts for two to four days per week. This served as a signal for the preparation of the land."

The land is then fenced off to prevent livestock from accessing it using natural materials, primarily thorns. It may take a month to complete the fencing by gathering thorns and even planting. Cowpea is planted during fencing because the leaves make a delicious vegetable. A feddan, or half-feddan, is 4,200 square meters, and it was used as a farm. But these days, the majority of rainfalls are erratic, and sometimes they even begin in May. The beginning of the rain, with the majority of FGD participants predicting that the good rain could arrive by the end of April. The farmers were confident in the success of their harvests, and they sowed sorghum.

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

As was previously said, the rainy season was adequate during the settlement period, and it may even rain during Christmas from March through December. According to Petersen and Fohrer's (2010) study, comparable research on the mechanics of flooding and drying of the seasonal Sudd flood plains, where the rainy season lasts from late March to early November, supports the findings 99.5% of respondents in Anyidi Payam reported experiencing more changes between 1979 and 2014 as they became aware of the start and end of the shift throughout time.

April through May, June, July, August, September, and October were the wet seasons. But there was variation in the amount of rain that fell during these months. For instance, 51.1% of respondents said there were fewer wet days, while 42.3% said there were more, and 6.6% said there were fewer rainy days during the specified months. According to the focus group discussion, there was either one brief shower spaced widely after a week or three instances of rain in June. This accounted for the irregular rainfall that had an impact on crops that had been sown in the farms in April and was consistent with the findings of (BRACED,2016a). Either in October or November, the rains stopped.

The yearly rainfall had changed, as reported by the respondents, and the descriptive analysis showed that 6.6% of respondents thought there had been more rainfall in some years, based on their personal experiences with floods in 1988 and 2013. As a result, 40.1% of respondents thought that the yearly intensity had dropped, while the majority (59.1%) said that the yearly rainfall was inconsistent. According to 99.3% of them, there has been an increase in the frequency of drought in their Payam.

There was an increase in temperature, according to respondents in Anyidi, and there was 100% annual temperature variability. As a result, the minimum and maximum temperatures in (Figures 1a and 1b) match the validity of the respondents when comparing their reactions to temperature increases with the meteorological data. The findings regarding temperature were consistent (Savenije & Mohamed, 2014). The heat from the sun was felt to be 98.9% hotter due to local warming.

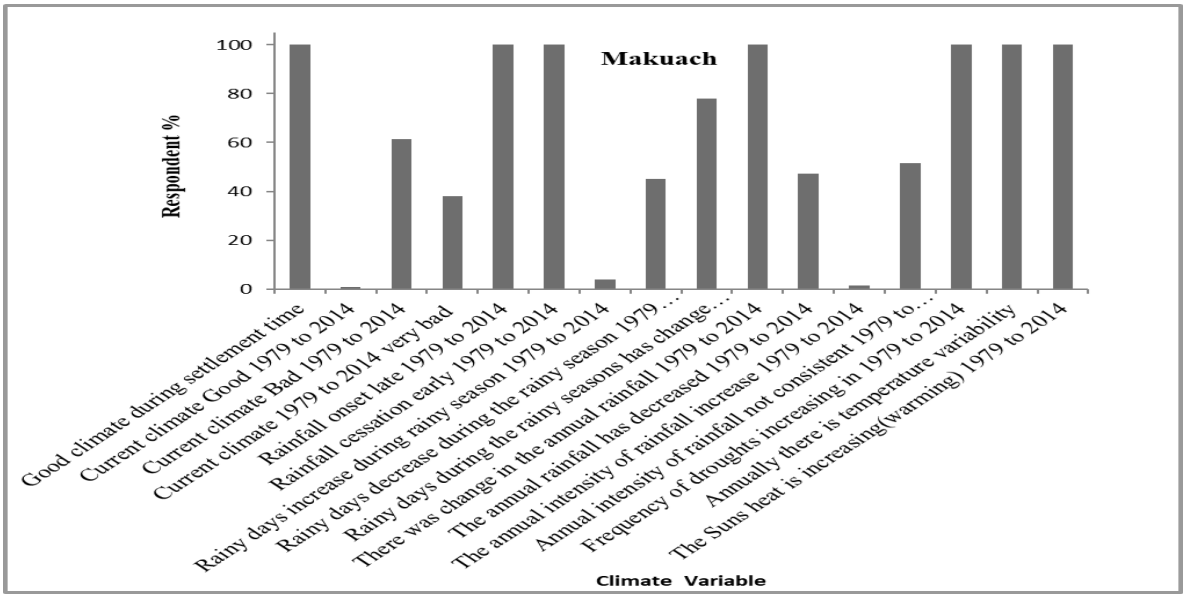
People's Climate Change and Climate Variability Coping Strategies in Anyidi

On their farm, the people interplanted corn with groundnuts, cowpea with groundnuts, or maize with okra. Intercropping (cowpea and groundnut, pumpkin, and maize) was practised by households in Mereng Boma. When May rains are delayed and the sorghum dries out, they move the planting date and wait for the rains to come back. Subsequently, sow sorghum in July for the November harvest. The UN agencies assist households in coping with the unpredictable rainfall and growing frequency of droughts.

For instance, we saw the FAO distributing short-maturing sorghum and okra varieties to the homes of vulnerable women while we were in the field. Under the Resilience and Food Security Program (RFSP) of transforming livelihoods, USAID, CRS, and Save the Children, a Consortium of NGO, have deepened the Wer mel water pan, which holds water for people's households and their animals. This result is consistent with Deressa et al. (2011), who found that increased temperatures affect water supplies as evaporation rates rise. A maximum of 100 cows, 5 bulls, 100 goats, and 20 sheep can be owned by one household. The livestock in Anyidi used the following strategies: (i) they moved to cattle camps in the marshy areas along the White Nile for open grazing; (ii) they used spears to practice fishing; and (iii) some of them grew veggies. An individual may provide 1–5 animals to form a herd of 45 in any cattle camp.

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

Figure 7: Perception of Climate and Climate Variability by the People of Makuach



The climate in the 1920s, when colonisation first began. The stories from key informants, oral histories, and interviews suggested that the climate was favourable. Rainfall was steady, the land was farmed, a decent crop was produced, and the cattle had access to healthy grass and ample milk from the goats and cows. In Makuach, people had a 100% positive opinion of the climate during the times of settlement. They perceived a negative environment from 1979 to 2014 as very bad (61.4%). Just 0.7% of respondents thought it was good, while 37.9% thought it was very bad (**Figure 7**).

Therefore, out of 6 during the focus group Discussion in Makuach, one of the discussant age above 53 years had been farming in his two feddans farm reacted "…*rainfall was enough we get enough harvest because our crops grew well in 1950s but the current climate of 1979-2014 very bad a lot of Yak. In the Jieng language, Yak means drought*.'

100% of focus group participants stated that the rainy season began late, with the reason being that good rains began in the middle of April. 100% of the homes said that the rainy season ended early because it stopped in October rather than in December. According to a study conducted in the Sudd area, December gets the least amount of rainfall (Rebelo et al., 2012).

Approximately 78% of respondents felt that the number of wet days throughout the rainy season had changed, with 45.1% perceiving a drop since there is only a two- to seven-day supply of rain in June and August, when there is a high expectation of rain. 3.9% of respondents acknowledged that there have occasionally been more rainy days. Of the respondents, 54% admitted that the annual intensity of rainfall was inconsistent, 51.6 % experienced a decline, and 1.3% perceived an increase.

One hundred percent of the responders in Makuach thought that the annual temperature had increased and become more unpredictable. The findings regarding temperature were in line with research conducted in the study area; there was an increase in the minimum temperature and a rise in the maximum temperature (Savenije, H. & Mohamed, Y. 2014). The respondents were 100% correct in their assessment that the heat from the sun had made their surroundings hotter. Even during the rainy season, there was a dry spell that lasted the entire duration of the open water sources in the FGD. Furthermore, field observations and interviews with key informants, the chiefs, disclosed a decline in the amount of water available in their payams' open water pan and stream.

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

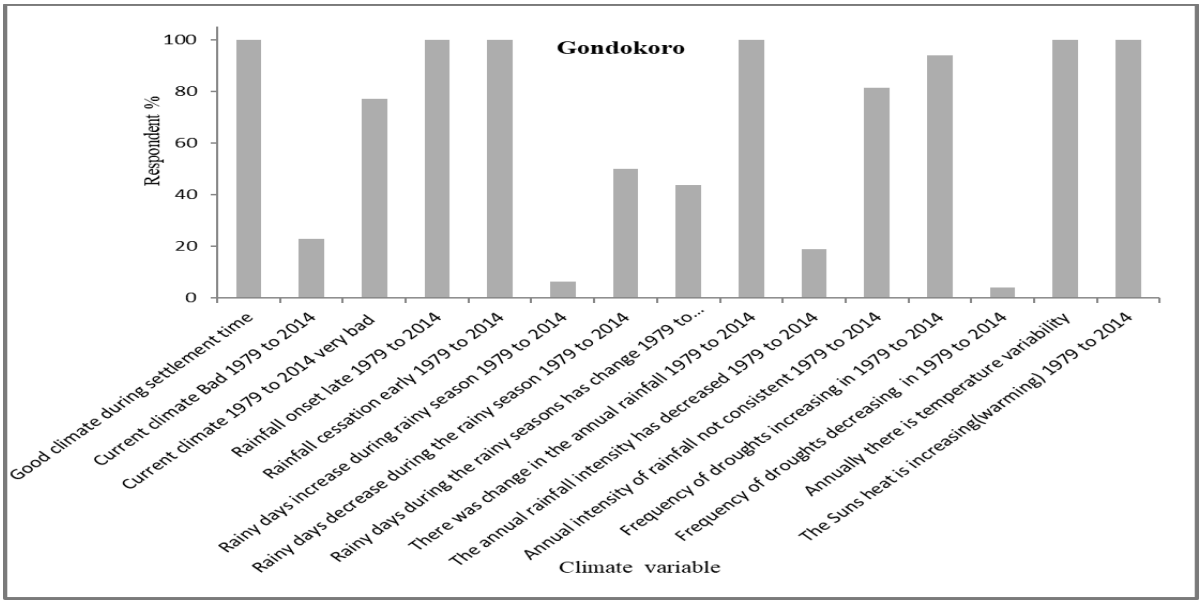
People's Climate Change and Climate Variability Coping Strategies in Makuach

The locals of Makuach cultivate their unique sorghum type, which is resistant to climatic fluctuations and is not consumed by birds. They intercrop, eat wild fruits during droughts, and move planting dates to June. The discovery of eating wild fruit was stated well (John et al., 2013). Roughly 50 cows, 2 bulls, 70 goats, and 20 sheep can be owned by a household. During the dry years, livestock had to travel five kilometres to find water in open water pans and establish camps next to the White Nile. According to published research, the results are similar across Africa (Boru & Koske, 2014; Cuni-Sanchez et al., 2019).

To provide water for residential use and drinking for livestock, Catholic Relief Services (CRS) built two hand pumps and animal troughs. Since 2015, those who live close to the chief's residence have received training on how to use the water that is constantly flowing to grow vegetables five meters in front of the trough. People who live distant from water sources travel great distances and establish cattle camps along the banks of the White Nile.

In summary, the residents of Anyidi and Makuach Payam felt that the climate was becoming more unpredictable year after year as the yearly rainfall decreased.
(FEWSNET, 2013a) states that in 2009, Anyidi and Makuach were covered by the entire state of Jonglei, with the onset occurring as late as July. Similar results were seen throughout the region (Ayanlade et al.,2017; Chandra & Mishra, 2013; Meze-hausken, 2018; Niles & Mueller, 2016) and in southern Sudan (FEWSNET, 2011).

Figure 8: Perception of Climate and Climate Variability by the People of Gondokoro



One of the Gondokoro Payam Head Chiefs, who was over seventy years old, described the weather during the settlement period based on what his father had told him. "Long ago, people had established in the settlements that are today known as Boma. It was even earlier than 1920, when British explorer Samuel Baker brought us to this land. Most of our ancestors were farmers, and it was from them that we acquired farming skills. Our land was good when my grandfather was a child; it rained all year long, starting in early February.

We farmed and collected enough vegetables, sorghum, and maize to last the family through the next year. We received adequate milk since our cows, sheep, and goats had enough forage in the same environment. The island had a pleasant climate when it was first settled in the 1920s. The major narrative aligned with the households, and 100% of respondents said that the climate was favourable in the past, as in **Figure 8**. Since there have been so many droughts between 1979 and 2014, it is difficult to predict when to plant due to

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

the unpredictable nature of the rainy season, as the chief continued. The SPI **Figure 2** reflects this.

People Observed Climate Change and Climate Variability in Gondokoro

Respondents in Gondokoro Payam rated the current climate from 1979 to 2014 as extremely bad (77.1%) and terrible (22.9%). Every respondent (100%) agreed that the rainy season started later than expected, and the FGD discussant also concurred. Because of the delayed onset, rain began to fall in April or May rather than March. The yearly rainfall was judged by 100% of respondents to have altered, and the pattern of rainfall was not consistent from year to year.

The FGD confirmed that the early cessation of rainfall occurred in November, as stated by 100% of the respondents. The rainy season took place in April, May, June, July, August, September, and October, according to UNEP (2018). However, there was variation in the amount of rain over these months. For example, during the one and only rainy season, the perceived number of rainy days decreased by 50%, changed by 43.8%, and increased by only 6.3%.

During the focus group discussion, they clarified that severe rain is expected three to five days a week in June, July, and August. Rainfall occurred four times in a month these days, or one small shower spaced widely apart. Respondents' awareness of drought frequency had grown by 100%. In Gondokoro Payam, 70% of respondents said that the yearly rainfall intensity was inconsistent, while 28.9% thought it had decreased, and 1.1% thought it had increased. The respondents in Gondokoro believed that the sun's heat was warming and that there was 100% yearly temperature unpredictability.

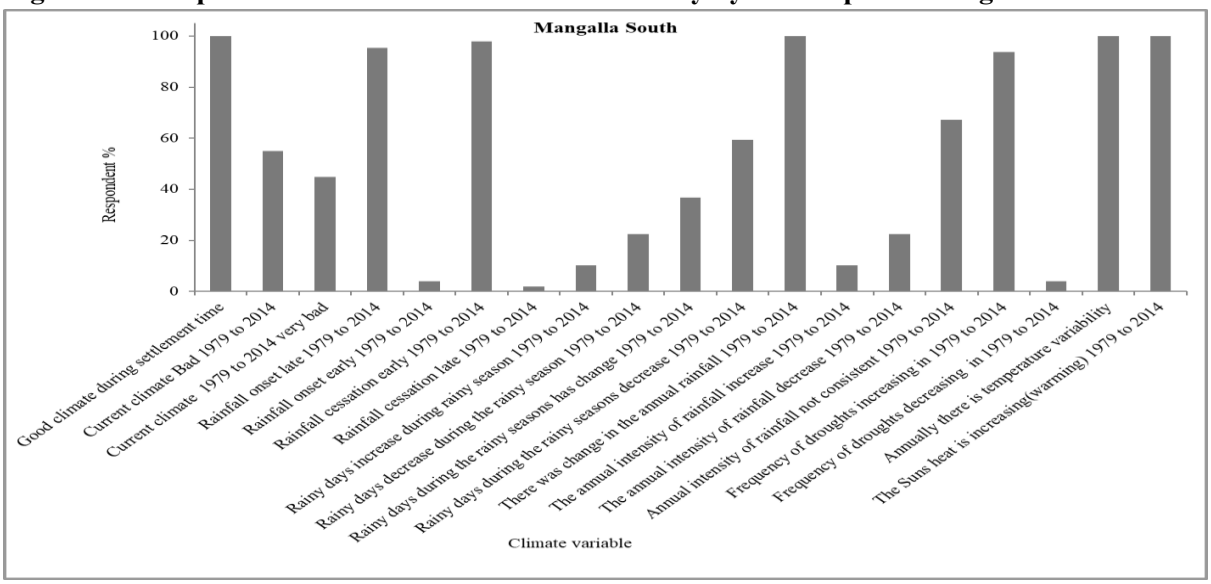
The Lekembe stream, which had entirely dried up, was cited by the FGD as an example of how their open water sources dry up earlier. There once was a way to cross the water from Gondokoro to Terekeka County. There were lots of fish and some crocodiles in there. The water table in Gumbolosok and Lengat decreased during the rainy season because these streams run dry even in December. The outcome is consistent with the Ministry of Environment's (2012) report, which said that South Sudan's numerous rivers and streams had been seasonalized and decreased due to changes in land use and climate. According to reports, Nepal's water resources are drying up as a result of fluctuating and declining precipitation (Poudel et al., 2017).

People's Climate Change and Climate Variability Coping Strategies in Gondokoro

The farmers in Gondokoro Payam moved to an island near the river and started using short-maturing plants that an organisation named BRACED had given them. Cowpea and sorghum were interplanted, or they would wait for more rain. In this area, there are 8 cows, 1 bull, 27 goats, and 4 sheep owned by locals. The sheep and goats were released to graze on dry sorghum stalks, and some of them took to the riverbank as coping mechanisms.

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

Figure 9: Perception of Climate and Climate Variability by the People of Mangala South



The 53-year-old head chief of Mangala South shared his observations about the local climate throughout the colonisation era and made a comparison between the 1979 and 2014 climates. The villages that are currently known as 'Boma' were not inhabited. The Turks brought the indigenous Bari people to this land before 1900, and we have lived here for a very long time, even before the British arrived. Our land was good when my grandpa was a child; it rained early in February and continued to do so until December, during which farmers would crop twice a year. The family had more than enough corn, sorghum, and vegetable produce. I own about seventy goats, two bulls, and fifty heads of cows. The current environment was terrible from 1979 to 2014.

We cultivated and were lucky to have a harvest because: (1) the rainfall was inconsistent, and (2) black pests attacked our crops. Our animals pass away from illnesses that are unknown to us, such as East African Fever. The inhabitants of Mangala gave 100% of their comments, which matched the stories told by their chief and the Gondokoro people. The climate was favourable. Rainfall was steady as indicated in **Figure 9.** The land was farmed, a good crop was produced, and the animals had access to healthy pasture and ample milk from the goats and cows. Here, a household raises a few chickens, 30-80 goats, and 15-20 cows.

Regarding the rainy days, 59.2% of respondents in Mangala thought they had reduced, 36.7% thought they had changed, and 4.1% thought they had increased. The FGD discussant, who stated that the rainfall pattern has become irregular and inconsistent, endorsed the altered and lowered proportion. According to their claims, the rain may not fall in May as predicted and may vary greatly in June, July, August, and September before ceasing altogether. This is comparable to research conducted by John et al. (2013) in the Sudd. The perception of decreasing rainfall was consistent with the fact that Southern Sudan has experienced a decline in rainfall since 1980 (UNEP, 2018). The two worst drought years were 1983 and 2000. Agropastoralists had a strong understanding of climate unpredictability, according to a comparable study (Boru & Koske, 2014).

In Mangala Payam, 50.3% of respondents acknowledged that the yearly rainfall intensity was inconsistent, 47.2% thought it had decreased, and 2.6% thought it had changed. The respondents said that the annual temperature varied by 100% and that the sun's heat increased by 100%. Hence, the validity of the respondents' replies to temperature increases in comparison to the minimum and maximum temperatures matched in the meteorological data.

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

People's Climate Change and Climate Variability Coping Strategies in Mangala South

Because of the rising temperatures in Radolo Boma, streams like Kulot and Kadoro begin to dry up in early December. The population moves to the bank of the White Nile River, where they begin cultivating mostly with short-maturing plants. Farmers either wait for more rain to fall or engage in intercropping (growing sorghum and cowpeas). This result is comparable to the Dabus watershed's coping mechanisms in North West Ethiopia. People in Mangala turn to selling some of their poultry and livestock.

Table 2: Significance of People's Coping Strategies during Climate Change and Climate Variability

Strategy	Anyidi N=136	Makuach N=153	Gondokoro N=48	Mangalla South N=49	Chi-square Value	Df	Asymp Sign(2-sided
Use of Early Maturing Seeds	84%	25.5%	22.9%	55.1%	117.232	3	.000*
Use of late Maturing crop	5.1%	.7%	100%	100%	9.821	3	.020
Rain harvesting for irrigation	3.6%	.7%	4.2%	100%	7.799	3	.050[b,.C]
Changing farming dates	72.3%	41.8%	100%	93.9%	84.392	3	.000*
Inter-cropping	81.8%	88.2%	100%	100%	19.257	3	.000*
Agro-forestry	2.2%	.7%	2.1%	2.1%	5.035	6	.0539[b,c]
Relocating to the riverbank	70.8%	11.8%	75%	71.4%	133.806	3	.000*
Seek Agricultural extension services	7.3%	6.5%	10.4%	14.3%	3.406	3	.333[b]
Do fishing	4.4%	13.7%	66.7%	32.7%	97.081	3	.000*
Relief from the NGOs and the Government	10.9%	76.5%	43.8%	20.4%	138.183	3	.000*
Other means	0.7%	5.2%	100%	100%	14.282	24	.0940[b,c]
Crop residues used as feed	2.9%	100%	18.8%	28.6%	33.371	3	.000*
Livestock watering from open water pans	10.2%	24.8%	100%	100%	59.600	3	.000*
Sales of some livestock	9.5%	30.1%	30.1%	40.8%	31.418	6	000*[b,c]
Migration with livestock to the riverbank	83.8%	69.3%	6.3%	44.9%	182.99	3	000*
Do fishing	10.2%	13.7%	100%	10.2%	7.433	3	.059*
Other coping strategies	99.3%	100%	100%	100%	1.830	3	609[b,c]

Source: *Field work 2022.*

Notes: Overall N= 387, significance at confidence level 95 % (0.05)

In **Table 2,** a noteworthy correlation was observed between a few techniques employed by farmers and livestock keepers and the strategy with a 95% confidence level. (0.05). * At 05. level, chi-square statistics are significant. People who believe that climate change and variability will negatively affect their farming also adopted multiple coping mechanisms in the research area, as did the cow keepers. Farmers in all the payams adjust their planting dates when there are insufficient or

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

inconsistent rainfalls and their anticipated crop yields are not met. According to studies by Asrat and Simane (2018) and Teshome (2017) and Sawe et al. (2018), and Eriksen et al. (2005), this result is comparable. Farmers adjust the timing of their agricultural operations in response to the cyclical phases of plant growth and the corresponding variations in temperature and moisture, as reported by Nyang'au et al. (2013). It happened after the rains had stopped, and they were certain that the soil had enough moisture to support development.

CONCLUSION AND RECOMMENDATION

Conclusions

Farmers in the Sudd Wetland Payams rely heavily on rain-fed agriculture, rendering them highly susceptible to the effects of climate change and variability. Over recent years, both minimum and maximum temperatures have risen. The Standardised Precipitation Index (SPI) has shown an increase in drought spells since 1979, with fewer wet periods. Residents across the four Payams have observed and understood changes in temperature and rainfall patterns as indicators of climate variability. They compare the favourable climate during settlement times with the period from 1979 to 2014, which they perceive as increasingly unfavourable. Rainfall has become unimodal and erratic, with noticeable decreases in monthly intensity and consistency, notably evidenced by floods in 1988 and 2013. Respondents have noted delayed rainfall onsets and earlier cessations, with concerns about decreasing rainfall intensity leading to stream drying. Although there were some contradictions among respondents, they were not significant. Coping strategies against climate change and variability have largely involved short-term measures. The intensifying heat in the Sudd Wetland exacerbates climate risks, contributing to heatwaves, reduced soil moisture, and stream drying. Given their reliance on rain-fed agriculture, farmers are particularly vulnerable. The national and state governments must create a supportive environment for climate adaptation strategies by allocating budgets for planned adaptations targeting farmers and livestock keepers.

Recommendations

The study utilised downscaled coarse-resolution satellite data due to limited gauge station data availability. To address this, we recommend the establishment of meteorological stations in Bor County and Juba County, encompassing Payams, to provide comprehensive meteorological variables for future research. During field data collection, female participation was notably low, underscoring the need to enhance women's involvement in upcoming research initiatives. Farmers should receive training on climate-smart agriculture principles and implementation through the creation of demonstration sites. The South Sudanese government must bolster coping mechanisms and integrate climate change adaptation across all relevant ministries, particularly in agriculture. Additionally, investments in drainage infrastructure in Anyidi and Mangalla South are essential to mitigate flooding observed during heavy rainfall periods.

REFERENCES

Asrat, P., & Simane, B. (2018). Farmers ' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. *Ecological Processes* 7:7 https://doi.org/10.1186/s13717-018-0118-

Ayanlade, A., Radeny, M., & Morton, J. F. (2017). Comparing smallholder farmers ' perception of climate change with meteorological data : A case study from southwestern Nigeria. *Weather and Climate Extremes*, *15*(September 2016), 24–33. https://doi.org/10.1016/j.wace.2016.12.001

Bodegom, A J Van., Brouwer, U., & Satijn, B., La Pluie, M &Buit, G. l. (2015). *Climate Change Profile*. Retrieved from climatehelpdesk@minbuza.nl

Boru, H. J., & Koske, J. K. A. (2014). Climate Variability and Response Strategies among the Gadamoji Agro-Pastoralists of Marsabit

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

County, Kenya Halkano J. Boru, *4*(11), 69–78.

Campbell and Fiske. (1959). Triangulation. In K. Cohen, Louis, Manion, Lawrence, & Morrison (Ed.), *Research Methods in Education* (pp. 141–142). New York: Routledge.

Chandra, N., & Mishra, D. (2013). Analysis of Perception and Adaptability Strategies of the Farmers to Climate Change in Odisha, India, *5*, 123– 127. https://doi.org/10.1016/j.apcbee.2013.05.022

Chen, H., Guo, J., Zhang, Z., Xu, C.V. (2013) Prediction and precipitation in Sudan and South Sudan using LARS-WG in future.Theor.Appl.Climatol.113(3-4)363-375.http:/doi.org/10.100704/s00704012-0793-9.

Cohen. L, Manion. L, M.. (2007). Research Methods in. In K. L.Cohen, Loius, Manion, Lawrence & Morrison (Ed.), *Research Methods in Education* (pp. 101–115). London and New York: Routledge.

Cuni-Sanchez A, Omeny P, Pfeifer M, Olaka L, Boru M, Marchant R, B. N. (2019). Climate change and pastoralists : perceptions and adaptation in montane Kenya. *Climate and Developement*, 22.

Deliens, T., Clarys, P., Bourdeaudhuij, I. De, & Deforche, B. (2014). Determinants of eating behaviour in university students : a qualitative study using focus group discussions, 1–12.

Deressa, T.T., Hassan, R.M and Ringer, C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *Journal of Agricultural Science*, *149*, 23–31. https://doi.org/10.1017/S0021859610000687

El agib, N.A and El haj, M. . (2011). Major Climate Indicators of on going droughts in Sudan. *Journal of Hydrology*, *409*, 612–625. Retrieved from 10.1016/j:hyrol.2011.08.047

Elum, Z. A., Modise, D. M., & Marr, A. (2017). Climate Risk Management Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. *Climate Risk Management*, *16*, 246–257. https://doi.org/10.1016/j.crm.2016.11.001

Eriksen, S. H., Brown, K., & Kelly, P. M. (2005). The dynamics of vulnerability: locating coping strategies in Kenya and Tanzania, *171*(4), 287–305.

FEWSNET. (2011). *A Climate Trend Analysis of Sudan*. Raston:V.A. https://doi.org/doi:10.3133/fs20113072

FEWSNET. (2013a). *South Sudan Livelihood Zones and Descriptions*. Retrieved from www.fews.net

FEWSNET. (2013b). SOUTH SUDAN Livelihood Zones and Descriptions August 2013, (August), 14pp.

Gandure, S., Walker, S., Botha, J.J. (2015) Farmers' perceptions of adaptation to climate change and water stress in South Africa Rural community.Environ.Develop(5) 39-53.

IPCC. (2007). *Climate Change 2007:Impact, Adaptation and Vulnerability.* (P. J. van der L. and C. E. H. M.L. Parry, O.F. Canziani, J.P. Palutikof, Ed.). Cambridge University Press, Cambridge, UK.

Israel, G. D. (1992). Determining Sample Size 1, (November), 1–5.

John, S., Tomor, B.M., Lado, M.M., Balli, J.J., Berg, T., Galla.J.O., Ngalamu.T., Salata, H.H., Moilinga, M.K., Athiba, A.L., Henry, B., & Oonya, J. (2013). Proceedings of the project planning workshop on South Sudan's Sudd Region. In J. O. Galla (Ed.), *A Workshop organized by University of Juba in collaboration with the Norwegian University of Life Sciences and Makerere University with Support from NORAD* (pp. 1–109). Juba.

Lukwasa, A.Z., Zeleke, T.T., Beketie, K.T., Ayal, D.Y. (2022) Spatio-temporal rainfall

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

variability and its linkage with large scale climate oscillatios over the Republic of South Sudan.Climate service(28)http://doi.org/10.1016/j.cliser.2022.100322.

Meze-hausken, E. (2018). Contrasting climate variability and meteorological drought with perceived drought and climate change in northern Ethiopia, *27*(1), 19–31.

Moretti, F., Vliet, L. Van, Bensing, J., Deledda, G., Mazzi, M., Rimondini, M., … Fletcher, I. (2011). Patient Education and Counseling A standardized approach to qualitative content analysis of focus group discussions from different countries. *Patient Education and Counseling*, *82*(3), 420–428. https://doi.org/10.1016/j.pec.2011.01.005

Niles, M. T., & Mueller, N. D. (2016). Farmer perceptions of climate change : Associations with observed temperature and precipitation trends, irrigation, and climate beliefs. *Global Environmental Change*, *39*, 133–142. https://doi.org/10.1016/j.gloenvcha.2016.05.002

Null, J. (2017). El Niño and La Niña Years and Intensities Based on Oceanic Niño Index (ONI). Retrieved from http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Nyang'au, J.O., Mohamed, J.H., Mango, N., Makate, C, Wangeci. A, N. (2021) Smallholder farmers' perception of climate change and adoption of smart agriculture practices in Masaba South Sub-county, Kisii, Kenya. Heliyon (7). doi.org/10.1016/jheliyon.2021.e06789

Ogalleh, S. A., Vogl, C. R., Eitzinger, J., & Hauser, M. (2012). Local Perceptions and Responses to Climate Change and Variability: The Case of Laikipia District, Kenya, 3302–3325. https://doi.org/10.3390/su4123302

Omoj,P.,Laban,A.O.,Oludhe,C.,Gitau,W(2016).Temporal and Spatial characteristics of the June-August seasonal rainfall and temperature over South Sudan.J.Meteorol Related Science.Vol. 9. http://doi.org/10.2098/jmrs.5.08.2016.

Ott, R. & Longnecker, M. (2010). *An Introduction to Statistical Methods and Data Analysis*. (M. Taylor, Ed.). Macmillan.

Petersen, G., Fohrer, N., & Zhang, Z. (2010). Flooding and drying mechanisms of the seasonal Sudd flood plains along the Bahr el Jebel in southern Sudan, *55*(1). https://doi.org/10.1080/02626660903525278

Poudel, S., Funakawa, S and Shinjo, H. (2017).Household perception about the impacts of climate change food security in the mountainous Region of Nepal. *Sustainability*(9)doi:10.3390/su9040641.

Quinn, C., Fox, A., & Baroang, K., Evans, D., Gomes. M., & Habib, J. (2019). *SOUTH SUDAN CLIMATE VULNERABILITY Profile : Sector- And Location-Specific Climate Risks And Resilience Recommendations*.

Rebelo, L. M., Senay, G. B., & McCartney, M. P. (2012). Flood pulsing in the Sudd wetland: Analysis of seasonal variations in inundation and evaporation in South Sudan. *Earth Interactions*, *16*(1), 1–19. https://doi.org/10.1175/2011EI382.1

Savenije, H & Mohamed, Y. (2014). Impact of climate variability on the hydrology of the Sudd wetland : signals derived from long term (1900 – 2000) water balance computations, 191–198. https://doi.org/10.1007/s11273-014-9337-7

Sawe, J., Mung, C. G., & Kimaro, G. F. (2018). The impacts of climate change and variability on crop farming systems in Semi-Arid Central Tanzania : The case of Manyoni District in Singida Region, *12*(September), 323– 334. https://doi.org/10.5897/AJEST2018.2481

Shrestha, R. P., Chaweewan, N., & Arunyawat, S. (2017). Adaptation to Climate Change by Rural Ethnic. https://doi.org/10.3390/cli5030057

Article DOI : https://doi.org/10.37284/ajccrs.4.2.3328

Soliman, G. & Soussa, H. (2011). Wetland change detection in Nile swamps of southern Sudan using multitemporal satellite Sudan using multitemporal satellite imagery. *Journal-of-Applied-Remote-Sensing*, *5*, 1–14. https://doi.org/10.1117/1.3571009

SSCCSE. (2010). *Southern Sudan Counts : Tables from the 5th Sudan Population and Housing Census,2008*. Juba. Retrieved from www.ssccse.org

Teshome, M. (2017). Perceived Impact of Climate Change on Crop Yield Trend in Denbia Woreda of Amhara Region, Northwest Ethiopia, *2*(7). https://doi.org/10.15406/mojes.2017.02.00047

Turhan, N.S. (2015). Kar Pearson's Chi square testsEduc.Res.Rev.Vol15(9)pp575-580.Doi:/10.58971/ERR2019.3817.

UNEP. (2018). *South Sudan: First State of Environment and Outlook Report 2018*. (M. Singh, A., Gilrurth, P., Lund, H., Barr, J.R., Kironde, E., Rugege, D., Ochieng, E.A., Feng, M., Liu, X & Moilinga, Ed.) (Ist). Nairobi: United Nations Environment Programme.

Weber, E. U. (2010). What shapes perceptions of climate change ?, *1*(June), 332–342. https://doi.org/10.1002/wcc.41

WMO. (2010). *Standardized Precipitation Index User Guide*.

WMO. (2015). *The Climate in Africa 2013*. Geneva-Switzerland.

Wolka, K., & Zeleke, G. (2016). Understanding Farmers' Perception on Climate Change and Adaptation Strategies in Karetha Watershed, Omo-gibe Basin, Ethiopia. *Asian J.Earth Sci*, *10*(1), 22– 32. https://doi.org/10.3923/ajes.2017.22.32

Yagoub, Y. E., Li, Z., & Musa, O. S. (2017). Detection of Drought Cycles Pattern in Two Countries (Sudan and South Sudan) by Using Standardized Precipitation Index SPI, *7*(4), 93–105. https://doi.org/10.5923/j.ajee.20170704.03

Zeleke, T.T., Lukwasa, A.Z.W., Beketie, K.T., Ayal, D.Y. (2024). Analysis of Spatio-temporal precipitation and temperature variability and trend over Sudd Wetland, Republic of South Sudan. *Climate Service* (28) https://doi.org/10.1016/j.cliser.2024.100451.

