Scientific Publishing House

Trends in Ecological and Indoor Environmental Engineering

Sylvester Odiana et al. *TEIEE 4(2) 2026*

RESEARCH ARTICLE **OPEN ACCESS**
https://doi.org/10.62622/TEIEE.026.4.2.12-21 **ISSN 2956-9761**

INTEGRATING LONG-TERM CLIMATE TREND ANALYSIS AND HOUSEHOLD SOCIOECONOMIC VULNERABILITY TO ASSESS CLIMATE STRESS IN THE NIGER DELTA FLOODPLAIN (UGHELLI, NIGERIA)

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Received: 21.02.2026; ***Accepted:*** 12.03.2026; ***Available online:*** 29.03.2026; ***Published:*** 30.06.2026

Cite this article: Odiana, S., Godwin, O. G., & Okoduwa, A. K. (2026). Integrating Long-Term Climate Trend Analysis and Household Socioeconomic Vulnerability to Assess Climate Stress in the Niger Delta Floodplain (Ughelli, Nigeria). *Trends in Ecological and Indoor Environmental Engineering*, 4(2), 12–21.

Background: Climate change increasingly affects livelihoods and socioeconomic stability in climate-vulnerable regions, particularly across Sub-Saharan Africa. However, limited empirical research links long-term climatic trends with household-level perceptions and socioeconomic outcomes in medium-sized urban communities. Understanding how climate variability translates into perceived stress and livelihood challenges is essential for developing locally grounded climate adaptation and resilience strategies. **Objectives:** This study aims to assess climate change-induced stress and its socio-economic impacts on households in Ughelli, Delta State, Nigeria, by examining public awareness, the occurrence of climate stressors, and the effects on livelihoods in a localized context. **Methods:** Data were collected from 100 respondents using a structured, five-point Likert-scale questionnaire, covering socio-demographics, awareness of climate change, occurrence of stress events, and socio-economic impacts. Remote sensing datasets, including CHIRPS rainfall and ERA5-Land temperature data from 1983–2022, were analysed using Google Earth Engine. Annual means were calculated, and trends assessed with the non-parametric Mann-Kendall test. Descriptive statistics summarized survey responses, while Python and SPSS were used for data processing and statistical analysis. This mixed-methods approach allowed triangulation of subjective perceptions and objective climatic trends, providing a comprehensive understanding of localized climate impacts. **Results:** Survey results indicated that residents were aware of climate change and recognized flooding and heatwaves as frequent stress-inducing events, particularly affecting the elderly and low-income households. Respondents reported that climate stress negatively influenced agricultural productivity and household income. Remote sensing analysis revealed a statistically significant increasing trend in mean annual temperature (0.018°C per year, $p<0.001$), whereas rainfall exhibited substantial interannual variability without a consistent trend ($p=0.432$). These findings demonstrate a combination of warming and erratic precipitation patterns contributing to localized climate stress. Perceptions of government interventions indicated that policies exist but are perceived as insufficient at the household level, highlighting gaps in adaptation implementation. **Conclusion:** The study provides empirical evidence linking long-term warming and variable rainfall to household-level socio-economic stress in Ughelli. Findings reveal frequent climate-induced disruptions to livelihoods, particularly for vulnerable populations, addressing a localized knowledge gap in Niger Delta climate research.

Keywords: climate change impacts; climate vulnerability; household resilience; climate stressors; remote sensing; Niger Delta; climate adaptation; Mann-Kendall trend analysis.

INTRODUCTION

Climate change represents one of the most significant environmental challenges of the twenty-first century, characterized by long-term alterations in temperature, precipitation patterns, and the frequency of extreme weather events. These changes are primarily driven by anthropogenic greenhouse gas emissions and have profound implications for ecosystems, economies, and human well-being worldwide (Bhattacharya, 2019; Kaini et al., 2022). Recent global assessments highlight that climate-related hazards such as heatwaves, floods, and droughts are increasing in both frequency and intensity, posing substantial risks to food security, water resources, and socioeconomic stability (IPCC, 2007; Tahir et al., 2023). As a result, climate change is increasingly recognized not only as an environmental issue but also as a critical driver of social vulnerability and development challenges, particularly in low- and middle-income countries (Afzal et al., 2024; Hadley et al., 2023).

Sub-Saharan Africa is widely regarded as one of the regions most vulnerable to climate variability and extreme weather events. High dependence on climate-sensitive sectors such as agriculture, rapid population growth, limited infrastructure, and constrained adaptive capacity exacerbate the region's exposure to climate risks (Nyangarika, 2024; IPCC, 2007). Increasing climate variability has already begun to disrupt livelihoods, reduce agricultural productivity, and strain public services across the region (Serdeczny et al., 2017; Thornton et al., 2023). Furthermore, climate change is increasingly linked to broader socioeconomic challenges including poverty, food insecurity, and migration, thereby amplifying existing development pressures (Rigaud et al., 2018; Woodland et al., 2023).

Nigeria, the most populous country in Africa, is particularly vulnerable to climate change impacts due to its diverse ecological zones, rapidly expanding population, and dependence on climate-sensitive economic activities. The country has experienced increasing climatic variability in recent decades, including rising temperatures, erratic rainfall patterns, prolonged droughts in northern regions, and more frequent flooding in southern coastal areas (Idowu et al., 2011; Williams et al., 2018; World Bank, 2019; Okoduwa & Mokhtarisabet, 2025). Approximately six percent of Nigeria's landmass is exposed to extreme climate-related hazards, and the frequency of severe flooding events has increased significantly in recent years (World Bank, 2019; Adesola et al., 2024). For example, the devastating floods of 2022 resulted in over six hundred fatalities and displaced more than 1.4 million people, causing widespread damage to infrastructure, agriculture, and housing (Okoduwa et al., 2024). Subsequent flood events, including those reported in 2025 in Borno State, further exposed the country's limited disaster preparedness and vulnerability to extreme climatic events (Mokhtarisabet & Okoduwa, 2025).

The Niger Delta region, located in southern Nigeria, represents one of the country's most environmentally sensitive and socioeconomically complex areas. Characterized by extensive wetlands, low-lying floodplains, and dense river networks, the

region is particularly susceptible to flooding, coastal erosion, and sea-level rise (Fitton et al., 2019; Ragatoa et al., 2019). Rapid urbanization, deforestation, and unsustainable land-use practices have further intensified environmental degradation and increased exposure to climate hazards (Ndakara & Eyefia, 2024). These environmental changes have significant implications for local livelihoods, especially in communities where economic activities depend heavily on agriculture, fisheries, and small-scale trade.

Ughelli, a medium-sized urban centre in Delta State located within the Niger Delta floodplain, exemplifies many of these challenges. In recent years, residents have increasingly reported climate-related stressors such as recurrent flooding, rising temperatures, and unpredictable rainfall patterns. These environmental changes disrupt agricultural cycles, reduce crop yields, damage infrastructure, and place additional pressure on already limited economic resources (Mthembu et al., 2025). Furthermore, the impacts of climate change extend beyond environmental degradation to affect public health, social stability, and community resilience. Rising temperatures and increased flooding have contributed to the spread of waterborne and vector-borne diseases such as malaria, cholera, and diarrhoea (Yeboah, 2024). At the same time, repeated exposure to climate-related disasters can lead to psychological stress, economic insecurity, and displacement among affected populations (Woodland et al., 2023).

These impacts are often disproportionately borne by socially and economically vulnerable groups, including low-income households, women, children, and elderly populations. Limited access to healthcare, financial resources, and institutional support reduces the capacity of these groups to adapt to climate-related risks. In many cases, households respond to environmental stress through livelihood diversification, migration, or relocation, which can create additional pressures on urban infrastructure and social services in receiving communities (Warner & Afifi, 2014; Rigaud et al., 2018).

Despite increasing recognition of climate change risks at national and international levels, significant gaps remain in localized empirical research. Much of the existing literature on climate change in Nigeria has focused on national climate projections, agricultural productivity, or coastal vulnerability, with comparatively fewer studies examining how long-term climatic trends translate into household-level experiences and socioeconomic outcomes in specific communities. In particular, medium-sized urban centres in the Niger Delta, such as Ughelli, remain underrepresented in climate vulnerability research. Moreover, relatively few studies integrate long-term climatic observations derived from remote sensing datasets with household perception data to better understand the relationship between objective climate trends and lived experiences of climate stress.

Addressing these knowledge gaps is essential for developing context-specific climate adaptation strategies and improving local resilience. Integrating climate data analysis with household-level socioeconomic assessments can provide a more comprehensive understanding of how climatic changes affect communities and livelihoods at the local scale.

Therefore, this study investigates climate change-induced stress and its socioeconomic implications for households in Ughelli, Delta State, Nigeria. Specifically, the study aims to: (i) assess public awareness and perceptions of climate change among local households; (ii) analyse forty-year trends in temperature and rainfall using satellite-derived climate datasets; (iii) identify the occurrence and frequency of climate-related stressors such as flooding and heatwaves; and (iv) evaluate the socioeconomic impacts of these stressors on household livelihoods and community well-being.

Based on existing climate projections for West Africa and increasing reports of climate-related hazards in Nigeria, this study advances three research hypotheses. First, long-term climate records will reveal a statistically significant warming trend in the study area over the past four decades. Second, households in Ughelli will report increasing exposure to climate-related stressors, particularly flooding and extreme heat events. Third, perceived climate stress will be associated with measurable socioeconomic challenges affecting household livelihoods and well-being.

By integrating long-term climate trend analysis with household-level socioeconomic data, this study aims to deepen understanding of how climatic changes translate into perceived stress and socioeconomic challenges at the household level in the Niger Delta region. The study therefore seeks to contribute empirical evidence that may support the development of locally grounded climate adaptation and resilience strategies for vulnerable urban communities in Sub-Saharan Africa.

MATERIALS AND METHODS

Study area

The study was conducted in Ughelli, a major town in Delta State, Nigeria, located within the western Niger Delta floodplains (Figure 1). Ughelli lies east of Warri and serves as the administrative headquarters of the Ughelli North Local Government Area. The town is positioned at approximately 5.5002° N latitude and 5.9938° E longitude, with an average elevation of 9 m above sea level. Covering 818 km², it had a population of 321,028 according to the 2006 national census. Ughelli is historically significant as a major town of the Urhobo ethnic group, with origins tracing back to the 14th–15th centuries.

The climate is humid tropical, supporting rich biodiversity and dense vegetation, including broadleaf evergreen trees (such as mahogany, iroko, oil palms), ferns, shrubs, and climbers (Ovie & Odiyirin, 2024; Edwin-Wosu, & Urhobotie, 2022). Rapid urbanization, mining, and industrial activities have significantly altered the original vegetation cover, leading to environmental challenges such as soil erosion, flooding, and habitat loss (Ataraire & Ezeomedo, 2016). Despite these pressures, Ughelli remains agriculturally fertile, supporting a range of crops and contributing to the local economy.

Research design

This study employed a descriptive cross-sectional research design, integrating both quantitative survey methods and remote sensing-based climate analysis to examine the socio-economic impacts of climate change-induced stress. This mixed-methods approach allows triangulation of findings, combining subjective perceptions with objective climate trends to improve validity.

The primary survey measured residents' awareness, experiences, and responses to climate-related events, while secondary climate datasets (CHIRPS and ERA5-Land) provided long-term records of rainfall and temperature trends.

Primary data collection

Survey instrument

A structured questionnaire was developed and divided into five sections:
Section A: Socio-demographic characteristics (age, gender, education, occupation);

Section B: Awareness and understanding of climate change and sources of information;
Section C: Frequency and severity of climate-induced events (flooding, heatwaves, erosion);
Section D: Perceived socio-economic impacts (income, food security, housing, health);
Section E: Community perceptions of government policies, adaptation strategies, and institutional responses.

All items were measured on a five-point Likert scale (strongly disagree = 1, strongly agree = 5), allowing standardized responses suitable for statistical analysis.

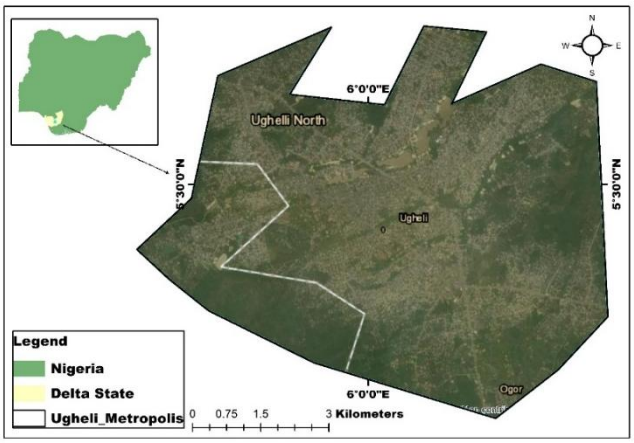

Figure 1. Study area in Ughelli Metropolis, Nigeria

Sampling and administration

A convenience sampling technique was employed to recruit participants, selecting respondents based on their accessibility and willingness to participate during the data collection period. The questionnaire was distributed both physically and online via Google Forms to ensure inclusivity, particularly for respondents with limited internet access. A total of 100 valid responses were collected. Respondent confidentiality and informed consent were obtained in line with ethical research standards.

Data analysis (survey)

Descriptive statistics were computed, including mean, standard deviation, and frequency distributions. Formulas used:

– mean:

$$\bar{x} = \frac{\Sigma x_i}{n}, \quad (1)$$

where $\bar{x}$ is mean; Σx_i is represents the summation of all individual responses, n is the total number of responses.

– standard deviation:

$$\sigma = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n}}, \quad (2)$$

where σ is standard deviation; $\bar{x}$ is the mean of all values.

A lower standard deviation indicates that responses are closely clustered around the mean, whereas a higher value suggests greater variability among respondents.

Secondary data (climate data)

Data sources

Primary climate observations for rapidly urbanizing areas such as Ughelli are not always adequately represented in national meteorological station networks. In Nigeria, observational coverage provided by the Nigerian Meteorological Agency (NiMet) remains spatially limited in several urbanizing regions, including Ughelli, which may constrain long-term climate assessments based solely on ground-based observations (Odiana & Ibrahim, 2015; Abaje & Oladipo, 2019). To address this limitation, satellite-derived and reanalysis climate datasets were used in this study.

Rainfall data were obtained from the CHIRPS dataset, which provides quasi-global precipitation estimates by integrating satellite observations with in situ station measurements. The dataset offers daily to monthly precipitation data from 1983 to 2023 with a spatial resolution of 0.05° (approximately 5.5 km). Owing to its high spatial resolution and the integration of satellite and ground-based observations, CHIRPS has been widely applied in hydro-climatic studies and has demonstrated good performance in tropical regions characterized by high rainfall variability (Funk et al., 2015; Bai et al., 2018; Gao et al., 2018; Cerón et al., 2020).

Temperature data were derived from the ERA5-Land reanalysis product, which provides hourly land-surface meteorological variables, including temperature, humidity, and wind speed, at a spatial resolution of 0.1° (approximately 11.1 km). For the purposes of this study, annual mean land surface temperature values were calculated from the available time series. ERA5-Land has been extensively validated and widely applied in climate and hydrological research due to its consistency and global coverage (Benali et al., 2012; Räisänen, 2021; Yilmaz, 2023).

Data processing

Both datasets were accessed and processed using the Google Earth Engine (GEE) cloud computing platform. Data extraction was performed through JavaScript scripts implemented in the GEE Code Editor to spatially subset the study area corresponding to the Ughelli region for the period 1983–2023. For each year, mean annual values of rainfall and air temperature were calculated based on the available observations within the defined spatial extent. The resulting datasets were subsequently exported as comma-separated values (CSV) files for further statistical analysis. Prior to statistical processing, a preliminary quality assessment was conducted in Microsoft Excel to identify potential missing values, outliers, and inconsistencies in the time series.

Trend analysis

To assess long-term trends in the analysed climatic parameters, the Mann–Kendall (MK) test was employed to detect statistically significant monotonic trends in the time series. The MK test is a non-parametric method widely used in hydro-climatic studies because it does not require assumptions of

normal data distribution or linear relationships between variables. Due to its robustness and suitability for environmental datasets, it has been extensively applied in climate trend analyses (Tabari et al., 2015; Aditya et al., 2021). The statistical analysis was performed in Python 3.14.3 using the pyMannKendall library.

Reproducibility and data availability

To ensure transparency and reproducibility of the research process, the materials and analytical procedures used in this study can be made available upon reasonable request. The survey instrument employed for data collection is available from the authors upon request. In addition, the scripts used for climate data extraction through the Google Earth Engine platform can be provided to facilitate replication of the data acquisition procedures. The Python scripts used to implement the Mann–Kendall trend test are also available and may be shared to allow full reproducibility of the statistical analysis.

Temperature trend (1983–2023)

Annual mean temperature values for Ughelli from 1983 to 2023 are presented in Figure 2. Over the 40-year period, temperatures exhibited inter-annual fluctuations with a general increasing trend. Between 1983 and 1990, mean annual temperatures remained relatively stable, averaging approximately 25.5°C, with the lowest recorded value of 25.1°C in 1985.

A gradual increase in mean temperatures was observed from 1998 onward, rising from 26.4°C to a maximum of 26.6°C in 2023. Trend analysis using the Mann–Kendall test (Table 1) confirmed a statistically significant upward trend ($Z = 5.283$, $p < 0.001$, Kendall's $\tau = 0.567$). The slope of 0.018°C per year indicates that the annual mean temperature increased, on average, by 0.018°C annually over the 40-year period.

These results provide empirical evidence of a consistent long-term warming trend in Ughelli over the past four decades.

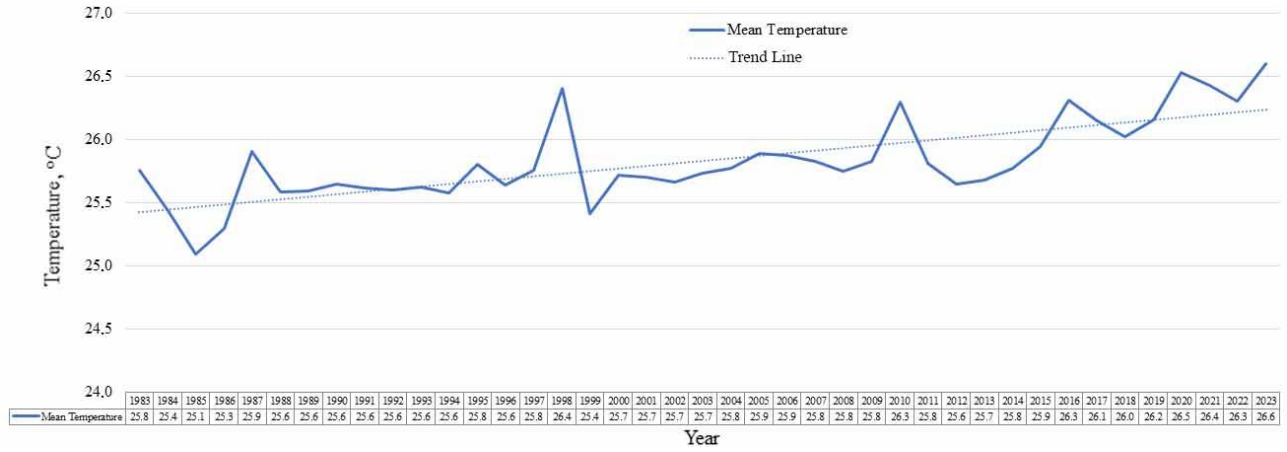

Figure 2. Trend in annual mean temperature in Ughelli Metropolis, 1983–2023

Table 1. Mann–Kendall test statistics for annual mean temperature in Ughelli Metropolis (1983–2023)

Trend	H	p-value	Z	Tau	Slope
Increasing	True	0.001	5.283	0.567	0.018

Rainfall trend (1983–2023)

Annual rainfall values for Ughelli from 1983 to 2023 are presented in Figure 3. Rainfall exhibited pronounced interannual variability over the 40-year period. The highest annual rainfall occurred in 1995 (3,060 mm), while the lowest was recorded in 2020 (1,999 mm). During the early years (1983–1990), annual rainfall fluctuated between 2,000 and 2,800 mm, and variability continued through 2018–2023, with values ranging from 1,999 mm in 2020 to 2,413 mm in 2023.

Trend analysis using the Mann–Kendall test (Table 2) indicated no statistically significant trend in annual rainfall ($Z = 0.786$, $p = 0.432$, Kendall's $\tau = 0.087$). The computed slope of –3.42 mm per year suggests a very slight decline, which is not statistically significant. These results indicate that, despite high interannual variability, there is no consistent long-term increase or decrease in rainfall in Ughelli over the studied period.

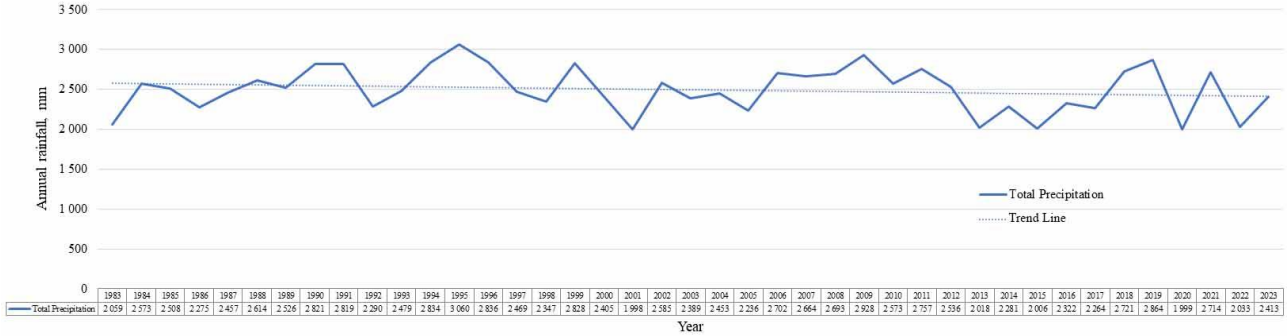

Figure 3. Annual mean rainfall trend in Ughelli Metropolis (1983–2023)

Table 2. Mann-Kendall test for rainfall in Ughelli Metropolis

Trend	H	p-value	Z	Tau	Slope
No trend	False	0.432	0.786	0.087	–3.42

Demographic characteristics of the respondents

The demographic characteristics of the 100 survey respondents are summarized in Table 3. Among the participants, 40.0% were male and 60.0% were female. The majority of respondents (67.0%) were under 30 years of age, 13% were between 31–40 years, 10% were between 41–50 years, and 10% were over 50 years.

Regarding marital status, 44% were married and 56% were single. In terms of educational attainment, 26% of respondents had secondary education, while 74% had tertiary education. These results indicate that most respondents were young and literate.

Awareness of climate change

The survey results regarding respondents' awareness of climate change are summarized in Table 4. The majority of respondents indicated that human activities are the main drivers of climate change and that climate change is associated with extreme weather events. Most respondents also acknowledged significant changes in weather patterns over time.

A smaller proportion of respondents reported being knowledgeable about the socioeconomic impacts of climate change or the environmental consequences of climate variability. Overall, the results show that respondents possess general awareness of climate change, particularly its anthropogenic origins and observable weather effects.

Occurrences of climate stress-causing events

The responses regarding the occurrence of climate stress-causing events are summarized in Table 5. The majority of respondents reported that flooding is common in Ughelli and that heatwaves are frequently experienced.

Respondents also indicated that vulnerable populations, such as the elderly and low-income households, are most affected by climate-related disasters. A smaller proportion of respondents reported that drought occurs frequently or that climate-related disasters are becoming more frequent in the town.

These results indicate the presence and recognition of specific climate stressors in the study area.

Table 3. Demographic characteristics of the respondents

Characteristics	Components	Frequency	Percentage, %
Gender	Male	40	40.0
	Female	60	60.0
	Total	100	100.0
Age	30 or less	67	67.0
	31–40	13	13.0
	41–50	10	10.0
	50 and above	10	10.0
	Total	100	100.0
Marital status	Married	44	44.0
	Single	56	56.0
	Total	100	100.0
Educational level	Secondary	26	25.0
	Tertiary	74	74.0
	Total	100	100.0

Table 4. Climate change awareness

Items	SA, %	A, %	UD, %	D, %	SD, %	Mean	STD	Remark
Human activities is the main cause of climate change	26	63	7	4	0	4.11	0.695	High awareness
Climate change is associated with extreme weather events	25	68	68	6	0	4.17	0.570	High awareness
There has been a significant change in weather patterns over the years	30	59	10	0	1	4.17	0.682	High awareness
I am well informed of the socioeconomic impacts of climate change	22	66	7	7	0	4.05	0.702	Low awareness
I am concerned about the impacts of climate change on the environment and households	20	67	9	1	3	4.00	0.778	Low awareness

Note: strongly agreed (SA) = 5; agreed (A) = 4; undecided (UD) = 3; disagreed (D) = 2; strongly disagreed (SD) = 1

Table 5. Climate stress causing events

Items	SA, %	A, %	UD, %	D, %	SD, %	Mean	STD	Remark
Drought frequently occurs in Ughelli town	7	44	31	15	3	3.37	0.93	Low stress
Flooding is common in Ughelli town	6	56	28	10	0	3.58	0.76	High stress
Heatwaves is a commonly experienced in Ughelli town	6	50	33	9	2	3.49	0.82	High stress
Climate related disasters are becoming more frequent in Ughelli town	8	44	25	18	5	3.32	1.02	Low stress
Climate change relayed disasters affect mostly the vulnerable population e.g. the elderly, low-income households	12	55	18	12	3	3.61	0.95	High stress

Note: strongly agreed (SA) = 5; agreed (A) = 4; undecided (UD) = 3; disagreed (D) = 2; strongly disagreed (SD) = 1

Effects of climate-induced stress on economic productivity and livelihoods

Survey responses regarding the effects of climate-induced stress on economic productivity and livelihoods are presented in Table 6. The majority of respondents indicated that climate change negatively impacts agricultural productivity and disrupts the food supply chain. Respondents also reported that income loss is associated with climate change in the study area.

A smaller proportion of respondents indicated that small businesses and entrepreneurship or retirement planning are affected by climate-related stressors.

These results provide an overview of the perceived socioeconomic impacts of climate-induced stress on households in Ughelli.

Table 6. Effects of climate-induced stress on economic productivity and livelihoods

Items	SA, %	A, %	UD, %	D, %	SD, %	Mean	STD	Remark
Climate change impacts agricultural productivity	24	69	5	1	1	4.14	0.64	High impact
Small businesses and entrepreneurship are affected by climate change	17	59	11	10	3	3.77	0.95	Low impact
Climate change disrupts the food supply chain	28	58	4	7	3	4.01	0.94	High impact
Climate-related stressors influence retirement	12	40	19	24	5	3.30	1.12	Low impact
Climate change leads to income loss	20	56	15	9	0	3.87	0.84	High impact

Note: strongly agreed (SA) = 5; agreed (A) = 4; undecided (UD) = 3; disagreed (D) = 2; strongly disagreed (SD) = 1

Government strategies and interventions on climate change

Survey responses regarding government strategies and interventions are summarized in Table 7. The majority of respondents agreed that climate change is a pressing environmental issue requiring government intervention and acknowledged the existence of policies aimed at reducing greenhouse gas emissions.

Conversely, most respondents indicated that government policies and programs have not been effective in addressing climate change impacts on households, that climate change risks are not adequately communicated to the public, and that incentives for climate-friendly technologies and practices are not provided.

These results provide an overview of public perceptions of government interventions related to climate change in Ughelli.

DISCUSSION

Mean temperature in Ughelli Metropolis (1983–2023)

The analysis of temperature data for Ughelli indicates a consistent and significant warming trend over the 40-year period. Mean annual temperatures increased from approximately 25.5°C in the early 1980s to 26.6°C in 2023. This trend is supported by the Mann–Kendall test, confirming a statistically significant positive trend. These findings are consistent with previous studies reporting rising temperatures across Nigeria and the Niger Delta region (Olaniyi et al., 2013; Ebele & Emodi, 2016; Elisha et al., 2017). Similarly, studies in Warri and Benin City observed comparable warming trends (Efe & Ojoh, 2013; Floyd et al., 2016), reflecting regional climate change patterns. Rising temperatures in the Niger Delta are expected to influence hydrological cycles, agriculture, and human health, emphasizing the need for local adaptation strategies.

Mean rainfall in Ughelli Metropolis (1983–2023)

Annual rainfall in Ughelli exhibited substantial interannual variability with no statistically significant long-term trend. The highest annual rainfall was recorded in 1995 (3,060 mm) and the lowest in 2020 (1,999 mm). These findings align with previous studies reporting inconsistent rainfall patterns in southern Nigeria, including Delta State (Ofordu et al., 2022; Edokpa, 2020). Despite warming temperatures, the absence of

a clear trend in rainfall suggests that climate variability, rather than consistent increases or decreases, continues to characterize precipitation patterns in Ughelli. Such variability can adversely affect water resource management and long-term agricultural planning, particularly for rain-fed crops, by increasing uncertainty in planting schedules and water availability.

Table 7. Government strategies and interventions on climate change

Items	SA, %	A, %	UD, %	D, %	SD, %	Mean	STD	Remark
Climate change is a pressing environmental issue that requires government intervention	28	60	8	3	1	4.11	0.75	High intervention
There are existing policies effective in reducing greenhouse gas emissions	19	52	13	11	5	3.69	1.06	High intervention
Government and institutional policies have effectively addressed the impacts of climate change on households	9	55	8	20	8	3.37	1.14	Low intervention
Government communicates climate change risks to the public	11	51	12	21	5	3.42	1.09	Low intervention
The government provides incentives for climate-friendly technologies and practices	11	36	18	25	10	3.13	1.20	Low intervention

Note: strongly agreed (SA) = 5; agreed (A) = 4; undecided (UD) = 3; disagreed (D) = 2; strongly disagreed (SD) = 1

Awareness of climate change

Survey results indicate that respondents are generally aware of climate change and its anthropogenic drivers, particularly its association with extreme weather events. These findings corroborate studies by Isiaka et al. (2023) and Suleiman (2023), which emphasized the effectiveness of targeted, community-specific awareness initiatives. Climate change education enhances climate literacy, supports informed decision-making, and strengthens local adaptation capacities (Ekpo & Aiyedun, 2019; UNESCO, 2018). Increased awareness, particularly among literate and young populations, provides a foundation for adopting mitigation measures and sustainable practices in vulnerable communities.

Occurrence of climate stress-causing events

Flooding and heatwaves were reported as the most frequent climate stressors in Ughelli, with vulnerable populations, such as the elderly and low-income households, being disproportionately affected. These findings are consistent with previous research in Nigeria and Sub-Saharan Africa, which identifies socioeconomically disadvantaged groups as particularly vulnerable to climate impacts (Lawanson et al., 2023; Woodley, 2011; Enete, 2014). Limited adaptive capacity and exposure to environmental hazards contribute to heightened risk for these populations. Understanding the spatial and demographic distribution of climate stressors is critical for developing targeted adaptation and disaster management strategies.

Effects of climate-induced stress on economic productivity and livelihoods

Respondents reported that climate-induced stress negatively affects agricultural productivity, disrupts food supply chains, and results in income loss. This observation aligns with findings from Coster & Adeoti (2015), Di Falco et al. (2011), and Gollin et al. (2002), which highlight the vulnerability of smallholder agriculture to climate variability in Sub-Saharan Africa. Reduced rainfall, flooding, and rising temperatures exacerbate food insecurity and threaten livelihoods (Ikudayisi et al., 2018; Gladys et al., 2017; Kumar et al., 2018; Lee et al., 2024;). In Ughelli, localized flooding has been identified as a major disruptor of agricultural activities and household income, corroborating studies by Odiana et al. (2022) and Odiana et al. (2023). These findings emphasize the socio-economic significance of climate-induced stressors and the need for interventions that protect livelihoods.

Government strategies and interventions on climate change

The study indicates that while government policies exist to address climate change, public perception suggests that interventions are insufficient and inadequately communicated. Respondents reported a lack of incentives for climate-friendly technologies and limited policy effectiveness at the household level. Previous studies have highlighted similar challenges, emphasizing the importance of integrating adaptation into local governance and providing financial incentives for risk reduction (Onyekuru & Marchant, 2011; Tari & Diah, 2024; Ifeanyi-obi & Nnadi, 2014). Effective adaptation requires well-resourced institutions and context-specific strategies to facilitate community-level interventions (Elbarky et al., 2024; Selje et al., 2024). Strengthening institutional capacity and ensuring implementation of policies with clear budget allocations are critical for improving climate resilience in Ughelli and similar urban centres.

CONCLUSION

This study investigated climate change-induced stress and its socio-economic implications in Ughelli Town, Delta State, combining household surveys with remote sensing analysis of long-term temperature and rainfall trends. Survey results indicate that residents are generally aware of climate change and its association with extreme weather events. Flooding and heatwaves were reported as frequent climate stressors, disproportionately affecting vulnerable populations, while droughts were perceived as less frequent. These stressors were observed to influence economic productivity and livelihoods, particularly through impacts on agricultural output and income generation.

Analysis of remote sensing datasets revealed a significant increasing trend in mean annual temperature over the 40-year period, whereas annual rainfall exhibited high interannual variability with no statistically significant long-term trend. This combination of warming and variable precipitation patterns contributes to the localized climate stress experienced by households in Ughelli.

The study provides empirical evidence linking long-term climatic trends to household-level socio-economic effects in a medium-sized urban centre in the Niger Delta, addressing a gap

in localized climate research in Nigeria. Remaining gaps include detailed quantification of adaptive capacity at the household level and the long-term economic consequences of repeated climate stress events, which warrant further investigation.

Acknowledgement

The authors wish to express their sincere appreciation to the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City, Nigeria for providing the enabling environment for carrying out this research.

Author's statements

Contributions

All authors contributed equally; all authors participated equally in all stages of the research and preparation of the manuscript.

Declaration of conflicting interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Financial interests

The authors declare they have no financial interests.

Funding

Not applicable.

Data availability statement

The data used in this study are made available upon request from the corresponding author.

AI Disclosure

The authors declare that generative AI was not used to assist in writing this manuscript.

Ethical approval declarations

Not applicable.

Additional information

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