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Climate change, conflicts and food security in North Darfur State, Sudan: Risks and implications

AUTHORS

Elamin Akoy
University of Al Fashir

Adam Sabbil
University of Al Fashir

Mohammed B. Altoom
University of KwaZulu-Natal

Salih Nurain
University of Al Fashir

Emad Eldeen Salim
University of Al Fashi

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CONTENTS

Abstract

Climate change and the conflicts in Sudan have severely impacted food security in the North Darfur State in Western Sudan with profound risks and implications for household diets, safety, coping strategies, and overall food security levels. This research paper investigates the impact of climate variability and the conflict on food security in North Darfur State by using climate time series data over the period 2000 to 2024. The study applied the Rainfall Anomaly Index (RAI) to investigate drought events and the impact of drought on agricultural production was evaluated using the Standardized Variable Crop Yield (SVCY) equation. Furthermore, employing the Kobo Toolbox and Enketo Express methodology, a comprehensive survey of the internally displaced persons (IDPs) household food security was conducted amid a significant national conflict and siege on Al Fashir town and Zamzam camp. An internet-based questionnaire was designed and randomly distributed to assess the nexus between climate change, conflicts, and agricultural production on household food security. The results showed a trend of marked increases in annual precipitation and a reduction in drought intensity. However, the results indicated that climate change and conflict over the last two decades have had a negative impact on the food security status of households. Moreover, the results showed that North Darfur State experienced severe food shortages between 2000 and 2024 with more than a million people food insecure in 2024. Furthermore, we found that conflict and climate change severely affected the cultivated area, disrupted agricultural activities, disrupted markets, reduced food supply and increased food prices. The study finds that, there is urgent need for humanitarian aid to protect IDPs at risk of famine and recommends international community intervention for ceasefire, the opening of humanitarian safe corridors and the lifting of the siege of Al Fashir.

About the authors

Elamin Akoy
Department of Environment and Climate, Faculty of Environmental Sciences and Natural Resources, University of Al Fashir, Al Fashir, North Darfur State, Sudan.
Corresponding author.
E-mail address: aminoz71@googlemail.com
Tel.: +201123235163

Adam Sabbil
Department of Economics, Faculty of Economics and Social Studies, University of Al Fashir, Al Fashir, North Darfur State, Sudan.

Mohammed B. Altoom
School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Westville Campus, Durban 4000, South Africa.
Department of Environment and Climate, Faculty of Environmental Sciences and Natural Resources, University of Al Fashir, Al Fashir, North Darfur State, Sudan.
mohbasharadam@gmail.com
altoomm@ukzn.ac.za

Salih Nurain
Department of Plant Protection, Faculty of Environmental Sciences and Natural Resources, University of Al Fashir, Al Fashir, North Darfur State, Sudan.

Emad Eldeen Salim
Department of Sociology and Anthropology, Faculty of Arts. University of Al Fashir, Al Fashir, North Darfur State, Sudan.

1. INTRODUCTION

Climate change poses a significant threat to food security worldwide, with particularly severe implications for the African continent (Muluneh, 2021). Africa is highly vulnerable to the impacts of climate change due to its dependence on rainfed agriculture, limited adaptive capacity, and socio-economic challenges (Awazi *et al.*, 2021). As temperatures rise and weather patterns become more erratic, the continent faces a myriad of challenges ranging from reduced agricultural productivity to increased frequency of extreme weather events (Adjei & Amaning, 2021). These impacts are exacerbated by factors such as rapid population growth, inadequate infrastructure, and limited access to resources, exacerbating food insecurity among vulnerable populations. The Intergovernmental Panel on Climate Change (IPCC) has highlighted the urgent need for action to address climate change and its impacts on food security, particularly in regions like Africa where the consequences are most severe (Asuamah Yeboah, 2023).

Climate change significantly impacts farming systems, primarily by altering growing conditions, increasing weather extremes, and impacting soil health and water resources. These impacts can lead to reduced crop yields, lower livestock productivity, and changes in farming practices (EPA, 2025). Studies have shown that temperature increases can accelerate crop maturation rates, leading to reduced grain-filling periods and lower yields for major staple crops, like wheat, rice, and maize. Elevated temperatures also exacerbate evapotranspiration, reducing soil moisture and increasing water stress on crops (Manucharyan, 2025). Climate change also affects precipitation patterns, leading to more frequent and severe droughts in some regions, but increased rainfall, and flooding in others. These changes disrupt traditional farming practices and can severely affect crop yields. For example, increased drought frequency and intensity have been linked to significant yield reductions in rain-fed crops. Conversely, excessive rainfall and flooding can lead to waterlogged soils, root diseases, and physical damage to crops (Manucharyan, 2025).

Crop diversification, the practice of growing a variety of crops, is an effective adaptation strategy that enhances resilience to climate-related stresses. Diverse cropping systems can improve soil health, reduce pest and disease pressures, and provide more stable yields under variable climatic conditions (Manucharyan, 2025)

FAO (2020) reported that climate variability and conflicts are major obstacles to eliminating hunger, malnutrition, and chronic food insecurity. Conflicts create immediate and lasting food insecurity by disrupting production, trade, and access to food. These disruptions, exacerbated by environmental factors, can lead to food shortages, resource competition, and increased social grievances. Food security encompasses four dimensions: food availability, food system, food safety and food accessibility. Climate variability threatens these dimensions by influencing livelihoods, food production and distribution, human health, and changes in market flow and purchasing power (Abdi *et al.*, 2023). Climate anomalies, particularly rainfall variability, impedes food security, whereas an increase in precipitation enhances it (Akbar *et al.*, 2018). Therefore, a population already vulnerable and exposed to hunger is more affected by climate change and conflicts.

Sudan is severely exposed to climate change. As one of the world's least developed countries, extreme weather, recurrent floods and droughts, and changing precipitation interact with other vulnerabilities – such as ecosystem degradation, unsustainable agricultural practices, natural resource scarcities and resource-based conflicts – limiting societal capacities to cope and adapt (NUPI, 2022). The ongoing conflict in Sudan also poses a significant threat to food security, particularly in areas of the country economically reliant on agriculture (Ndip and Touray, 2019).

North Darfur State is one of the most drought-prone areas of Sudan, made worse by climate change and inter-communal conflicts. The food security situation in North Darfur State is the result of a complex interplay of factors that the ongoing conflict has exacerbated. The ongoing armed conflict between the Sudanese Armed Forces (SAF) and the Rapid Support Forces (RSF) which erupted on 15 April 2023 has led to mass displacement, creating large populations of internally displaced persons (IDPs). It is estimated that 6.6 million people were displaced internally from the start of the conflict through to April

2024 (IFPRI and UNDP, 2024). Sudan's agricultural sector, the backbone of the economy, has suffered significantly due to the conflict. Insecurity and displacement have prevented farmers from accessing their fields in certain areas, while military operations have led to the destruction of crucial agricultural infrastructure. This is expected to lead to decreased agricultural output and diminished food availability (FAO, 2023).

Access to food and nutrition for millions of people across the country continues to deteriorate. The UN Food and Agriculture Organization (FAO) reported in 2024 that four months after famine was first confirmed in Zamzam camp in Sudan's North Darfur State, more areas in North Darfur and the Western Nuba Mountains were identified as experiencing famine conditions. Moreover, the IPC (2024) identified famine in at least five areas of Sudan: Zamzam, Abu Shouk and Al Salam camps in North Darfur and in the Western Nuba Mountains for both residents and internally displaced persons (IDPs). Famine is projected in five additional areas between December 2024 and May 2025: Um Kedada, Mellit, Al Fashir, Altewasha and El Lait in North Darfur State. Conflict, displacement, and restricted humanitarian access remain the primary drivers of this crisis. In North Darfur's Al Fashir town, where millions of people suffering from starvation, conditions remain critical due to the siege of Al Fashir, hindered humanitarian food assistance deliveries. Sustained violence and economic hardship have disrupted markets, displaced millions, and driven prices of staple goods to unaffordable levels for most people (FAO, 2024).

Food insecurity is prevalent among displaced populations and poor rural populations whose household sources of food and income are impacted by natural disasters. Currently, more than 24.6 million people across Sudan are experiencing high levels of acute food insecurity (IPC Phase 3 or above.) This includes 8.1 million in Emergency conditions (IPC Phase 4) and at least 638,000 people in IPC Phase 5 (Catastrophe.). The latest IPC alert has classified 755,000 people as living in Catastrophe (IPC Phase 5), the most severe classification on the IPC scale, as people are experiencing destitution and starvation, having exhausted coping mechanisms to access food and proper nutrition (IPC, 2025 https://www.ipcinfo.org).

Climate change causes food insecurity through its adverse effects on agricultural production and food availability (Kinda & Badolo, 2019). Due to significant population growth and stagnation in food production, climate change poses major significant threats to food security in Africa (Pickson & Boateng, 2022). Moreover, Kinda and Badolo (2019) reported that civil conflicts impede food security in 71 developing and least-developed countries. Thus, the repercussions of climate change are larger in countries that are vulnerable to conflicts. In the same vein, armed conflicts undermine food security in West African countries (Ujunwa *et al.*, 2019). The critical appraisal of the literature indicates that least developed countries are most at risk from climate change, conflict, and food insecurity (Warsame *et al.*, 2024).

This study aims to explore the impacts of climate change and conflicts on food security in North Darfur State, particularly related to household food security. This is focused on the period from 2000 to 2024. More specifically, this study addresses the following objectives:

1. To investigate drought events using the Rainfall Anomaly Index (RAI);
2. To evaluate the impacts of drought on agricultural production;
3. To analyze the impact of climate variability and conflicts on North Darfur State food security status;
4. To assess the impacts of climate change and conflicts on IDP household food security and to identify coping strategies.
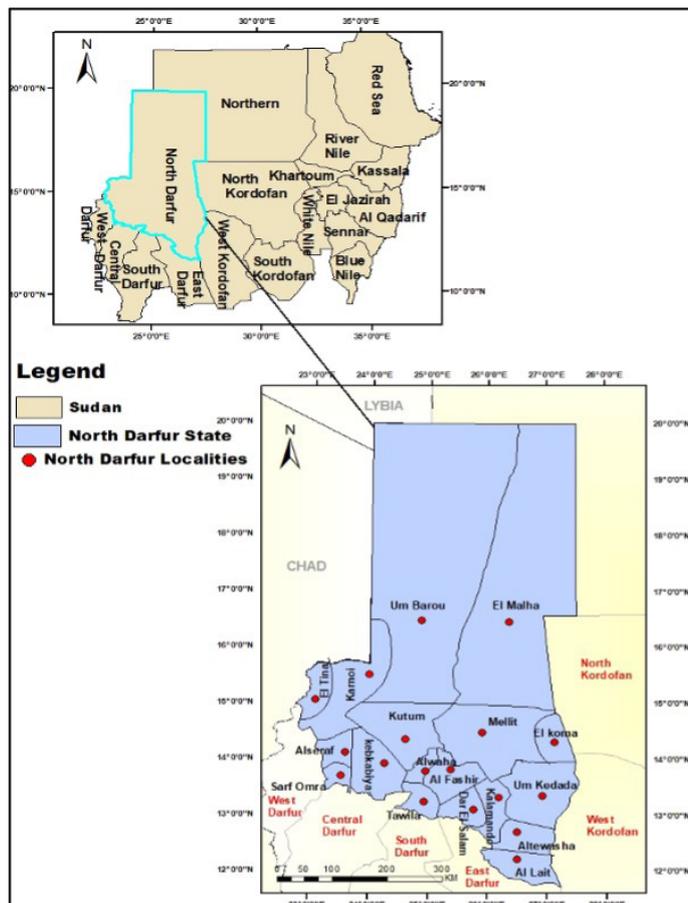
2. MATERIALS AND METHODS

2.1. Study area

The study is focused on North Darfur State in western Sudan (12°N–16°N, 22°E–27.5°E). As shown in Figure 1, the state occupies more than half the territory of the Greater Darfur region. The state is bordered to the northeast by the Northern State, to the east by North Kordofan, and to the southeast by West Kordofan. To the south are East Darfur, South Darfur, and Central Darfur, while West Darfur is to the southwest (Osman and Cohen, 2014). North Darfur also shares a common border with Chad and Libya. The state has an area of about 296,420 km^2 and in 2023 had an estimated population of 2.8 million. The state consists of 18 localities: Al Fashir, El Malha, Mellit, Sarf Omra, Alseraf, Kebkabiya, Kutum, Alkoma, Um Kedada, Kalamando, Altewasha, El Lait, Alwaha, Um Barou, Karnoi, El Tina, Dar El Salam and Tawila (UNICEF, 2023).

North Darfur has a Sahelian vegetation type and features the Marrah Mountains which reach 3,042 m above sea level (Osman, 2012). The region experiences an arid to semi-arid climate, with annual rainfall ranging from 152 mm in the north to 430 mm in the south, about 85% of which falls in August and September. Temperatures vary between 42°C (max) and 11°C (min) (Mohmmed *et al.*, 2018). The climate is characterized by a mono-modal rainy season, most rainfall in North Darfur comes from south-westerly winds and the rainy season is mainly from June to October (Mohmmed *et al.*, 2018). Rainfed agriculture is the primary economic activity, engaging 85% of the population. Crops such as millet, groundnuts, and vegetables (tomatoes, onions, okra, sweet potatoes) are cultivated in Goz sand lands and Wadi beds, with millet, sorghum, groundnuts, and tobacco (tombac) being essential for food security and the local economy. Productivity depends entirely on land fertility and rainfall availability (Osman, 2012).

Figure 1. Map of the study area showing the localities of North Darfur State, Sudan

2.1.2 Rainfall Anomaly Index (RAI))

The Rainfall Anomaly Index (RAI) was calculated from the precipitation data to analyze the frequency and intensity of the dry and rainy years in the study area. The positive and negative RAI indices were computed by using the following equations (van Rooy, 1965):

$$RAI = 3\left[\frac{N - \bar{N}}{\bar{M} - \bar{N}}\right] \text{ For positive anomalies} \tag{1}$$

Where:

N = current monthly/yearly rainfall (mm).

$\bar{N}$ = monthly/yearly historical series' rainfall average (mm).

$\bar{M}$ = the historical series' 10 highest monthly/ yearly rainfall average (mm).

$$RAI = -3\left[\frac{N - \bar{N}}{\bar{X} - \bar{N}}\right] \text{ For negative anomalies} \tag{2}$$

Where:

$\bar{X}$ = the historical series' 10 lowest monthly/yearly rainfall average (mm).

The rainfall data from Al Fashir meteorological station over period 2000 to 2024 were processed using Microsoft Excel (2016) software for calculating the RAI equation parameters as described by Abbas (2024). In this study, drought frequency is defined as the number of drought occurrences over a given period determined by RAI values and drought class as shown in Table 1. The rainfall Standard Deviation (SD) and Coefficient of Variation (CV) were also calculated to show rainfall reliability.

Table 1. Drought Class and drought indices value for RAI

RAI	Drought Class [DC]
≥ 3	Extremely wet
2.00 to 2.99	Very wet
1.00 to 1.99	Moderately wet
0.50 to 0.99	Slightly wet
0.49 to – 0.49	Near normal
-0.50 to -0.99	Slightly dry
-1.00 to -1.99	Moderately dry
-2.00 to -2.99	Very dry
≤ -3	Extremely dry

Source: van Rooy

2.1.3 Crop yield analysis

The most efficient way to assess how droughts affect agriculture is to evaluate agricultural productivity (Foster *et al.*, 2015, Madadgar *et al.*, 2017). Since rainfed agriculture is predominant in the study area, crop production largely depends on precipitation and potential evapotranspiration (PET).

Climate data, mainly related to precipitation over the period of 2000 to 2024, was obtained from the meteorological authority of North Darfur State. Crop yield data for

millet and sorghum over the period of 2000 to 2024, the main staple food crops in this region, were provided by the Ministry of Agriculture of North Darfur State.

To evaluate the impact of drought on agricultural production, the study applied the Standardized Variable Crop Yield (SVCY) equation. Yield-per-hectare data were used to compute SVCY for North Darfur State using the following formula (Altoom *et al*, 2024):

$$SVGY = \frac{(Y_j - \bar{y})}{\sigma}$$
(3)

Where Yj, $\bar{y}$ and σ were the crop yields in j year for the state, the long-term average crop yield, and the standard deviation of Y, respectively.

After computing SVCY, the correlation between RAI and SVCY was analyzed using Pearson's r (Correlation Coefficient) to assess the impact of climate variables on crop production. Table 2 shows Drought and yield classification based on the RAI and SVCY values.

Table 2. Drought and yield classification based on the RAI and SVCY values

RAI	Drought Class [DC]	SVCY value	Yield class
≥ 3	Extremely wet	1≥	No yield losses
2.00 to 2.99	Very wet	0 to –0.49	Normal yield
1.00 to 1.99	Moderately wet	-0.5 to -0.99	Low yield losses
0.50 to 0.99	Slightly wet	-1.0 to -1.49	Moderate yield losses
0.49 to – 0.49	Near normal	-1.5 to -1.99	Severe yield losses
-0.50 to -0.99	Slightly dry	≤ –2.0	Extreme yield losses
-1.00 to -1.99	Moderately dry		
-2.00 to -2.99	Very dry		
≤ -3	Extremely dry		

Source: van Rooy (1965) & Altoom et al. (2024)

2.1.4 Food security status of North Darfur State

Cereals are often used as a proxy for food security. This is based on a study reported that cereals represent 60–70% of the average calorie per capita consumption required (Byrnes and Bumb, 1998). Previous studies have also used cereals as a measurement of food security (Ujunwa *et al*., 2019; Pickson & Boateng, 2022).

In order to determine food shortage across North Darfur State, food balance data was obtained from the Department of Agricultural Planning Administration, Ministry of Agriculture. The food security data were based on the crop yield of staple food crops: millet (Pennisetum glaucum) and sorghum (Sorghum bicolor) from 2000 to 2024. Food balance of North Darfur State was calculated according to the assumptions of the Ministry of Agriculture of North Darfur state. Consequently, the balance between the available and annual need of food was estimated following these parameters:

- The annual individual human consumption of cereal is 146 Kg.
- Transportation and storage losses represent 2% of the production.
- Annual livestock's consumption of cereal represents 5% of human consumption.
- Cereal substitute from other food represents 20%.
- The population information is from census 2008 updated using growth rate (3. 14%). Accordingly:
- The available food = Total cereal Production (millet & sorghum) + Total stocks (households + market) + Cereal substitutes   (4)

- The cereal consumption needed = (Annual human consumption of cereal + Transportation and storage losses + Annual livestock's consumption of cereal)   (5)
- Total cereal consumption needed = equation (4) – equation (5)   (6)

2.2 Household food security data collection and analysis

The household food security survey was conducted in Zamzam IDP camp and Tawila IDP camp (Figure 2). Zamzam IDP camp is located about 14km south of Al Fashir town, just 2.5 km away from the north western corner of Al Fashir town. It is one of the biggest IDP camps in Sudan and contains four zones: A, B, C, and D. The camp is in Al Fashir locality (UNICEF, 2023). Tawila camp is in Tawila locality, which is situated in North Darfur State approximately 35–50 km from the state capital Al Fashir (UNHCR, 2021).

Figure 2. **Map showing the household data collection area.**

2.2.1 Survey design and data collection

A comprehensive survey of the North Darfur State IDPs household food security was conducted during February 2025 amid a major national conflict and siege affecting Al Fashir town and Zamzam camp. To conduct the study and overcome data collection challenges in conflict settings, the Kobo Toolbox and Enketo Express methodology were used.

2.2.2 Kobo Toolbox and Enketo Express as the research instrument

Kobo Toolbox is a free and open-source integrated *set* of tools for Mobile Data Collection (MDC), allowing the building of forms and questionnaires, aggregating and analyzing interviews. This approach ensures the continuation of research activities under crisis conditions through permitting a wider set of innovations to respond to and overcome barriers to research in conflict-affected regions. Research data was transmitted online so that the data tabulation process was automatic (Nampa *et al.*, 2020).

Kobo Toolbox and Enketo Express provided the advantages of conducting paperless research; ability to record data in complex formats such as numerical data, descriptive data, photos, videos, sounds, coordinates and other data, dynamically making forms changes when conducting research; and displaying interactive applications (Nampa *et al.*, 2020). Enketo Express allows data entry by anyone using a web browser as long as they have the URL. Enketo Express also has an intuitive interface and seems easier to navigate and can be run off-line, made it possible to collect field data in remote locations without an internet network. The research data was transmitted online so that the data tabulation process was automatic. Kobo Toolbox was appropriate for generating information from the IDPs households' survey including household profile on demographic and socio economic, agricultural production and productivity, perception of household on climate change and conflicts, food security status of household and coping and adapting strategies developed by the household.

Kobo Toolbox was used for data collection instruments in the form of questionnaires/forms that can be filled quickly in a smartphone. The survey was performed in several stages: compiling a research questionnaire; compiling a digital questionnaire on the Kobo Toolbox server; deploying forms/questionnaires; recruiting enumerators (field officers); conducting training in the use of instruments to enumerators; collecting data; sending data (uploading data); and downloading data and data presentation (Nampa *et al.*, 2020).

2.2.3 Sampling procedures and sample size

Due to the ongoing conflict, only the population of Zamzam camp and Tawila camp were used for this study by using simple random sampling techniques with the consideration of probability proportion to its size. A total of 400 households in the two camps (200 households per camp) were taken into consideration for investigation and were selected through simple random sampling techniques (Shiferaw, 2005). In order to represent the study population, Yemane (1967) simplified formula was used at 5% margin of error. According to Inter-Cluster Assessment Report: Zamzam IDP camp; Al Fashir, Locality, North Darfur State, 27 August 2024 HAC and community leaders estimated the newly displaced families to be around 110,000 HHs and old IDP around 160,000 HHs, while IOM/DTM estimate the new IDPs in Zamzam are 28,518 HHs/142,595 people and the old IDPs are 73,000 HHs/295,000 people (OCHA, 2024). Consequently, Yemane (1967) simplified formula was used at 5% margin of error as follows:

$$n = \frac{N}{1 + N(e)^2} \qquad\qquad (7)$$

Where n is sample size, N is the total number of households in selected two camps and e is the margin of error.

Primary data were collected by using semi-structured questionnaires. An Internet based questionnaire was designed using the Kobo Toolbox, allowing for access to survey responders which was otherwise restricted due the ongoing armed conflict in Sudan. The second stage was the basic data collection which included household profile on demographic and socio economic, agricultural production and productivity of staple cereal crops mainly

millet and sorghum and cash crops, food security, perception of households on impacts of climate change, conflicts and adaptation strategies developed by the household. Secondary data were obtained from various agriculture offices at different levels. To confirm the real existence of climate change, temperature data over 25 years was also accessed from Nasa Power climatic data Datasets (NASA, www.nasa.gov).

To triangulate the information obtained from the household survey and meteorological data, key informant interviews were carried out with officers, the former minister and the current acting minister of Ministry of Agriculture of North Darfur State. The interviews covered climate change; conflicts and food security in North Darfur State; a change in temperature; precipitation; crop pests; agricultural production and productivity; food security status; and adaptation strategies developed in response to climate and conflict at the household and community level.

2.3. Data analysis

Descriptive statistics using percentages, frequencies, mean and standard deviation were used to analyze the quantitative data to give some insights about household food security. A simple linear regression model was used to analyze rainfall and temperature trends.

3. RESULTS AND DISCUSSION

3.1 Climate data and drought analysis

Drought analysis indicates that drought events are represented by negative values. Based on the Rainfall Anomaly Index (RAI) results (Table 3 and Figure 3), the study area has experienced varying levels of drought over time. Extremely dry (RAI: ≤ -3.00) was observed in 2004, 2009, 2016, and 2017, while very dry (RAI: -2.00 to -2.99) occurred in 2001, 2002, 2003, 2011 and 2015, highlighting the region's vulnerability to climate variability.

Table 3 shows the RAI events for the period 2000 to 2024. It displays the value of RAI for Al Fashir station during the study period and the number of occurrences of each event class. For example, the "extremely wet" event class in Al Fashir station occurred three times, and this class is important to indicate certain flood occurrences in the region. At the same time, "extremely dry" occurred four times and "very dry" occurred five times which means certain drought occurrence and consequently crop failure. In the low-rate annual rainfall, "slightly dry" and "near normal" both occurred twice. Thus, it is clear that in the study site the rainfall variability and drought were serious problems. Generally speaking, the impact of rainfall variability on crop production depends on either an excess or a shortage of rainfall; floods and droughts have an impact on crop productivity and can result in other factors like dry spells and soil erosion, which lower productivity and ultimately cause food insecurity and shortages in the study area.

Figure 3 shows multi-successive drought years in Al Fashir station; the longest drought period of four years from 2001 to 2004 is obvious with RAI ranging from -2.28 to -4.25. Moreover, the negative rainfall anomaly in this station extended for 11 years to 2017, with RAI ranging from --0.67 to -4.46, and recovered from the longest drought years to an "Extreme wet" year of 2018 with RAI = 3.11. The extreme wet of 2018 was followed by two successive "Very wet" years, then a "Slightly dry " year in 2021 and finally a trend of marked increases in the RAI reaching the heights value of 9.29 in 2024 are evident, which led to disaster and floods. Al Fashir station, which is in Al Fashir city, capital of North Darfur State, faced 13 years of drought conditions over the period 2000 to 2024, which led to crop failure. These findings are in agreement with that of Altoom *et al.* (2024) who conducted drought assessment based on the Standardized Precipitation Index (SPI) and the Reconnaissance Drought Index (RDI) to assess the drought events and their impact on millet production in North Darfur State from 1981 to 2020. However, the results also showed a trend of marked increases in annual precipitation and a reduction in drought intensity. These findings align with results of Ahmed *et al.* (2025).

Table 3. **The RAI and Drought Class (DC) for the period 2000 to 2024**

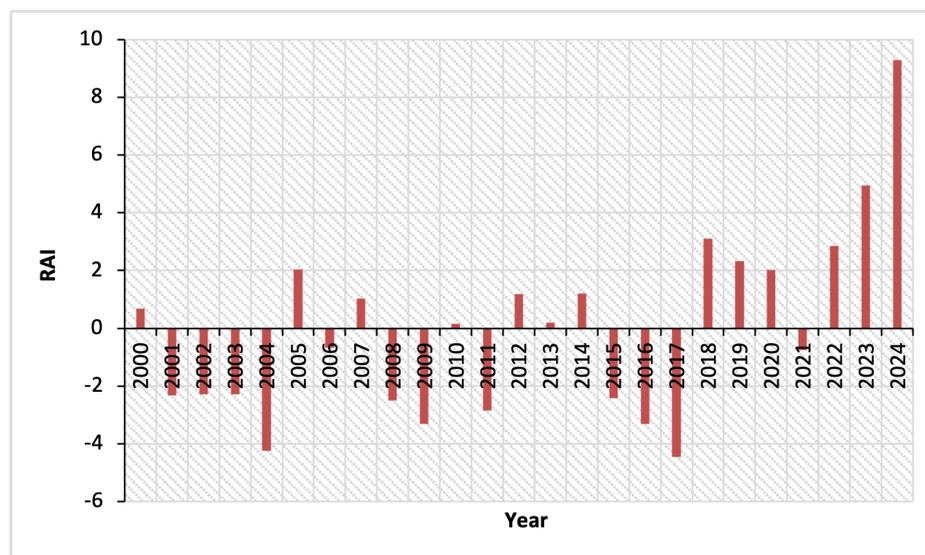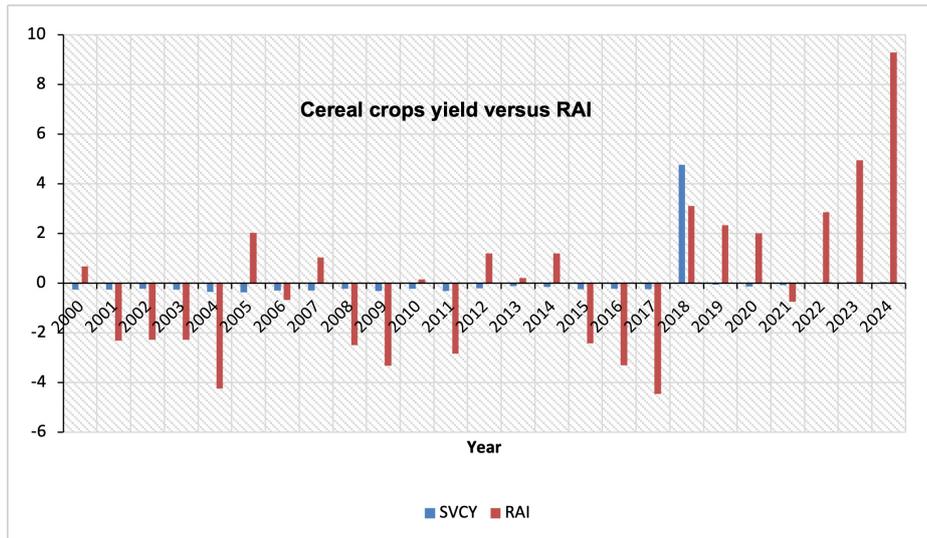| Year	RAI	Drought Class (DC)	Number of occurrences
2000	0.68	Slightly wet	1
2001	-2.32	Very dry	5
2002	-2.28	Very dry	
2003	-2.28	Very dry	
2004	-4.25	Extremely dry	4
2005	2.03	Very wet	4
2006	-0.67	Slightly dry	2
2007	1.03	Moderately wet	3
2008	-2.5	Very dry	
2009	-3.32	Extremely dry	
2010	0.15	Near normal	2
2011	-2.84	Very dry	
2012	1.19	Moderately wet	
2013	0.2	Near normal	
2014	1.2	Moderately wet	
2015	-2.43	Very dry	
2016	-3.31	Extremely dry	
2017	-4.46	Extremely dry	
2018	3.11	Extremely wet	3
2019	2.33	Very wet	
2020	2.01	Very wet	
2021	-0.75	Slightly dry	
2022	2.86	Very wet	
2023	4.95	Extremely wet	
2024	9.29	Extremely wet	

Source: calculated from rainfall data

Figure 3. **Rainfall Anomaly Index (RAI) for Al Fashir station over period 2000–2024**

Figure 4. Drought index (RAI) and Standardized Variable Crop Yield (SVCY) for Cereal crops

3.2 Drought impact on cereal crops production

Based on the yield data from the Ministry of Agriculture, there is significant variation between the planted and harvested areas for cereal crops (millet and sorghum) in North Darfur State during the study period (2000–2024), as shown in Figure 5. This variation could be attributed to drought conditions and conflict-related disruptions. Drought affects crop survival, while armed conflicts force farmers to abandon their cultivated fields. These findings align with the official reports from the Ministry of Agriculture of North Darfur. Based on the SVCY results, North Darfur State experienced a crop deficit throughout the study period, except in 2018, when the region had a surplus production. However, in 2024 the RAI was the heights = 9.29 and there was a crop deficit, this could be attributed to the ongoing armed conflict which erupted on 15 April 2023 meaning that farmers may be forced to abandon their fields leading to decreased food production.

Droughts have persisted in North Darfur and threaten agricultural productivity (Mohmmed *et al.*, 2018). However, there is a trend of marked increases in annual precipitation and a reduction in drought intensity in the study area. The results of the impact of drought on millet and sorghum crop yields showed that droughts generally lead to decreased production in North Darfur State. Yield losses in cereal crops occurred from 2000 to 2024, except in 2018, when the region had a surplus production. North Darfur State experienced cereal crops deficit (yield losses) over the period 2000 to 2024 with the SVCY = negative values, except in 2018, when the region had a surplus production (No yield losses) with the SVCY = 4.78 and the RAI = 3.11 as shown in Table 4. These results agree with the findings of Elhag and Zhang (2018) and Altoom *et al.* (2024). However, North Darfur State experienced three "Extremely wet" years in 2018, 2023 and 2024 with RAI = 3.11, 4.95 and 9.29, respectively. As explained above, the negative values of SVCY in 2023 and 2024 could be attributed to the ongoing armed conflict. Climate change results in yield reduction and affects food availability and accessibility. This impacts household food security (Mekonnen *et al.*, 2021), whereas conflicts often lead to the displacement of communities, which can disrupt farming and other agricultural activities (Raleigh & Kniveton, 2012). Farmers may be forced to abandon their fields, leading to decreased food production and eventually impacting access to proper nutrition and meaning that retaining an adequate food supply becomes challenging. Climate change is expected to have mostly negative implications on food production as it puts agrifood systems at risk (Muriuki *et al.*, 2023).

The statistical relationship between Standardized Variable Crop Yield (SVCY) and the Rainfall Anomaly Index (RAI) was examined using the Pearson correlation coefficient (r). The analysis revealed a weak correlation (r = 0.3), indicating that rainfall variability alone does not strongly account for fluctuations in crop yield. Several factors may contribute

to this weak association, including suboptimal farming practices, declining soil fertility, and land degradation, all of which can independently reduce yields. Additionally, the RAI may not adequately reflect intra-seasonal rainfall characteristics such as timing, intensity, or the frequency of rainy days, which are critical for crop growth. Moreover, insecurity and conflict in farming regions can significantly suppress agricultural productivity, often having a more severe impact on yields than climatic variability itself.

Figure 5. Total area planted versus total area harvested with cereal crops
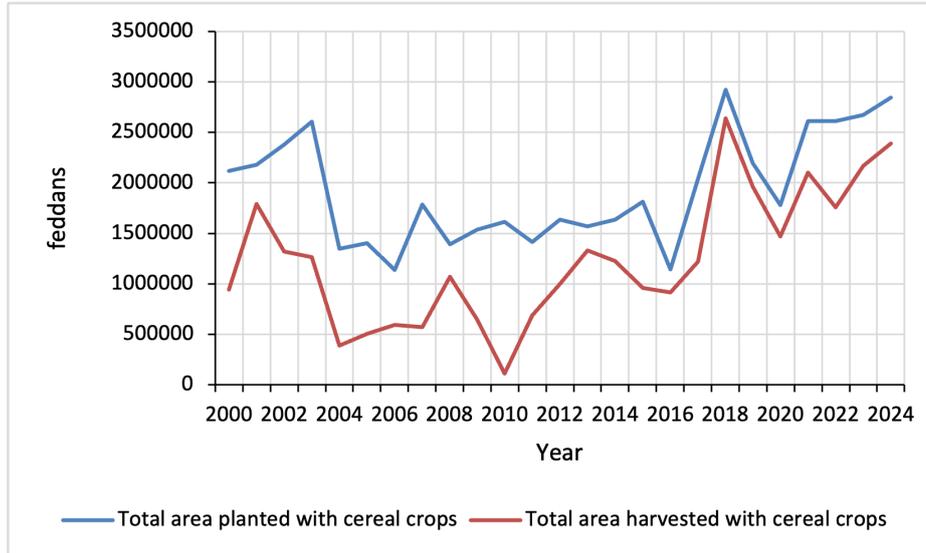
Table 4. The RAI and the Standardized Variable Crop Yield (SVCY) for cereal crops

Year	Total Yield ()	SVCY	RAI	Drought Class (DC)	Yield Class
2000	80396	-0.24	0.68	Slightly wet	yield losses
2001	73891	-0.25	-2.32	Very dry	yield losses
2002	96198	-0.21	-2.28	Very dry	yield losses
2003	74163	-0.25	-2.28	Very dry	yield losses
2004	24369	-0.33	-4.25	Extremely dry	yield losses
2005	7074	-0.35	2.03	Very wet	yield losses
2006	52721	-0.28	-0.67	Slightly dry	yield losses
2007	53502	-0.28	1.03	Moderately wet	yield losses
2008	102034	-0.2	-2.5	Very dry	yield losses
2009	38799	-0.3	-3.32	Extremely dry	yield losses
2010	101374	-0.21	0.15	Near normal	yield losses
2011	47630	-0.29	-2.84	Very dry	yield losses
2012	113633	-0.19	1.19	Moderately wet	yield losses
2013	177283	-0.1	0.2	Near normal	yield losses
2014	148691	-0.13	1.2	Moderately wet	yield losses
2015	91100	-0.22	-2.43	Very dry	yield losses
2016	104921	-0.2	-3.31	Extremely dry	yield losses
2017	91417	-0.22	-4.46	Extremely dry	yield losses
2018	3290305	4.78	3.11	Extremely wet	No yield losses
2019	206730	-0.04	2.33	Very wet	yield losses
2020	157624	-0.12	2.01	Very wet	yield losses
2021	109641	-0.19	-0.75	Slightly dry	yield losses
2022	182590	-0.08	2.86	Very wet	yield losses
2023	194122	-0.06	4.95	Extremely wet	yield losses
2024	196473	-0.06	9.29	Extremely wet	yield losses

Source: calculated from rainfall data and cereal crops production data

3.3 Food security status analysis of North Darfur State

Table 5 shows the food security status for North Darfur State during the period 2015 to 2024. Cereal production increased from 153291 metric tons in 2015 to 168520 metric tons in 2016 then decreased to 168520 metric tons in 2017. This substantial reduction could be attributed to the armed conflicts that broke out in 2003 and the droughts. Notably, peak cereal production was recorded in 2018 with 417997 metric tons from 153291 metric tons in 2015. Since then, cereal production has been decreasing. North Darfur state experienced severe food shortages at various degrees over the study period, with the highest number affected being 54.17% in 2017, followed by 50.7% in 2021, then 48.26% in 2016, followed by 44.62% in 2015, finally 35.77% in 2022 as shown in Table 5. However, the percentage experiencing food shortages decreased in 2023 and then increased in 2024. More than a million people were food insecure in 2024 in a situation aggravated with the ongoing conflict. Furthermore, North Darfur State experienced a food shortage throughout the study period, except in 2018 as shown in Figure 6, when the region had a surplus production. This could be attributed to the value of RAI = 3.11 and fewer conflicts and less pest infestation in the region. These findings align with the results of the Ministry of Agriculture (2024). However, in 2024 the RAI was at = 9.29
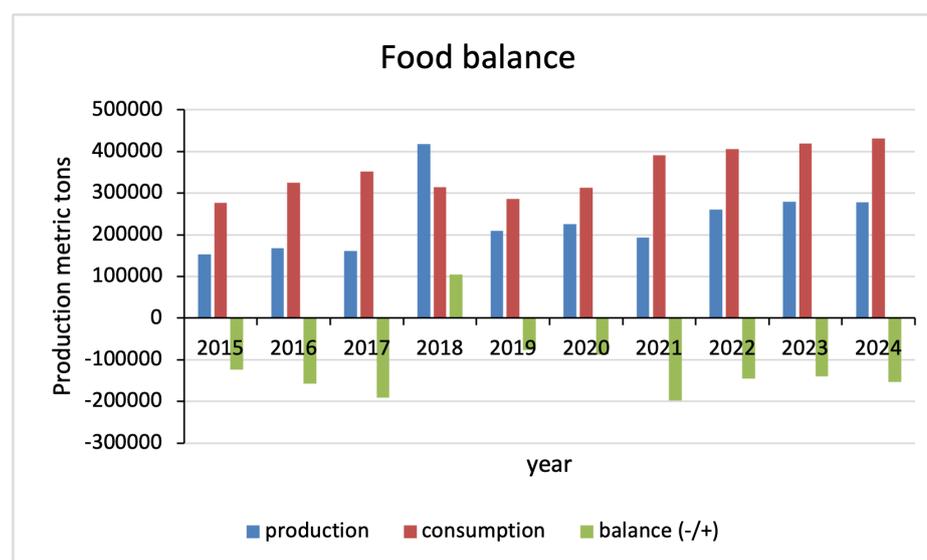
and there was a crop deficit – possibly due to the ongoing conflict. Conflicts undermine agriculture production by forcing people to flee from their residences and farms owing to insecurities (Warsame *et al*., 2024). Climate change impedes agriculture production, which in turn leads to less domestic production (Warsame & Sarkodie, 2022).

Table 5. Food security status of North Darfur State over the period 2015–2024

Year	Production	Consumption	Balance (+/-)	Shortage (%)
2015	153291	276786	-123495	44.62
2016	168520	325736	-157216	48.26
2017	161088	351505	-190417	54.17
2018	417997	313897	+104100	surplus
2019	209565	286280	-76715	26.8
2020	225343	313264	-87921	28.07
2021	192844	391181	-198337	50.7
2022	260849	406129	-145280	35.77
2023	279245	419000	-139755	33.35
2024	278344	431915	-153571	35.56

Source: calculated from cereal crops production data

Figure 6. Food security status of North Darfur State over the period 2015–2024

3.4 Demographic and socioeconomic characteristics of household

In this study, the demographic and socio-economic profile of household heads that could have key implications on food security and developing coping and adaptation strategies were analyzed. As shown in Table 6, among the total sampled respondents, 60.25% were female-headed households and the rest were male-headed households, this high rate of female headship among IDPs could be due to the spouse being absent; it could indicate that husbands have remained behind, presumably to care for property in Al Fashir town; or it could be because the husbands have moved on, likely for work or safety. These results align with results of report entitled key obstacles to durable solutions and peace building for the displacement-affected communities in Tawila locality, North Darfur (UNHCR, 2021). Moreover, 88.55% of sampled households were within the productive age (18–60

years old), revealing that age of household heads can influence the food security status and coping and adaptation strategies through the lesson learned from past severe weather events. Through these previous experiences, households could adapt strategies like improving crop production to cope up with the change in climate. Similar results were also reported by Mekonnen *et al.* (2021) who found that the experience rather than age matters the adaptation of climate change impacts.

Among the IDP households living in Zamzam and Tawila camps, 75.25% were married, whereas 9.5% were widowed, these results showed strong social cohesion. The household family size was 6.8 on average, which could have a negative effect on food security of households. Turning to the educational status of the respondents 83.5% of them were able to read and write which could have a positive impact on the willingness to adopt new technologies and practices in agriculture in general and for coping and adapting climate change and conflicts measures in particular. 77.5% of the households were found to be IDPs and 13.75% were returnees displaced for the second time from camps within Al Fashir town to Tawila camp. The majority of sampled households were farmers (68%), but 20.5% of the households' heads reported having a disability that prevents them from coping with all the things they need to do. Furthermore, 82.5 % of households reported that agriculture was the main source of income, this finding aligns with the literature of previous studies in the area.

Table 6. Demographic and socio-economic characteristics of household (n=400)

Variables	Category	Frequency	Percent (%)	Mean	St. deviation
Sex of household head	Male headed Female headed	159 241	39.75 60.25	-	-
Age of household head, years	18-39 40-59 Above 60	180 174 46	45 43.5 11.5	-	-
Marital status	Married Single Widowed Divorced	301 43 38 18	75.25 10.75 9.5 4.5		
Family size				6.70	2.62
Educational level	Illiterate Below Primary Primary/Basic Intermediate Secondary Institute University	66 60 63 40 97 3 71	16.5 15 15.75 10 24.25 0.75 17.75		
Migratory status	IDPs Host Community Returnees Nomad	310 33 55 2	77.5 8.25 13.75 0.5		
Occupation	Farmer Trader Government employee Casual Labor Housewife Other	272 36 35 27 29 1	68 9 8.75 7.25 6.75 0.25		
Disability	Yes No	82 318	20.5 79.5		
Main source of income	Agriculture Livestock Salaried Casual labor Seasonal labor Petty trade Has no source of income Other	330 35 31 80 5 37 23 7	82.5 8.75 7.75 20 1.25 9.25 5.75 1.75		

Source: Field survey, February 2025

3.5 Agricultural production and productivity

As depicted in Table 7, the dominant cereal crops grown in the study area are millet and sorghum as food crops. Alongside this, groundnut, sesame, watermelon seed and tombac (tobacco) are grown as cash crops. These findings align with previous studies in the area. The average productivity of millet was 80 kg / feddan, which aligns with results of Ministry of Agriculture (2024) which was 71 kg /feddan, whereas sorghum production was 108 kg/ feddan, also aligning with results of Ministry of Agriculture which was 95 kg / feddan. A small majority (45.75%) of the households said that their crop productivity had decreased, whereas 43.75% evaluated their crop productivity as increased and 10.5% evaluated their crop productivity as unchanged. In terms of crop production, reduced rainfall (50.5%), insecurity (82.75%), and spread of pests (47%) were the most commonly reported challenges. Key informants suggested that techniques such as water harvesting, pest control, agricultural extension services and agricultural inputs were necessary to solve these obstacles. The majority, 97.5%, of the respondents reported that rainwater was the main source of water for irrigation. In North Darfur State, cereal crops production faced a range of challenges that significantly impact productivity for farmers. Key threats included pests and diseases, among which locusts (56%); birds (18.25%); mice (5.5%); and the parasitic weed Striga (20.25%) stand out. Locusts destroy agricultural crops and threatening food security in the North Darfur State and are among the oldest migratory pests. They differ from ordinary grasshoppers as they swarm over long distances. Birds pose a notable risk during the ripening phase of millet, often leading farmers to deploy traditional deterrents like scarecrows, which may not be sufficiently effective. In contrast, more innovative solutions such as protective netting are emerging, especially in regions like India. The Striga weed, known for its ability to siphon nutrients from millet plants, presents another daunting challenge, particularly in Sudan and India. Farmers have found success through integrated pest management techniques that include crop rotation and the cultivation of resistant millet varieties, which can mitigate the adverse effects of this invader (Hassan *et al.,* 2024). The study revealed that 47.5% of the households faced insufficient annual rainfall rate; 46.75% of the households faced unfair distribution of rainfall rates during the season; 57.5% of the households faced delaying in time of rainfalls; 31.5% of the households faced the short period of rainfall; and 6.75% of the households faced other periods of rainfall (see Table 7). These findings align with the results of FAO (2022). The agricultural sector in Sudan is currently facing many challenges, including high rainfall variability, outbreaks of pests and diseases, agricultural input unavailability and inaccessibility and irrigation difficulties (FAO, 2022).

Table 7. Agricultural production and productivity

Variables	Category	Frequency	Percent (%)	Mean
Food crops	Millet Sorghum	381 286	95.25 71.5	
Land size	Millet Sorghum			4.7 feddan 2.2 feddan
Productivity sacks (90kg) per feddan	Millet Sorghum			0.9 sack 1.2 sacks
Do you grow cash crops?	Yes No	305 95	76.25 23.75	
Cash crops	Groundnut Sesame Watermelon seed Tombac (Tobacco) Other	196 62 14 115 27	49 15.5 3.5 28.75 6.75	
Land size	Cash crops			2.19 feddan
Productivity sacks (90kg) per feddan	Cash crops / Groundnut			2.35 sacks
How do you evaluate your productivity this season compared to last season?	Increased Did not change Decreased	175 42 183	43.75 10.5 45.75	
What difficulties have you encountered in growing crops this season and previous seasons?	Reduced rainfall Insecurity Spread of pests Other	202 331 188 38	50.5 82.75 47 9.5	
What are the most common pests on the farm this season and the previous seasons?	Locusts Birds Mice Other	224 73 22 81	56 18.25 5.5 20.25	
Source of water for agriculture	Rainwater Water harvesting Wells Running surface water (seasonal valleys) Other	390 33 17 68 32	97.5 8.25 4.25 17 8	
What are the problems household faces in access to water for rain-fed agriculture?	Insufficient annual rainfall rate Unfair distribution of rainfall rates during the season Delaying in time of rainfalls The short period of rainfall Other	190 187 230 126 27	47.5 46.75 57.5 31.5 6.75	

Source: Field survey, February 2025

3.6 Perception of households on climate change and conflicts

As depicted in Table 8, with respect to households' perception on climate change, 98% of the households had noticed changes in weather patterns over the last 10 years confirming that there was a change in climate: households reported a decrease in the amount of annual rainfall (60.75%); delayed rainy seasons (53.75%); an increase in temperature (74.5%); and increased drought frequency (26.5%). The change in climate resulted in: reduced crop yield (86.25%); loss of livestock (26.5%); increased cost of production (72%); and decreased cultivated area (40.75%). Considering household perception of conflict, 99.75% of the households confirmed that there was a conflict or war in the area, the reasons for conflicts in the region were: armed conflict, tribal clashes, insecurity due to armed looting gangs, and conflict over natural resources and other (see Table 8 for a full breakdown). Furthermore, the study revealed that 98.75 % of the households reported that the conflict in the region had severely affected the cultivated area. As far as the direct impact of conflict on agricultural production is concerned, the study revealed that 81% of the households reported decreased crop production, with others reporting decreased cultivated areas (52%); increased agricultural production costs (66.25%); burning of cultivated areas due

to fires (41.25%); and intentional damage of cultivated areas (59.75%). Regarding how the conflict affected the household's access to food, the study revealed that many households experienced reduced availability of food, increase prices of food, disruption of markets, loss of income source (see Table 8). However, the study also revealed that 54% of households did not feel safe accessing markets or food sources (Table 8). These findings align with the results of Mekonnen *et al.* (2021) and Warsame *et al.* (2024). Climate change results in yield reduction, affects food availability and accessibility which impacts on household food security (Mekonnen *et al.*, 2021). Conflicts often lead to the displacement of communities, which can disrupt farming and other agricultural activities (Raleigh & Kniveton, 2012). Farmers may be forced to abandon their fields, leading to decreased food production and eventually impacting access to proper nutrition and adequate food supply.

As shown in Figure 7, the maximum temperature has increased at an annual rate of 0.0037 °C for the period from 2000 to 2024. Whereas the minimum temperature of Al Fashir station increased by about 0.049 °C annually. These findings reflect the households' perception that temperature has increased and align with results of Mekonnen (2021). However, the rainfall showed an increasing trend by 8.13 mm annually for the last two decades. As shown in Figure 8, the average rainfall of the Al Fashir station for the period 2000 to 2024 was 245.48 mm and it has increased at the same period by the 8.13 mm. According to the data obtained from Sudan Metrological Authority, the coefficient of variation (CV) of the study area was 45.45% for Al Fashir station which indicated that there was high variability of rainfall over the period 2000–2024, reflecting the households' perception that drought frequency has increased.

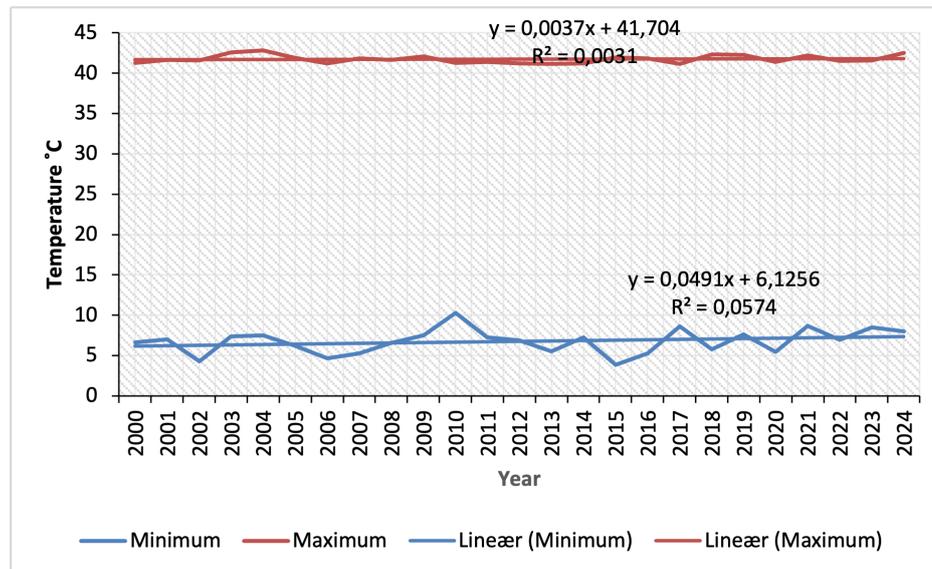**Figure 7. Trend of maximum and minimum temperature in the study area (2000 to 2024)**

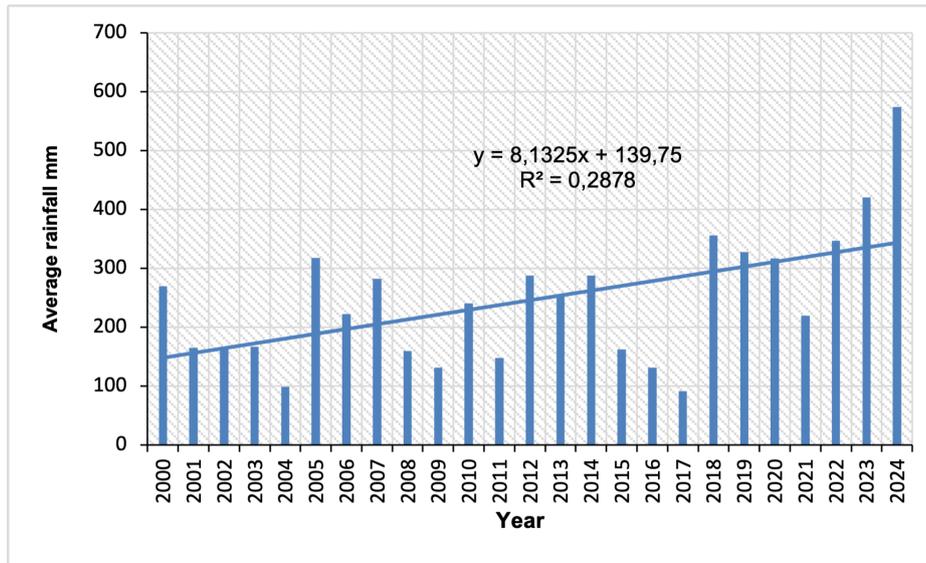**Figure 8. Trend of average rainfall of Al Fashir station (2000 to 2024)**

$$y = 8,1325x + 139,75$$
$$R^2 = 0,2878$$

Table 8. The impacts of climate change and conflicts on household food security

Variables	Category	Frequency	Percent (%)
Have you noticed changes in weather patterns in the past 10 years?	Yes No	392 8	98 2
If your answer is yes, what changes have you observed? Select all that apply	Reduced rainfall Increased temperatures Delayed rainy season Increased drought frequency Other	243 298 215 106 48	60.75 74.5 53.75 26.5 12
How have these changes affected your agricultural activities? Select all that apply	Reduced crop yield Loss of livestock Increased cost of production Decreased cultivated areas Other	347 106 288 163 49	86.75 26.5 72 40.75 12.25
Is there a conflict or war in your area? Select one option	Yes No	399 1	99.75 0.25
What are the reasons for the conflicts? Select all that apply	Armed conflict Tribal clashes Insecurity due to armed looting gangs Conflict over natural resources Other	374 152 187 201 58	93.5 38 46.75 50.25 14.5
Has the conflict affected the cultivated areas in the region? Select one option	Yes No	395 5	98.75 1.25
What is the direct impact of the conflict in the region on agricultural production?	Decreased crop production Decreased cultivated areas Increased agricultural production costs Burning of cultivated areas due to fires Intentional damage of cultivated areas Other	324 208 265 165 239 54	81 52 66.25 41.25 59.75 13.5
How did the conflict affect your household's access to food?	Reduced availability of food Increased prices of food Disruption of markets Loss of income source Other	319 316 271 251 58	79.75 79 67.75 62.75 14.5
Do you feel safe accessing markets or food sources?	Yes No	184 216	46 54

Source: Field survey, February, 2025

3.7 Coping and adapting strategies of households

As depicted in Table 9, in response to the challenges of climate change, households adopted the following coping strategies: migration (44.75%); selling assets (29%); borrowing money (33.25%); reduced food consumption (48.75%); and requesting social support (49.25 %). Households also adapted to climate change by improving seeds (69.25%); improving post-harvest practices (21.5%); and growing crops resistant to high temperatures (21.25%). Additionally, some households (45%) cultivated early maturity crops. Another climate change mitigation strategy was sustainable land use (11.5% of households). These findings are in agreement with findings of Mekonnen *et al.* (2021). The study revealed that 34% of households depended on their own production for food security, however, 56.5% still purchase food items from markets, which means there is no self-sufficiency in food security with what they produce from their farms. This could be attributed to climate change and conflict constrains. Violence and displacement are disrupting agricultural activities, reducing domestic food supply, and raising prices, while increasing vulnerability to further shocks, including those induced by climate change (Raleigh & Kniveton, 2012). To cope with food security, 90.5% of the respondents reported that they consumed two meals per day. Other coping mechanisms included reducing portion sizes of meals, skipping meals, consuming less preferred or cheaper foods, or prioritizing feeding children over adults (see table 9). The study also revealed that 95% of the households had no access to food storage facilities. 58.5% of households reported that there were local organizations or programs addressing food security in the area providing support such as food distribution, agricultural inputs, and training (see Table 9). The survey also asked what additional support do you think is necessary to improve food security in your region? 35% of the sampled households reported humanitarian aid; followed by food distribution, social support, cash support, and security. Reliance on humanitarian aid and external support is common during periods of conflict or crisis (Mena & Hilhorst, 2022). The respondents also reported that the main drivers of food insecurity in North Darfur State were conflicts, climate change, and poor infrastructure, and lack of government support (see Table 9). Finally, the study revealed that 71.5% of the households employed traditional practices or local knowledge to cope with food insecurity, consuming groundnut oil cake, wild crops, some plant leaves and grass. These findings are in agreement with that of OCHA (2024), which reported that many people resort to drastic coping mechanisms. In Nigeria, households facing conflict-induced shocks resorted to negative coping strategies, such as consuming less nutritious food, which exacerbated the severity of food insecurity and deteriorated dietary diversity (Olanrewaju and Balana, 2023). In Zamzam camp and Al Fashir town, people eat grass and groundnut oil cake to survive due to the siege.

Table 9. Coping and adapting strategies of households

Variables	Category	Frequency	Percent (%)
What coping strategies has your household adopted due to the challenges of climate change?	Migration Selling assets Borrowing money Reduce food consumption Request social support Other	179 116 133 195 197 42	44.75 29 33.25 48.75 49.25 10.5
In recent years, have you or your household used measures to adapt climate change?	Use of improved seeds Improving post-harvest practices (reducing losses – good storage…Etc.) Growing crops resistant to high temperatures Cultivation of early maturity crops Sustainable land use	277 86 85 180 46	69.25 21.5 21.25 45 11.5
What is the main source of food for your household?	Own production Purchasing Food aid Wild crops Other	136 226 18 11 9	34 56.5 4.5 2.75 2.25
How many meals does your household consume per day?	One Two Three or more	34 362 4	8.5 90.5 1
Over the past month, has your household experienced any of the following situations?	Reduced portion size of meals due to lack of food Skipped meals due to lack of food Consumed less preferred or cheaper foods Restricting the amount of food consumed by adults in favor of small children Other	145 115 80 46 14	36.25 28.75 20 11.5 3.5
Does your household have access to food storage facilities?	Yes No	20 380	5 95
Are there local organizations or programs addressing food security in your area?	Yes No	234 166	58.5 41.5
If yes, what kind of support is provided? Select all that apply	Food distribution Agricultural inputs Training Other	162 9 32 50	40.5 2.25 8 12.5
What additional support do you think is necessary to improve food security in your region?	Humanitarian aid Food distribution Social support Cash support Security Other	140 100 40 48 60 12	35 25 10 12 15 3
What are the main drivers of food insecurity in North Darfur in your opinion? Select all that apply	Conflicts Climate change Poor infrastructure Lack of government support Other	343 240 128 123 61	85.75 60 32 30.75 15.25

Are there any traditional practices or local knowledge that helps your community cope with food insecurity?	Yes
	No
	If yes specify
	  Groundnut oil cake
	  Wild crops
	  Plant leaves and grass
	  Other
		286
		114
		
		45
		35
		142
		64
			71.5
			28.5
			
			15.7
			12.2
			49.7
			22.4

Source: Field survey, February, 2025

4. CONCLUSIONS

The study investigated drought events using the Rainfall Anomaly Index (RAI). Only Al Fashir station was considered for the drought events. The results revealed that the area experienced alternating successive dry and wet years at various degrees over the period 2000 to 2024. However, the results showed a trend of marked increases in annual precipitation and a reduction in drought intensity in the study area.

The study assessed the impacts of climatic conditions on food production by evaluating the Rainfall Anomaly Index (RAI) and the Standardized Variable Crop Yield (SVCY) equation. The results showed that North Darfur State experienced cereal crops deficit (yield losses) over the period 2000 to 2024 with the SVCY = negative values, except in 2018, when the region had a surplus production (No yield losses) with the SVCY = 4.78 and the RAI = 3.11.

This study analyzed the impact of climate variability and conflicts on North Darfur State food security status using cereal crops production data. The results showed that North Darfur State experienced severe food shortages over the period 2015 to 2024, except in 2018, when the region had a surplus production. A striking result of the study was that conflicts impeded crop yield more than rainfall variability.

The study assessed the combined impact of conflict and climate change on agricultural productivity and food security. The results indicated that conflict and climate change severely affected the cultivated area, disrupted agricultural activities, disrupted markets, reduced food supply and increased food prices

The study assessed the impacts of climate change and conflicts on IDPs household food security. Results indicated that climate change and conflicts have profound risks and implications for household food security and safety. Moreover, the disproportionate effect on IDPs, particularly in terms of coping capacity and access to food, the results revealed that the IDPs consumed fewer meals per day and did not feel safe accessing markets or food sources.

The study identified coping strategies during food shortage, revealing that respondents reduced the portion size of meals, skipped meals, consumed less preferred or cheaper foods, and restricted the amount of food consumed by adults in favor of small children. Furthermore, the study revealed that 71.5% of the households employed traditional practices or local knowledge to cope with food insecurity. Finally, the study revealed that the sampled respondents reported that the main drivers of food insecurity in north Darfur state were: conflicts, climate change, poor infrastructure, and lack of government support.

RECOMMENDATIONS

To ensure food security and human safety in North Darfur State, our findings offer some insights that can be pursued. Initial recommendations:

1. The international community should intervene for a ceasefire, the opening of humanitarian safe corridors and the lifting of the siege of Al Fashir;
2. NGOs and humanitarian agencies should intervene to urge the international community to prioritize funding for humanitarian efforts.
3. It is imperative that all parties to the conflict ensure safe, immediate, unhindered access to areas classified as IPC Phase 3 and above.
4. Government institutions need to intervene for a political solution that includes all Sudanese voices and for an accountability to break the cycle of violence and impunity. Without immediate action, Sudan's crisis threatens to escalate further in 2025, with millions more at risk.
5. Short term strategies should focus on immediate humanitarian and food assistance for households facing severe food insecurity and income loss, emergency food aid, market access, and support for IDPs.
6. Long-term strategies like building climate-resilient agriculture should focus on implementing practices that help farmers adapt to changing climates and reduce vulnerability to droughts, floods, and other weather events. Governments can provide incentives for sustainable agricultural practices, invest in research and development of climate-resilient, digital technologies, and support farmers through extension services and financial assistance. International cooperation is also essential to address the global nature of climate change and its impacts on food security. Whereas, restoring community-based conflict strategies should focus on strengthening local mechanisms for peaceful dispute resolution and conflict prevention.
7. Finally, further in-depth assessment of the nexus between climate change, conflicts and food security in North Darfur state using climate data for the most localities of North Darfur State is highly recommended.

ACKNOWLEDGEMENTS

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Contact us
Phone: +47 93 80 00 (from Norway)
Phone: +47 55 70 55 65 (from abroad)

cmi@cmi.no
www.cmi.no

P.O. Box 6033,
N-5892 Bergen, Norway
Jekteviksbakken 31, Bergen

CMI CHR.
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