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To cite this article: Abdinasir Omar Osman *et al* 2026 *Environ. Res. Commun.* **8** 055038

Environmental Research Communications

OPEN ACCESS

RECEIVED
17 August 2025

REVISED
23 April 2026

ACCEPTED FOR PUBLICATION
6 May 2026

PUBLISHED
19 May 2026

PAPER

Impact of climate change on agricultural production and food security in Somalia: a case study of Jowhar district

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Keywords: food security, climate resilience, adaptation strategies, sustainable agriculture

Abstract

Climate change poses significant challenges to agricultural sustainability and food security in fragile environments such as Somalia, yet district-level empirical evidence remains scarce, particularly for riverine farming systems like Jowhar district. This study fills that gap by examining the socio-demographic characteristics, perceptions of climate change, observed impacts on agricultural production, and adaptation strategies among rural households in Jowhar. Using a cross-sectional quantitative survey, primary data were collected in 2025 from 205 respondents in Jowhar district and analyzed using descriptive statistics and Spearman's rank correlation (ρ) to examine associations between climate change awareness, perceived impacts on agriculture, household food insecurity, and adaptation responses. Results show that 99% of respondents recognize the adverse effects of climate change on agricultural productivity and livelihoods, alongside widespread food insecurity and reliance on food assistance. Climate change awareness is high (96.1%), mainly informed by radio/TV and workshops; however, traditional coping strategies remain prevalent yet inadequate without institutional support. At the 1% significance level ($p < 0.01$), climate change awareness is strongly associated with perceived reductions in food availability ($\rho = 0.700$). Respondents strongly prioritize investments in irrigation infrastructure, climate-resilient seeds, and early warning systems, viewing a national climate-resilient food security policy as crucial. The findings reveal that effective adaptation in Somalia requires integrating indigenous knowledge with formal policies, strengthening institutional capacity, and ensuring sustained financial and technical support to build resilient agricultural systems. The study contributes novel district-level empirical insights to the limited body of literature on climate change and food security in Somalia, offering practical policy directions for climate-resilient agricultural development.

1. Introduction

Climate change poses one of the most critical challenges of our time, with global temperatures rising by an average of 0.06 °C per decade since 1850 (Yuan *et al* 2024). This warming trend has far-reaching implications for food security, as approximately 870 million people, primarily in developing and fragile countries, remain chronically undernourished (Dawson *et al* 2016). Scientific consensus confirms that human activity over the last century has significantly contributed to global warming (Parry *et al* 1999), with cascading effects on environmental quality, biodiversity, agricultural systems, and overall food security (Muluneh 2021). While global food consumption has surged in recent decades, climate change threatens to reverse these gains. Its impact on agriculture is both direct, altering crop cycles, yields, and quality, and indirect, through increased frequency of extreme weather events, soil degradation, water scarcity, and pest and disease outbreaks (Yuan *et al* 2024). These pressures compromise agricultural sustainability, disrupt rural livelihoods, and exacerbate hunger and poverty, impeding global efforts towards achieving sustainable development goals (Berhane 2018). The consequences are particularly

severe in tropical regions (Aydinalp and Cresser 2008) and regions with similar climate Characteristics, where changing rainfall patterns and temperature shifts will lead to uneven and potentially devastating outcomes.

In East Africa, climatic variability is especially pronounced, with complex rainfall patterns and a bimodal seasonal cycle, long rains from March to May, and short rains from October to December. The region has a history of climate-induced disasters such as droughts and floods, which undermine key sectors like agriculture, livestock, fisheries, and water supply. These shocks are expected to intensify due to climate change, deepening existing vulnerabilities and social inequalities (Kimaro and Chibinga 2013, Egeru 2016, Cappelli *et al* 2024, Kiptum *et al* 2025). Consequently, food insecurity remains a persistent issue in East Africa, closely tied to rainfall variability. As many livelihoods depend on seasonal rains, rainfall forecasts have become essential early warning tools (Yuan *et al* 2022); however, the effectiveness of these forecasts in guiding response strategies is debated, given the complexity of food security dynamics and recurrent droughts (Coughlan de Perez *et al* 2019).

Somalia's agricultural sector depends primarily on the Shabelle and Juba Rivers, which sustain irrigated farming systems in the southern regions; however, increasing climate variability, manifested through recurrent floods and prolonged droughts has severely disrupted farming activities and reduced agricultural productivity. Specifically, approximately 8000 hectares of farmland were inundated during major floods in Jowhar and Balcad districts in 2013 (Duale and Owour 2016). These hydrological shocks compound the structural weaknesses of Somalia's agriculture-based economy, which, despite contributing over 75% of GDP and 93% of national revenue (Nor and Yusof 2025, FGS-MOP Somalia 2020, Hassan and Mohamed 2024). The sector's fragility is further intensified by deforestation, land degradation, and the overexploitation of natural resources due to poor environmental awareness and sustainability practices, and insufficient legal frameworks. As a result, Somalia's forest cover, which constitutes only about 10.5% of total land area, is rapidly diminishing at an estimated rate of 429 000 hectares annually between 2000 and 2021 (Nor and Yusof 2025). Moreover, the expansion of unsustainable agricultural practices, particularly those dependent on fossil-fuel-based mechanization has accelerated methane and nitrous oxide emissions, exacerbating both environmental degradation and climate change impacts (Ali Warsame and Hassan Abdi 2023).

Somalia has faced persistent cycles of drought and flooding since the severe 2010–2011 drought, intensifying the country's food insecurity crisis. Beyond climatic fluctuations, the agricultural sector continues to struggle with structural limitations, including the predominance of smallholder farms and the reliance on traditional, low-input cultivation practices. The productivity of key staple crops, such as maize, sorghum, rice, and beans has declined markedly in recent years, reflecting the profound effects of climate change on agricultural output and posing a serious threat to national food security. These challenges mirror global trends, where stagnation in agricultural performance has contributed to rising hunger and food system instability, undermining progress toward the Sustainable Development Goal of achieving zero Hunger (Abbas 2022, Abdi *et al* 2024). Furthermore, Climate fluctuations have become an enduring feature of Somalia's environmental landscape, rendering dependence on predictable rainfall patterns increasingly unsustainable for agricultural production. Strengthening water resource management and governance is therefore essential to mitigate the impacts of climate-induced hazards, reduce humanitarian vulnerability, and enhance food security as a foundation for broader social and economic stability. According to the Food and Agriculture Organization's Somalia Water and Land Information Management (SWALIM) reports, the country has experienced either drought, flooding, or both in 19 of the past 20 years, with the past decade exhibiting a pronounced escalation in the frequency and intensity of such climatic events (Johnston and Lemaitre 2024).

Agricultural production in Jowhar District follows the Gu (April–June) and Deyr (October–December) rainy seasons, which are increasingly associated with riverine flooding, as well as the Hagaa (July–September) and Jilaal (January–March) dry seasons, marked by water scarcity and heightened drought stress. The dominant cropping systems comprise maize, sorghum, sesame, rice, and horticultural vegetables. The interaction of these seasonal hazards with fragile irrigation infrastructure and contested floodplains exposes farming households to recurrent production shocks (Ahmed and Ali 2024). Localized flooding in 2013 affected 11 000 households across 33 villages in Jowhar, forcing many households into aid dependence (Duale and Owour 2016). Jowhar District, a crucial riverine farming area along the Shabelle River has experienced at least three major flood events, including severe riverine flooding in 2016–2017, 2019–2020, and 2021, driven by elevated Shabelle River levels and canal breakages. These floods inundated thousands of hectares of cropland, destroyed standing crops, damaged irrigation infrastructure, disrupted market access, and displaced farming households. This is indicative of a recurring pattern of seasonal river overflow during the Gu and Deyr rains, with rainfall intensity in the Ethiopian highlands having a significant impact on flood magnitude (Sebhat 2014).

Riverine flooding, particularly along the Shabelle River in Middle and Lower Shabelle, has intensified, exemplified by the 2021 Jowhar floods, when river breakages in Bodale and Halgan villages, combined with rising water levels exceeding 3.9 m, inundated farmland, destroyed crops, and displaced households. These climatic shocks are further exacerbated by deforestation, environmental degradation, and inadequate infrastructure, thereby amplifying community vulnerability (Ahmed *et al* 2022a). From a historical perspective, during the 1960s and 1980s, Somalia achieved near self-sufficiency in cereal production, particularly in its southern regions. However, recurrent climate-induced shocks, most notably floods, have progressively undermined this productive agricultural foundation, resulting in chronic food deficits and an increasing dependence on cereal imports. Today, more than 7.1 million people face severe food insecurity, and over 90% of the country is affected by drought. Despite these challenges, agriculture, comprising crop production, livestock, and fisheries, remains central to livelihoods and exports. Strengthening agricultural resilience through improved water access, riverbank protection, early warning systems, and climate adaptation measures is therefore essential for advancing food security and promoting economic stability in the country (Hussien and Kulmie 2024).

The governance for adaptation to climate change is a core component of the Jowhar Off-stream storage programme (JOSP), led by MoAI and MoEWR with multi-ministerial coordination and implemented by a UN consortium. It strengthens climate-resilient water governance to reduce flood and drought risks while advancing Somalia's resilience and environmental peacebuilding goals (Johnston and Lemaitre 2024).

Despite growing recognition of climate change impacts on agriculture and food security, empirical evidence from Somalia remains limited, particularly at the district level and within riverine farming systems that face compounded risks of floods and droughts. Existing studies largely rely on national aggregates or secondary data, offering limited insight into household-level perceptions, food insecurity experiences, and local adaptation responses. To address this gap, the present study employs a cross-sectional quantitative survey in Jowhar District, Middle Shabelle, using primary data. Descriptive statistics and Spearman's rank correlation analysis are applied to examine the relationships between climate change awareness, perceived agricultural impacts, food security outcomes, and adaptation support, providing context-specific evidence to inform climate-resilient agricultural policy and planning in Somalia.

2. Literature review

Global and regional empirical studies demonstrate that climate change poses a serious and escalating threat to human lives, property, and economic systems worldwide. Mustafa *et al* (2019) Saleem *et al* (2025) document significant negative impacts on agricultural productivity and food security. At the community level, Zenda (2024) reports substantial livelihood losses among smallholder farmers due to altered rainfall patterns. Socioeconomic factors, including access to agricultural inputs, institutional support, and geographic location-strongly shape levels of climate awareness, particularly among farming communities. Furthermore, traditional ecological knowledge plays a central role in influencing local perceptions of climatic variability (Ajuang *et al* 2016). In this regard, farmers from sub-Saharan communities have observed rising temperatures, decreasing rainfall, and recurrent droughts; as a result, a portion of these interpretations remains rooted in cultural or spiritual explanations rather than scientific discourse (Korir 2019, Ahmed *et al* 2022a). Although climate risk awareness has increased in many African contexts, particularly through targeted communication, it does not automatically lead to adaptive action; therefore, it must be coupled with capacity-building, institutional support, and community-based interventions to generate meaningful behavioral and policy responses (Thompson *et al* 2010, Maponya *et al* 2013, Williams *et al* 2018).

The agricultural sector has been identified as one of the most climate-sensitive domains worldwide. Various research works in Europe, and the Mediterranean have discovered that climate variability has led to regional disparities in water availability and productivity despite advanced agricultural systems (Iglesias *et al* 2012, Knox *et al* 2016). Scholars have further emphasized that these climatic shifts are altering cropping patterns, reducing yields, and reshaping rural socio-economic structures globally (Aydinalp and Cresser 2008, Ayinde *et al* 2011). Low adaptive capacity, especially in the Mediterranean and southern Europe (Olesen *et al* 2011), reflects a broader need for integrated natural and social research approaches to address the complexity of climate–agriculture interactions.

Similar patterns have been observed across different regions, where rising temperatures, erratic rainfall, and the increasing frequency of extreme events such as droughts and floods have markedly undermined agricultural productivity (Nastis *et al* 2012). This vulnerability is particularly pronounced in sub-Saharan Africa, where nearly 97% of cultivated land depends on rain–fed agriculture, making farming

systems highly sensitive to climatic variability (Alvaro *et al* 2009). Consequently, climate-related stressors, including prolonged droughts, pest outbreaks, and heatwaves are increasingly compounding existing socio-economic and food security challenges in already vulnerable regions.

The studies indicate that the impacts of climate variability on agricultural productivity are highly crop- and context-specific. Said *et al* (2023) emphasize that shifts in temperature and precipitation patterns can significantly alter agricultural systems, contributing to land degradation, water scarcity, and yield losses in vulnerable settings. In contrast, empirical evidence from Ghana shows that climate change has enhanced maize and soybean yields in both the short and long term (Ntiamoah *et al* 2022). Similarly, projections by Zhang *et al* (2021) suggest that future climate conditions may sustain or modestly increase yields of key staples such as maize, rice, and wheat, thereby supporting food security. A positive association between temperature, relative humidity, and sugarcane productivity in Pakistan. Overall, these findings highlight the heterogeneous effects of climate change on crop yields across regions and crop types (Ali *et al* 2017, Abdi *et al* 2024).

Food security, defined by the Food and Agriculture Organization as stable access to sufficient, safe, and nutritious food, is closely tied to climate variability (Schmidhuber and Tubiello 2007). Accordingly, projections suggest that by 2080, between 5 and 170 million people could be at risk of acute food shortages as a direct consequence of climate change (Schmidhuber and Tubiello 2007). These disruptions not only destabilize rural livelihoods but also undermine national economies and regional markets, increasing population displacement and vulnerability (Masipa 2017, Arce *et al* 2024). According to Devereux and Edwards (2004) the declining domestic agricultural production, especially in developing countries, contributes to rising food prices and reduced access for vulnerable populations. The is findings supported by Toromade *et al* (2024) who found that climate-induced disruptions undermine all four pillars of food security, availability, access, utilization, and stability. Recent empirical research from sub-Saharan Africa context, particularly in Ethiopia and Somalia (Ahmed and Wadud 2023, Habtie *et al* 2024), demonstrates that recurrent droughts, flooding, and unpredictable rainfall exacerbate malnutrition, deepen poverty, and reverse development gains. These global patterns are particularly evident in Somalia, one of the most drought-prone countries in East Africa, where historical evidence shows persistent drought events since the 1970s, which have severely reduced crop productivity and devastated livestock assets. As noted in recent analyses by Ahmed and Ali (2024), Adam and Kulmie (2024), the 2016–2017 drought significantly deepened hunger in rural areas, disproportionately affecting smallholder farming households.

Numerous empirical studies from various contexts indicate that, in response to these risks, farmers are increasingly adopting community-based climate adaptation strategies. The adaptation strategies practiced in the sub-Saharan region, particularly in Uganda and Tanzania, include the use of drought-tolerant and early maturing crop varieties, small-scale irrigation, crop diversification, and improved water management techniques (Magesa *et al* 2023). These approaches are similar to practices observed in Bangladesh (Chowdhury *et al* 2025). Recently, Adeagbo *et al* (2023) and Incoom *et al* (2025) highlight that access to credit, education, farm size, and institutional support are key factors influencing adaptation strategies, based on their studies in Nigeria and Ghana. At the micro level, studies such as Gebre *et al* (2023) from Ethiopia argue that households employing multiple adaptation strategies experience measurable improvements in food security outcomes. However, in Somalia, adaptation remains limited due to structural barriers, including weak extension services, inadequate irrigation infrastructure, and limited financing. Addressing these constraints requires strategic investments, knowledge transfer, and inclusive policymaking (Magesa *et al* 2023, Kabote *et al* 2024).

Studies from Kenya and Ethiopia, (Evangelista *et al* 2013, Ketiem *et al* 2017, Stefanovic *et al* 2019), consistently show that climate adaptation strategies differ by farming system, with food-crop and horticultural farmers adopting distinct responses shaped by risk perception, extension access, and livelihood conditions in Kenya while in Ethiopia, spatial modeling and empirical climate analyses reveal declining suitability for major cereals and increasing drought frequency, largely driven by rainfall variability, highlighting the importance of diversification, early warning systems, and adaptive planning to strengthen agricultural resilience. Beyond socio-economic dimensions, gender and family dynamics play a critical role in shaping adaptation outcomes in agricultural and rural communities. According to The Jowhar Off-stream storage program (JOSP) baseline survey, the main decision-makers in most key economic areas, including farm investments and household budgeting, reflect long-standing gender roles and power structures. At the same time, decision-making over food purchases is more balanced, with approximately 35% of decisions made jointly and about 30% led by women. Women hold a central role in managing domestic responsibilities. Joint decision-making is also becoming more common in non-food spending and off-farm activities, indicating a gradual shift toward more shared governance within households. These patterns align with broader evidence indicating that when both men and women participate in

household decision-making, communities are better equipped to adapt to climate stress and build resilience (Johnston and Lemaitre 2024).

Building on these social dimensions, national climate policies and institutional frameworks in Somalia provide a crucial enabling environment for adaptation. The Federal Government of Somalia has increasingly mainstreamed climate adaptation into its development agenda through instruments such as the national development plan (NDP) (2020–2024), the National Adaptation Programme of Action (NAPA) (2013), and the National Climate Change Policy (NCCP) (2020). These frameworks, developed in line with United Nations Framework Convention on Climate Change commitments, emphasize strengthening institutional capacity and enhancing resilience in vulnerable sectors, particularly agriculture and livestock (FGS-MOECC 2023). Complementary initiatives, including the National Environment Policy (2019), National Disaster Management Policy (2018), and the Drought Impact Needs Assessment and Recovery and Resilience Framework (2018) seek to address climate shocks through disaster preparedness, risk reduction, and coordinated adaptation strategies (Directorate of Environment and Climate Change 2022).

3. Materials and methods

3.1. Description of the study area

The study was conducted in Jowhar District (figure 1) in 2025, located in the Middle Shabelle region of Hirshabelle State, Somalia (2°46′48.0″N, 45°30′02.9″E). Jowhar covers an estimated 4731.4 km^2 and has a population of approximately 432 455, according to recent population estimates. The district lies at an average elevation of about 100 m above sea level within the agriculturally important Shabelle River basin, a zone characterized by flat topography and fertile alluvial soils that support intensive agricultural activity. Agricultural livelihoods in Jowhar depend on a combination of rainfed and irrigated farming, with production concentrated along the river and associated canal networks. Seasonal climate variability in Jowhar District, as shown in table 1, the district experiences a semi-arid to arid climate, with mean annual rainfall ranging from 400 to 600 mm, occurring mainly during the Gu (April–June) and Deyr (October–December) rainy seasons. These are followed by two dry seasons, Jilaal (January–March) and Hagaa (July–September), which are associated with water scarcity and drought stress. Average annual temperatures range from 26 °C to 34 °C, with peak temperatures typically recorded between March and May. This pronounced climatic seasonality, combined with recurrent flooding and drought, makes Jowhar a critical setting for examining climate change impacts on agriculture and food security.

3.2. Sampling procedures and sample size

This study employed descriptive research design using a cross-sectional quantitative approach, integrating quantitative survey data with literature insights to examine climate change perceptions, food security outcomes, and adaptation responses. The target population comprised individuals directly engaged in or supporting agricultural livelihoods in Jowhar District, including smallholder farmers and key sectoral stakeholders. A total population of 420 eligible individuals was identified across five stakeholder categories: farmers, agricultural traders, government employees, NGO workers, and community leaders. From this population, a sample of 205 respondents was selected using purposive sampling. This approach was considered appropriate given the study's objective of capturing context-specific knowledge and lived experiences of climate-related shocks in a riverine, flood-prone setting, as well as the absence of a complete and stable sampling frame due to population mobility, displacement, and security constraints. Non-Probability-based sampling methods were therefore not feasible. The final sample consisted of 100 farmers, 26 traders, 23 government employees, 26 NGO workers, and 30 community leaders, all of whom were deliberately selected based on their direct exposure to climate variability, agricultural production, food security challenges, or institutional response mechanisms. While the purposive sampling approach limits statistical generalization beyond the study area, it enhances internal validity and analytical relevance by capturing informed perspectives on climate–food security dynamics in Jowhar district. The achieved sample size ($N = 205$) is adequate to detect moderate associations in correlation analysis, supporting the robustness of the reported relationships. Accordingly, statistical tests and p-values are interpreted as evidence of associations within the study sample rather than as population-level inference. The findings therefore, offer context-specific insights for Jowhar District and should be generalized beyond the study area with appropriate caution.

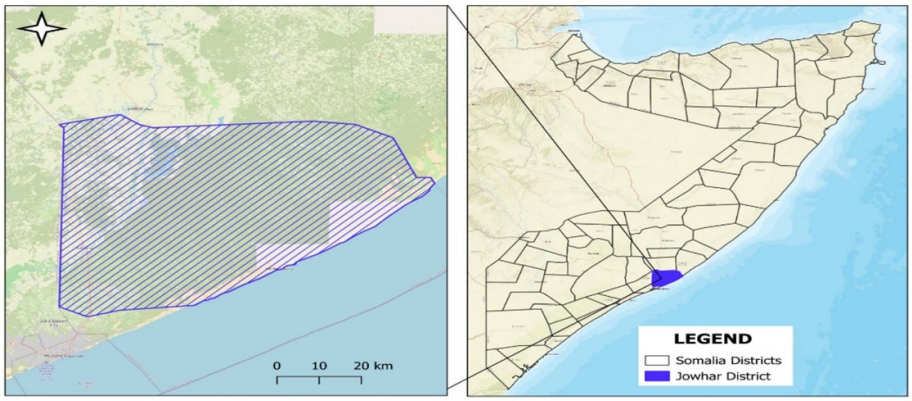

Figure 1. Study area map.

Table 1. Seasonal climate shocks, agricultural impacts, and food security conditions in jowhar district (2021–2025).

Year	Jan–Mar	Apr–Jun	Jul–Sep	Oct–Dec	Sources
2021	Persistent drought	Riverine flooding around Jowhar	Waterlogging and heat stress	Heavy rains and flooding	(Ahmed *et al* 2022b)
2023	Aftermath of multi-season drought	Flood impacts delayed cropping	Residual waterlogging, pests	Severe Deyr floods	(FEWS NET 2024)
2024	Dry conditions; rising food insecurity	Above-average Gu rains (125%–200% LTA); severe flooding	Elevated river levels; damaged fields	Flood risk advisories	(FEWS NET 2024)
2025	Early rains; rising river levels	Heavy rainfall; riverine flooding	Prolonged dry spell	Delayed onset; below-normal rainfall	(FAO-SWALIM 2025 a); (FAO-SWALIM 2025 b)

Table 2. Internal consistency reliability analysis using Cronbach's alpha.

Construct	No. of Items	Cronbach's alpha	Interpretation
Community awareness of climate change	3	0.88	Good reliability
Impacts of climate change on agricultural production and food security	7	0.78	Acceptable reliability
Community-based adaptation strategies	5	0.92	Excellent reliability
Institutional response	8	0.90	Excellent reliability

3.3. Data collection, instruments and analysis

Primary data were collected using structured questionnaires designed to capture socio-demographic characteristics, climate change awareness, observed agricultural impacts, food security experiences, access to adaptation support, and perceptions of institutional responses. The instrument was adapted from previous studies conducted in similar regional contexts. Specifically, 3 items on climate awareness were adapted from Said *et al* (2023) and Ajuang *et al* (2016); 7 items on agricultural impacts were sourced from Aided (2023) and Connolly-Boutin and Smit (2016); 5 items on adaptation strategies were obtained from Omer *et al* (2025); while 8 items on institutional response were adapted from Moses *et al* (2024). These items were selected based on their relevance to the study objectives and local context. To ensure linguistic and conceptual accuracy, the English instrument underwent a formal translation and back-translation process involving expert consultation. The tool was then piloted with a small group of respondents in Jowhar, resulting in minor revisions to improve contextual relevance. Moreover, the quantitative data were coded, entered, and analyzed using the statistical package for the social sciences (SPSSs). The internal consistency and reliability of the multi-item constructs were evaluated using Cronbach's alpha (α). As shown in table 2, all constructs demonstrated robust reliability, with alpha coefficients ranging from 0.78 to 0.92, exceeding the recommended threshold of 0.70.

3.4. Ethical consideration

Ethical considerations are paramount in this research to ensure the protection and well-being of all participants. The study adhered to a strict ethical framework based on principles of voluntary participation, informed consent, confidentiality, and data protection. Therefore, this study received ethical approval from the Research Ethics Committee of the University for Peace, Somali programme, Somalia, has granted approval for this study (Ref. No. UPEACE/EC/0032).

4. Results and findings

This study examines the interrelationships between climate change awareness, perceived impacts on agricultural production, household food insecurity, and adaptation practices using quantitative data collected from local residents. The data presented in table 3 indicate that the socio-demographic characteristics of the respondents reflect a predominantly male (73.6%) and agriculturally active population, with the majority aged between 31–40 years (33.7%) and a significant proportion (55.1%) lacking formal education. This demographic structure suggests that climate change adaptation strategies in Jowhar District must account for limited educational attainment, which may hinder access to climate information and the adoption of adaptive practices. With nearly half of the participants identified as farmers (48.8%), Accordingly, the findings emphasize the urgent need for targeted agricultural support and inclusive policy frameworks that engage not only male farmers but also underrepresented groups such as women and youth. This reflects the prevailing socio-cultural and labor dynamics of the agricultural communities like Jawhar farmers, where farming and farm-related business activities are largely male-dominated and physically demanding.

The descriptive statistics in table 4 highlight key community perceptions and responses to climate change in Jowhar district. Respondents view climate change as a serious threat to agriculture and food security, with a high mean score of 3.27, indicating strong agreement across the population. The frequency of climate-induced food insecurity is also reported to be high ($M = 3.63$), though variability in responses ($SD = 1.33$) suggests that the severity of this issue differs among households. A near-universal awareness of climate change impacts is evident, as shown by very low mean values for belief in climate effects on the community ($M = 1.01$) and observed climate impacts in the past 5–10 years ($M = 1.00$). These variables also exhibit extremely low standard deviations (0.10 and 0.07 respectively), confirming a strong consensus that climate change is already being felt locally. Despite this awareness, access to adaptation training or support remains relatively high ($M = 1.28$), with limited variation across responses ($SD = 0.45$), suggesting systemic gaps in capacity building. Similarly, while traditional adaptation strategies are in use to some degree ($M = 1.32$), they are not widespread or consistently applied. Perceptions of government response are also low ($M = 1.33$, $SD = 0.55$), reflecting dissatisfaction with institutional efforts to address climate-related challenges. Finally, the type of support needed for climate-resilient agriculture had a moderate mean ($M = 2.02$) and a relatively high standard deviation (1.20), indicating varied opinions on whether financial aid, training, technology, or policy support is most needed.

In table 5, the findings reveal high climate change awareness among respondents, with 96.1% indicating they have heard about it. The most common source of information was radio/TV (47.8%), followed by schools or workshops (26.3%), and social media (19.5%), while community discussions (2.4%) played a minimal role. Notably, 99.0% of respondents believe that climate change is currently affecting their community, indicating a strong local perception of climate-related impacts and a population highly attuned to environmental changes.

The results in table 6 indicate near-universal experiential awareness of climate change, with 99.5% of respondents reporting noticeable climatic changes over the past 5–10 years, reflecting repeated exposure to droughts, floods, and increasing rainfall variability in Jowhar District. More than half of the households (53.7%) perceive climate change as a major threat to agricultural production and food security, a view that is consistent with the area's strong reliance on climate-sensitive farming and livestock systems. Correspondingly, 98.0% of respondents report that climate change has directly affected household food availability, mainly through higher food prices (46.8%) linked to production shortfalls and market disruptions, and losses of crops and livestock (39.5%) caused by extreme weather events. Food insecurity emerges as a persistent condition rather than an occasional shock, with 60.0% of households indicating that they are often or always food insecure due to climate-related factors. Although 66.8% of households received food assistance during climate-related crises, dependence on government, humanitarian organizations, and community support suggests that existing coping mechanisms are largely reactive, underscoring limited adaptive capacity and the need for more sustained, resilience-oriented interventions.

Table 3. Socio-demographic profile of respondents ($N = 205$).

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	151	73.6
	Female	54	26.4
	total	205	100
Age group	Below 20	3	1.5
	21–30	61	29.8
	31–40	69	33.6
	41–50	31	15.1
	Above 50	41	20
	Total	205	100
Education Level	No formal education	113	55.1
	Primary education	18	8.8
	Secondary education	20	9.8
	College/University	54	26.3
	Total	205	100.0
Occupation	Farmers	100	48.8
	Traders	26	12.7
	Government employees	23	11.2
	NGO workers	26	12.7
	Community leaders	30	14.6
	Total	205	100.0

Table 4. Descriptive statistics of key variables on climate change perception and impacts.

Variable	N	Mean	Std. Error	Std. Deviation	Variance
Perceived threat to agriculture and food security	205	3.27	0.06601	0.95	0.89
Frequency of food insecurity due to climate issues	205	3.63	0.09272	1.33	1.76
Belief that climate change affects the community	205	1.01	0.00688	0.10	0.01
Observed climate impacts in past 5–10 years	205	1.00	0.00488	0.07	0.01
Access to adaptation support/training	205	1.28	0.03137	0.45	0.20
Use of traditional adaptation strategies	205	1.32	0.03552	0.51	0.26
Perception of government response	205	1.33	0.03822	0.55	0.30
Type of support needed for climate-resilient agriculture	205	2.02	0.08412	1.20	1.45

N = sample size, mean = average, Std. Error = standard error, Std. Deviation = standard deviation.

Table 5. Assessing community awareness of climate change.

Question	Response	Frequency (n)	Percentage (%)
Have you ever heard about climate change?	Yes	197	96.1
	No	8	3.9
If yes, where did you learn about climate change?	Radio/TV	98	47.8
(Multiple responses allowed)	Social media	40	19.5
	Schools/workshops	54	26.3
	Friends/community discussions	5	2.4
	Total (respondents answering 'Yes')	197	96.1
Do you believe that climate change is affecting your community?	Yes	203	99.0
	No	2	1.0
	Total	205	100.0

A large majority of respondents (69.8%) in table 7 reported the existence of traditional or community-led strategies to adapt to climate change, indicating a strong base of indigenous knowledge and practices. Furthermore, 72.2% of participants acknowledged receiving some form of support or training related to climate change adaptation. Among the providers of this support, the government (41%) was the leading source, followed by NGOs (36.1%) and community-based initiatives (22.9%). This reflects a multi-stakeholder involvement in climate adaptation efforts, though with room for

Table 6. Assessing impacts of climate change on agricultural production and food security.

Question/variable	Response category	Frequency (*n*)	Percentage (%)
Noticeable climate-change impacts in the past 5–10 years	Yes	204	99.5
	No	1	0.5
	Total	205	100.0
Perceived threat of climate change to agriculture & food security	No threat at all	16	7.8
	Minor threat	23	11.2
	Moderate threat	56	27.3
	Major threat	110	53.7
	Total	205	100.0
Has climate change affected food availability in your household?	Yes	201	98.0
	No	4	2.0
	Total	205	100.0
If yes, how has food availability been affected? *(Multiple answers allowed)*	Higher food prices	96	46.8
	Deterioration of nutritional status	28	13.7
	Loss of crops & livestock	81	39.5
Frequency of food insecurity due to climate issues	Never affected	23	11.2
	Rarely affected	17	8.3
	Sometimes affected	42	20.5
	Often affected	53	25.9
	Always affected	70	34.1
	Total	205	100.0
Receipt of food assistance during climate-related crises	Yes	137	66.8
	No	68	33.2
	Total	205	100.0
If yes, provider of assistance *(Multiple answers allowed)*	Government	56	40.9
	NGOs/international organisations	32	23.4
	Local community support	49	35.7
	Total	137	100.0

enhanced collaboration and outreach. When asked about the adequacy of government response to climate change impacts on agriculture and food security, 71.2% of respondents felt the efforts were sufficient, while about a quarter (24.9%) believed otherwise, revealing a generally positive perception but also a critical minority with reservations. Although respondents acknowledge that the government is making efforts to address climate-related challenges, these efforts are not necessarily perceived as effective in meeting farmers' practical needs. The apparent divergence between the low mean score for perceived government response (table 4; $M = 1.33$, $SD = 0.55$) and the higher proportion reporting that the government is 'doing enough' (table 7; 71.2%) reflects differences recognition of effort versus perceived effectiveness.

Similar patterns have been documented across sub-Saharan Africa, where farmers are aware of public agricultural and climate initiatives but remain critical of their limited reach and impact. For instance, Maake and Antwi (2022) report that South African farmers recognized government extension services yet perceived them as largely ineffective, while evidence from KwaZulu-Natal shows that advisory services existed but failed to substantially support climate-related decision-making (Zoleka and Sixolise 2025). Nyawo and Olorunfemi (2023), observed that although agricultural cooperatives in the study area rendered some level of support services to their members, the majority of respondents in Mpumalanga province of South Africa perceived their cooperatives as ineffective in delivering key services that could substantially improve livelihoods. This finding is consistent with broader evidence across sub-Saharan Africa showing that weak implementation, inadequate coverage, and poor targeting continue to limit the effectiveness of otherwise well-intentioned policies and institutional interventions. In terms of needs, nearly half of the respondents (46.3%) emphasized the importance of improved irrigation infrastructure as the most critical form of support. This was followed by access to climate-resilient seeds and livestock (24.9%) and better weather forecasting services (14.6%). Financial support and training were also cited, albeit by smaller proportions.

Table 7. Identifying community-based adaptation strategies.

Question	Response	Frequency (*n*)	Percentage (%)
Are there any traditional or community-led techniques/strategies used to adapt to climate change?	Yes	143	69.8
	No	58	28.3
	Not sure	4	2.0
	Total	205	100.0
Do you receive support or training on climate change adaptation?	Yes	148	72.2
	No	57	27.8
	Total	205	100.0
If yes, who provides this support? *(Multiple answers allowed)*	Government	84	56.8
	NGOs	74	50.0
	Community-based initiatives	47	31.8
Do you think the government is doing enough to address the effects of climate change on agriculture and food security?	Yes	146	71.2
	No	51	24.9
	Not sure	8	3.9
	Total	205	100.0
What type of support is most needed to combat the effects of climate change on agriculture?	Improved irrigation infrastructure	95	46.3
	Access to climate-resilient seeds and livestock	51	24.9
	Better weather forecasting	30	14.6
	Financial support (grants/loans)	18	8.8
	Training in climate adaptation practices	11	5.4
	Total	205	100.0

Table 8. Perceived importance of key policies for food security, climate resilience, and agricultural development in Somalia.

Policy/Strategy	Not important (Freq/%)	Slightly important (Freq/%)	Important (Freq/%)	Fairly important (Freq/%)	Very important (Freq/%)	Total ($N = 205$)
National climate-resilient food security policy	7/3.4%	39/19.0%	41/20.0%	50/24.4%	68/33.2%	205
Promote climate-smart agriculture (CSA)	7/3.4%	31/15.1%	60/29.3%	64/31.2%	43/21.0%	205
Strengthen water resource management	8/3.9%	24/11.7%	60/29.3%	58/28.3%	55/26.8%	205
Integrate early warning systems in planning	7/3.4%	47/22.9%	46/22.4%	51/24.9%	54/26.3%	205
Support agroforestry & land use policies	14/6.8%	35/17.1%	51/24.9%	49/23.9%	56/27.3%	205
Enhance R&D in climate-resilient agriculture	14/6.8%	32/15.6%	50/24.4%	56/27.3%	53/25.9%	205
Land tenure & land use for smallholders	7/3.4%	44/21.5%	44/21.5%	62/30.2%	48/23.4%	205
Agricultural insurance for climate shocks	14/6.8%	36/17.6%	49/23.9%	59/28.8%	47/22.9%	205

Table 8 demonstrates a strong consensus on the importance of integrated policy responses to climate change, food security, and agricultural resilience in Somalia; more than half of respondents rated all proposed strategies as very important. The national climate-resilient food security policy received the highest level of support (57.6%), underscoring the perceived need for coordinated national leadership and policy coherence. High levels of endorsement were also observed for water resource management

Table 9. Spearman's rho correlations on climate change awareness, impact, and adaptation in Jowhar district.

Variables	Heard about climate change	Belief climate affects community	Climate threat to agriculture & food security	Climate affects food availability	Frequency of food insecurity	Adaptation support or training	Government action on climate & food
Heard about climate change	1.000	0.493**	0.156*	0.700**	0.208**	0.325**	0.618**
Belief climate affects community	0.493**	1.000	0.077	0.704**	0.102	0.160*	0.304**
Climate threat to agriculture & food security	0.156*	0.077	1.000	0.109	0.934**	0.482**	0.465**
Climate affects food availability	0.700**	0.704**	0.109	1.000	0.145*	0.227**	0.432**
Frequency of food insecurity	0.208**	0.102	0.934**	0.145*	1.000	0.640**	0.617**
Adaptation support or training	0.325**	0.160*	0.482**	0.227**	0.640**	1.000	0.925**
Government action on climate & food	0.618**	0.304**	0.465**	0.432**	0.617**	0.925**	1.000

N: 205 respondents, **; $p < 0.01$, *; $p < 0.05$.

(55.1%), climate-smart agriculture (52.2%), early warning systems (51.2%), agroforestry and land-use policies (51.2%), and investment in climate-resilient agricultural research and development (53.2%), reflecting recognition of both immediate risk-reduction measures and long-term adaptation priorities. Although comparatively less emphasized, land tenure reform and agricultural insurance for climate shocks were still widely supported, highlighting the importance of institutional and financial mechanisms as essential complements to technical and ecological interventions.

Table 9 shows that climate change is strongly associated with perceived declines in food availability ($\rho = 0.700$, $p < 0.01$) and with perceptions of government action ($\rho = 0.618$, $p < 0.01$), indicating that experiential exposure to climate variability translates into heightened risk recognition and expectations of institutional engagement. More critically, the perceived threat of climate change to agriculture and food security exhibits an exceptionally strong correlation with the frequency of food insecurity ($\rho = 0.934$, $p < 0.01$), confirming that agricultural risk perceptions closely reflect lived food insecurity rather than abstract concern. The strong associations between adaptation support or training and both food insecurity frequency ($\rho = 0.640$, $p < 0.01$) and government action ($\rho = 0.925$, $p < 0.01$) further suggest a largely reactive adaptation landscape, in which institutional support intensifies in response to vulnerability rather than preventing it.

5. Discussion

Societies today confront significant challenges, particularly in agricultural sustainability and environmental security, with climate change posing threats to vulnerable communities, such as those in Somalia. This study evaluated the impact of climate risk on agricultural production and food security in Jowhar, Somalia. The findings reveal that climate change is not just an abstract concept for the community—nearly all participants recognize its impacts, reflecting a strong, lived awareness of environmental changes affecting their daily lives. This high level of awareness provides a solid foundation for adaptation and resilience in rural agricultural communities, while limited awareness is unlikely to be the main barrier to resilience in this setting. Moreover, in Africa, awareness of climate risks is increasing through targeted communication or personal observation. Climate information can be passed via various channels depending on the context; however, Jowhar community acknowledged the significance of traditional information channels such as radio and television (47.8%) as their source of climate information, and only 19.5% of respondents in this community identify social media as their primary source. This may reflect low technology adoption, limited internet access, or security restrictions, which mostly causes militant groups opposing the government to have banned the internet in these areas. However, since 81.40%

of global climate change is attributed to human activities, high awareness can promote sustainable and resilient agricultural practices (Pandve *et al* 2011). To further strengthen efforts, youth-led climate action projects and community consultations and workshops are vital for sharing knowledge and experiences, linking local knowledge to national frameworks, and enhancing inclusivity and localized solutions. This approach enhances the dissemination of climate information, utilizing multi-channel communications as a strategy to improve climate literacy among vulnerable communities (Barreda 2018).

Numerous studies, including Abdi *et al* (2024), Ahmed and Ali (2024), Hassan and Mohamed (2024), Warsame *et al* (2021), and Hassan and Mohamed (2024), highlight the severe climate-related challenges facing Somalia. In this study, the majority of respondents state that climate change is actively affecting their community, reflecting a strong perception of negative local environmental impacts and disruptions in the food supply chain. As previously noted by Warsame *et al* (2021) and Amir (2024), the country is experiencing recurrent droughts, floods, land degradation, and locust invasions that have significantly disrupted agricultural production, which is the primary livelihood for most Somalis. These events not only impair crops and livestock systems but also threaten food security, increase morbidity and livestock mortality, and exacerbate the spread of disease due to declining water and pasture availability. Such evidence underscores the real and immediate effects of climate change on both livelihoods and community well-being across Somalia. Additionally, the results of the current study reveal that unpredictable rainfall and rising temperatures, due to climate change, are reducing crop yields. This pattern is common in South Asia and sub-Saharan Africa (Hussain *et al* 2018, Aryal *et al* 2019). In many regions, including sub-Saharan African countries, agricultural productivity is declining while food insecurity is increasing. According to the country reports, Somalia struggles to produce enough food to meet local demand, forcing a greater reliance on imports. These challenges reflect deeper vulnerabilities, as unfavorable geographic and climatic conditions, combined with underdeveloped agricultural technologies and regional markets, intensify the impacts of climate change and jeopardize food security and rural livelihoods (Omotoso *et al* 2023).

Understanding these community-based responses is essential for designing effective adaptation policies. This approach is evident in Somalia, where most respondents (69.8%) reported using traditional or community-led strategies to cope with climate change, with support primarily coming from the government (41%), and NGOs (36.1%), these strategies typically include practices such as diversifying crops, using drought-tolerant and early-maturing seed varieties, employing traditional water harvesting techniques, maintaining communal irrigation channels, and adjusting planting calendars in response to changing rainfall patterns. In parallel, support and training on climate adaptation commonly focus on improved irrigation management, soil and water conservation, sustainable farming methods, and the introduction of climate-resilient seed systems. On the other hand, only 22.9% of respondents indicated that local initiatives are limited; this challenge is likely linked to resource constraints within local governments and their limited reach due to security issues. Thus, agricultural and water-focused adaptation—including irrigation improvements, water conservation, and climate-resilient crops and livestock—remains essential (Kurukulasuriya and Mendelsohn 2007, Hassan and Nhemachena 2008), despite ongoing security and political challenges. Additionally, similar to pastoral areas of Ethiopia and Kenya (Bryan *et al* 2011), the study found that Jowhar community recognize the need for better infrastructure, capacity-building, and policy support to reduce their vulnerability, ensure food security, and build sustainable resilience to ongoing climate variability.

From a policy perspective, the study highlights the importance of climate-related policies, emphasizing targeted strategies for national climate-resilient food security, water resource management, and climate-smart agriculture. Climate policy frameworks are essential for directing efforts and resources toward localized priorities. Somalia's national policy instruments, including the National Irrigation Policy (NIP), the NCCP (2020), and the NAPA —already outline strategic directions for improving irrigation efficiency, mainstreaming adaptation, and strengthening institutional coordination. These frameworks, based on proactive and strategic thinking, emphasize modernizing irrigation systems, enhancing early warning mechanisms, and promoting climate-resilient crop varieties, which directly correspond to the adaptation priorities identified by respondents. Furthermore, effective policies are evidence-based and long-term in nature, as noted by Abdi *et al* (2024) and Said *et al* (2023). Therefore, interventions aimed at sustaining agricultural productivity under increasing climate risks should be grounded in existing frameworks to address key priorities and avoid duplication during the implementation of current and future programs. In short, policy-guided interventions promote better resource allocation, strengthen institutional capacity, and foster closer integration of local adaptation practices, thereby reinforcing national food security systems.

6. Conclusion

This study provides empirical evidence that climate change is exerting significant pressure on agricultural production and food security in Jowhar District, Somalia. The findings highlight high perceived climate impacts combined with constrained adaptive capacity, reflecting limited access to technical knowledge, financing, and functional irrigation infrastructure. Respondents consistently prioritized irrigation rehabilitation, followed by the adoption of climate-resilient crop and livestock systems and the strengthening of early warning and response mechanisms, underscoring the need for structured, sequenced interventions. These priorities are consistent with broader national and regional policy frameworks that emphasize sustainable water resource management as the foundation for climate-resilient agriculture. At the national level, Somalia has made notable policy advances through instruments such as the NIP, NAPA, and NCCP. The NIP, in particular, reflects a strategic shift toward modern irrigation management, improved institutional coordination, and efficient resource utilization aligned with the NDP and regional commitments under CAADP and the SDGs. However, the translation of these frameworks into measurable outcomes will require sequenced implementation, targeted investment, and strong institutional arrangements.

Irrigation practices remain a critical priority in Jowhar, given the district's structural reliance on water-controlled agriculture supported by the Shabelle River and its heightened exposure to recurrent floods and droughts. Ongoing initiatives such as the JOSP show that irrigation rehabilitation and water governance reforms are both technically feasible and institutionally grounded within Somalia's current policy and implementation context. Climate-resilient seeds can be scaled through extension and community networks, while early warning systems require stronger inter-agency coordination and technical capacity.

7. Study limitations and future research

Given the study's geographic and methodological limitations, future research should adopt longitudinal and mixed-method approaches to capture both temporal and contextual dynamics of climate change impacts on food security and agricultural production. This includes systematically assessing the effectiveness of national adaptation frameworks in addressing localized climate risks, examining how gender and youth participation influence adaptive behaviors and household decision-making, and evaluating how irrigation governance can be integrated more effectively into climate-resilient food security strategies. Further studies should also investigate financing mechanisms, policy coherence, and localized implementation models, with a particular focus on how climate-smart technologies, sustainable water resource management, and institutional capacity-building can support scalable and resilient agricultural systems in Somalia.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

Funding

This study received no specific financial support.

Institutional Review Board Statement

The Research Ethics Committee (REC) of the University for Peace, Somali Programme, Somalia, has granted approval for this study (Ref. No. UPEACE/EC/0032).

Transparency

The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.

Conflict of interest

The authors declare that they have no competing interests.

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