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Research Article

Climate Change Awareness and Climate-Related Challenges Affecting Smallholder Farmers in Southern Sierra Leone

Mohamed Jalloh[1], Denis Magnus Ken Amara[2], Prince Tongor Mabey[3, 4, *], Lamin Rahman Mansaray[1]

[1]Institute of Geography and Development Studies, Njala University, Freetown, Sierra Leone
[2]Department of Soil Science, Njala University, Freetown, Sierra Leone
[3]Department of Health Education and Behavioural Science, Njala University, Freetown, Sierra Leone
[4]Institute of Environmental Management and Quality Control, Njala University, Freetown, Sierra Leone

Abstract

This study assessed climate change awareness, understanding, observed climatic changes, and climate-related challenges affecting smallholder farmers in the Southern Region of Sierra Leone. A convergent mixed-methods research design was employed, integrating quantitative and qualitative approaches. Data were collected from 614 smallholder farmers selected through a multistage sampling procedure. Household surveys, Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and secondary data sources were utilized. Quantitative data were analyzed using descriptive statistics, ordinal logistic regression, binary logistic regression, and the Kruskal-Wallis H test. The findings revealed that 80.2% of farmers had heard of climate change, with Radio/TV (56.0%), community groups (47.7%), and family/traditional knowledge (43.5%) serving as the major information sources. Farmers reported increasing temperatures (79.0%), irregular rainfall (69.5%), and prolonged dry seasons (58.6%) as the most noticeable climatic changes. Unpredictable rainfall (91.9%), soil degradation (79.2%), drought (68.9%), and pests and diseases (67.3%) emerged as the most severe climate-related challenges. Ordinal logistic regression showed that age ($OR = 1.723$, $p < 0.001$), education level ($OR = 1.552$, $p < 0.001$), and residency status ($OR = 1.516$, $p = 0.032$) significantly influenced climate change understanding. Binary logistic regression identified irregular rainfall ($OR = 3.367$), lack of irrigation ($OR = 3.086$), soil degradation ($OR = 2.824$), and drought ($OR = 2.328$) as major predictors of severe climate-related impacts ($p < 0.001$). Significant district-level differences in climate vulnerability were observed, while the Kruskal-Wallis test indicated significant variation in extreme weather frequency across districts ($\chi^2 = 71.08$, $p < 0.001$). The study concludes that climate change awareness is relatively high, but vulnerability remains substantial. Strengthening climate information services, extension support, irrigation development, and the adoption of climate-smart agricultural practices is recommended to enhance resilience and promote sustainable agricultural development among smallholder farmers in Southern Sierra Leone.

Keywords

Climate Change Awareness, Smallholder Farmers, Climate-related Challenges, Adaptation, Logistic Regression, Climate-smart Agriculture, Sierra Leone

*Correspondence: Prince Tongor Mabey (pmabey@njala.edu.sl)

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1. Introduction

Climate change has emerged as one of the most pressing global challenges of the 21st century, prompting worldwide efforts aimed at both climate change adaptation and mitigation to reduce its adverse impacts. Climate variability and climate change continue to pose significant threats to ecosystems, livelihoods, and socio-economic development across the world [1, 43, 75]. According to Asfaw et al. [14], most people in developing countries depend on climate-sensitive livelihoods and possess limited adaptive capacity, making them particularly vulnerable to climate-related shocks. Numerous studies have documented the impacts of observed and projected climate change on the physical environment, ecosystems, and human activities [29, 56, 86] Climate change has altered land-use patterns, increased pressure on water resources, affected ecosystem services, reduced the capacity of ecosystems to sustain food production, and threatened the availability of freshwater resources [42, 73, 91]. However, while the global and regional impacts of climate change are well documented, less attention has been given to understanding local-level experiences and community-specific contexts [22]. Consequently, understanding how communities perceive climate change and its associated risks is essential for designing effective and context-specific adaptation and mitigation strategies.

Sub-Saharan Africa (SSA) is among the region's most vulnerable to climate change due to its high dependence on natural resources and limited adaptive capacity [19, 72]. Recent studies indicate that climate change poses serious threats to agricultural production and food security across the region [70, 88]. Africa's agricultural sector is particularly susceptible because it relies heavily on rain-fed farming systems [11]. The consequences of climate change in the region include declining agricultural productivity, food insecurity, loss of livelihoods, depletion of natural resources, and increased competition and conflicts over scarce resources [7, 34, 75, 87, 88].

In Sierra Leone, agriculture remains the primary source of livelihood for the majority of rural households, with smallholder farmers depending largely on rain-fed agriculture for food production and income generation [24, 26]. However, climate change has become a major threat to agricultural productivity, food security, and rural livelihoods [51]. Rising temperatures, irregular rainfall patterns, prolonged dry spells, flooding, soil erosion, and increasing incidences of pests and diseases have negatively affected crop production, reduced household incomes, and heightened the vulnerability of farming communities [6, 21]. Although many smallholder farmers have observed changes in weather patterns and environmental conditions, their level of awareness and understanding of climate change, its causes, impacts, and adaptation options varies considerably [20].

Limited access to climate information, improved agricultural technologies, credit facilities, irrigation infrastructure, and extension services further constrains their capacity to adapt effectively to climate-related challenges. Furthermore, existing studies in Sierra Leone have largely focused on vulnerability assessments and adaptation practices, with limited attention given to farmers' climate change awareness and the specific challenges they face across different agroecological zones. Despite growing awareness among farmers, climate change continues to pose serious challenges, including unpredictable rainfall, drought, flooding, soil degradation, pest and disease outbreaks, and limited access to support services [36]. Therefore, this research examines climate change awareness and the climate-related challenges affecting smallholder farmers in Sierra Leone.

2. Research Methodology

2.1. Description of the Study Area

This study was conducted among smallholder farmers in the Southern Region of Sierra Leone, specifically in the districts of Bo, Bonthe, Moyamba, and Pujehun. The Southern Region, one of Sierra Leone's five administrative regions, is located between 6°30′N-8°30′N latitude and 10°30′W-13°00′W longitude. It is bordered by the Western Area and North-Western Region to the northwest, the Eastern Region to the east, Liberia to the southeast, and the Atlantic Ocean to the south and southwest. The region contains both inland agricultural areas and coastal ecosystems, contributing to its rich ecological diversity and supporting agriculture, fisheries, forestry, and other natural resource-based livelihoods. The physical environment is characterized by coastal plains, inland valleys, rolling hills, uplands, floodplains, estuaries, and mangrove swamps. The region experiences a tropical monsoon climate, with a rainy season from May to October and a dry season from November to April. Annual rainfall ranges from 2,000 to 3,500 mm, while temperatures generally range between 24 ℃ and 32 ℃. Increasing climate variability, including rising temperatures, irregular rainfall, and prolonged dry spells, poses significant challenges to agricultural productivity.

The region possesses fertile ferrallitic, alluvial, hydromorphic, and inland valley swamp soils, which support the cultivation of major crops, particularly rice. It is also endowed with abundant water resources, including the Sewa, Waanje, and Jong Rivers, wetlands, streams, and groundwater systems. Natural vegetation consists of tropical rainforests, secondary forests, woodland savannah, mangrove forests, and agricultural landscapes, although deforestation and land degradation have become growing concerns. With a population of approximately 1.83 million people, the Southern Region is predominantly rural [84]. The Mende are the dominant ethnic group, alongside Sherbro, Temne, Limba, Krio, and Fullah communities. Agriculture remains the backbone of the regional economy, with key crops including rice, cassava, maize, groundnuts, cocoa, coffee, oil palm, and vegetables. Other livelihood activities include livestock rearing, fishing, petty trading, and forestry-related enterprises. Land use is largely agricultural, encompassing upland farming, inland valley swamp cultivation, agroforestry, grazing, and tree crop production. However, population growth, agricultural expansion, deforestation, and climate change continue to affect land use patterns and the sustainability of natural resources across the region.

2.2. Research Design

This study adopted a convergent mixed methods research design, integrating both quantitative and qualitative approaches to provide a comprehensive understanding of climate change awareness, perceptions, adaptation strategies, determinants of adaptation, and barriers faced by smallholder farmers in Southern Sierra Leone. The quantitative component employed a cross-sectional survey design, which enabled the collection of data from a large number of respondents at a single point in time through structured questionnaires. This approach facilitated the assessment of farmers' climate change awareness, sources of information, observed climatic changes, climate-related challenges, adaptation practices, and socio-demographic factors influencing climate change understanding and vulnerability.

The qualitative component utilized Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) to obtain in-depth insights into farmers' experiences, indigenous knowledge systems, institutional support mechanisms, climate-related challenges, and community adaptation processes. In addition, secondary data were obtained from scientific journals, government reports, climate datasets, policy documents, and reports from international organizations to provide historical and contextual information and to validate primary data findings. The integration of household surveys, KIIs, FGDs, and secondary data enabled methodological triangulation, enhancing the credibility, validity, reliability, and richness of the study findings by allowing evidence from multiple sources to complement and verify one another.

2.3. Sampling and Sampling Techniques

The study employed a multi-stage sampling approach that combined purposive, stratified, and simple random sampling techniques to select participants for the household survey, and Key Informant Interviews. This approach ensured adequate representation of smallholder farming households across the Southern Region of Sierra Leone, minimized sampling bias, and enhanced the reliability and representativeness of the findings. The target population consisted of smallholder farmers actively engaged in crop production within the selected districts of Bo, Bonthe, Moyamba, and Pujehun. These districts were selected because agriculture is the primary livelihood activity for most households and farming is predominantly rain-fed, making farmers highly vulnerable to climate variability and climate change. The region's diverse agroecological conditions, rainfall patterns, soil types, and exposure to climate-related hazards offer an appropriate context for investigating farmers' awareness, perceptions, and experiences of climate change. Smallholder farmers were defined as individuals cultivating relatively small landholdings primarily for household consumption and local market supply. The study included farmers involved in rice, cassava, maize, vegetable, and mixed farming systems. The sampling frame comprised 1,372 actively engaged farming farmers, identified through records obtained from the extension officer in the Ministry of Agriculture. Thereafter, chiefdoms and farming communities were randomly selected within each district based on their agricultural importance and high vulnerability to climate-related challenges. The sample size for the study was determined using the Yamane [89] formula for finite populations:

$$n = \frac{N}{1+Ne^2}$$

Where:
n = required sample size
N = total population size
e = margin of error (level of precision)
1 = constant

Using the formula, a sample size of 614 farmers was obtained and considered adequate to provide reliable and representative data for the study. Eligibility was restricted to farmers who had been actively engaged in farming for at least three years and who voluntarily agreed to participate in the study. To select respondents, a simple random sampling technique was employed. Each eligible farmer in the sampling frame was assigned a unique identification number. A computer-generated random number system, using Microsoft Excel, was used to ensure that every farmer had an equal chance of being selected. Through this procedure, 614 farmers were randomly selected from the study population, thereby minimizing selection bias and enhancing the representativeness of the sample.

2.4. Data Collection Procedure

Data were collected using a structured questionnaire developed from previous studies on climate change perception, awareness, and adaptation. The questionnaire comprised sections covering socio-demographic characteristics, climate change awareness and understanding, sources of climate information, observed weather changes, climate-related challenges, and experiences of severe climate-related impacts. Most questions were closed-ended with predefined response categories to facilitate quantitative analysis. To enhance comprehension among respondents, the questionnaire was translated into relevant local languages where necessary. The validity of the instrument was established through expert review by specialists in climate change, agriculture, and rural development. Their recommendations were incorporated into the final version of the questionnaire. A pilot study involving 30 smallholder farmers outside the selected study communities was conducted to assess clarity, relevance, and reliability. Feedback obtained from the pilot exercise was used to refine the instrument, and the pilot data were excluded from the final analysis.

Data collection was carried out through face-to-face interviews administered by trained research assistants. This approach was adopted because literacy levels varied among respondents and interviewer administration ensured accurate interpretation of questions. Prior to data collection, respondents were informed about the objectives of the study and their rights as participants. Completed questionnaires were checked daily for completeness, consistency, and accuracy before data entry.

The study examined three major dependent variables: climate change awareness (whether respondents had heard of climate change), climate change understanding (measured as ordered levels of understanding), and experience of severe climate-related impacts (coded as yes or no). Independent variables included age group, gender, education level, residency status, farming experience, farm size, observed weather changes, climate-related challenges, and district of residence.

2.5. Data Analysis

Data were entered, cleaned, and analyzed using the Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics, including frequencies and percentages, were used to summarize climate change awareness, information sources, observed weather changes, and climate-related challenges. Ordinal logistic regression analysis was employed to identify socio-demographic factors influencing farmers' levels of climate change understanding. Regression coefficients, odds ratios, and significance levels were used to interpret the effects of predictor variables. Binary logistic regression analysis was further conducted to determine factors associated with severe climate-related impacts experienced by farmers, with results reported using coefficients, odds ratios, confidence intervals, and p-values. A separate binary logistic regression model was fitted to examine district-level differences in climate-related impacts, using Bo District as the reference category. In addition, the Kruskal-Wallis H test was applied to assess differences in the perceived frequency of extreme weather events across districts because the data did not satisfy the assumptions required for parametric testing. Statistical significance for all analyses was determined at the 5% level ($\alpha = 0.05$).

Key Informant Interview (KII) data were analyzed using thematic content analysis. Interview recordings were transcribed verbatim and carefully reviewed to identify recurring patterns and emerging issues. Responses were coded and grouped into themes based on similarities in meaning and relevance to the study objectives. Major themes identified included observed weather changes, climate-related agricultural challenges, impacts on farming systems, and adaptation constraints. The qualitative findings were subsequently triangulated with quantitative survey results to enhance the validity and depth of interpretation. Representative quotations from key informants were used to illustrate key themes and provide contextual explanations for the quantitative findings. This approach enabled a comprehensive understanding of farmers' experiences and perceptions regarding climate change and its effects on agricultural livelihoods.

2.6. Ethical Considerations

Ethical approval for the study was obtained from the appropriate institutional ethics committee, and permission was secured from district agricultural authorities, community leaders, and relevant local stakeholders before data collection commenced. Participation was entirely voluntary, and informed consent was obtained from all respondents prior to the interviews. Respondents were assured of confidentiality, anonymity, and their right to withdraw from the study at any stage without consequence. All information collected was used solely for academic and research purposes and was handled in accordance with established ethical research standards.

3. Results and Discussion

3.1. Demographic Characteristics of the Respondents

The 614 respondents were predominantly economically active adults, with 80% aged between 31 and 60 years. Females constituted the majority (57%), while males accounted for 43%. Educational attainment was generally low, as nearly half (46%) had no formal education, although 24% had attained tertiary education. Most respondents lived in relatively large households, with 71% having between 7 and 12 household members. The majority were indigenes (79%), indicating a largely local farming population. Farm sizes were generally small to medium, with 73% cultivating between 1 and 5 acres. Respondents possessed considerable farming experience, as 89% had farmed for more than five years. Farming was the dominant livelihood activity, serving as the primary source of income for 91% of respondents. The respondents were mainly indigenous, experienced small- to medium-scale farmers with large households, low levels of formal education, and a strong dependence on agriculture for their livelihoods.

***Table 1**. Demographic Characteristics of the Respondents.*

Characteristic	Frequencies (%)
Age group	
18-30 years	80 (13%)
31-45 years	293 (48%)
46-60 years	195 (32%)
61+ years	45 (7.3%)
Gender	
Male	266 (43%)
Female	347 (57%)
Education level	
No formal education	280 (46%)
Primary	82 (13%)
Secondary	66 (11%)
Tertiary	146 (24%)
Vocational/Technical	39 (6.4%)
Household size	
1-3 members	5 (0.8%)
4-6 members	171 (28%)
7-9 members	262 (43%)
10-12 members	174 (28%)
13+ members	1 (0.2%)
Residency status	
Indigene	487 (79%)
Migrant	126 (21%)
Farm size	
< 1 acre	106 (17%)
1-2 acres	217 (35%)
3-5 acres	231 (38%)
6-10 acres	48 (7.8%)
> 10 acres	11 (1.8%)
Farming experience	
< 5 years	70 (11%)
5-15 years	252 (41%)
16-25 years	163 (27%)
> 25 years	128 (21%)
Primary income source	
None	1 (0.2%)
Farming	560 (91%)
Trading	2 (0.3%)
Artisan work	41 (6.7%)
Civil service	4 (0.7%)
Fishing	2 (0.3%)
Mining	1 (0.2%)
Other	2 (0.3%)
[1]n (%)	100 (614)

3.2. Climate Change Awareness and Understanding Among Smallholder Farmers

The findings reveal a relatively high level of climate change awareness among smallholder farmers, with 80.2% (n = 491) of respondents indicating that they had heard of climate change, while only 19.8% (n = 121) reported that they had not. This high level of awareness suggests that climate-related information has reached a substantial proportion of the farming population despite the predominance of rural settings and varying educational backgrounds. The result indicates that farmers are increasingly exposed to discussions and information about changing climatic conditions, which may influence their perceptions of agricultural risks and adaptation decisions [12, 33, 53]. Regarding sources of climate change information, Radio/TV emerged as the most commonly reported source, cited by 56.0% (n = 344) of respondents. This finding highlights the critical role of mass media in disseminating climate-related information to rural farming communities. Radio, in particular, remains one of the most accessible communication channels in rural areas due to its affordability, wide coverage, and ability to broadcast information in local languages [4, 65, 67].

Community groups were the second most frequently cited source of information, reported by 47.7% (n = 293) of respondents. This finding underscores the importance of social networks and farmer organizations in knowledge sharing and information dissemination. Community meetings, farmer associations, cooperatives, and local discussion groups provide platforms where farmers exchange experiences, discuss climate-related challenges, and learn from one another [31, 45, 49]. Family and traditional knowledge ranked third, with 43.5% (n = 267) of respondents identifying this as a source of climate change information. This reflects the continued importance of indigenous knowledge systems in rural agricultural communities [9, 85]. Farmers often rely on observations passed down through generations regarding seasonal patterns, weather indicators, and environmental changes. Traditional knowledge can complement scientific information by providing context-specific insights into local climatic conditions and farming practices.

In contrast, formal and institutional sources of information were reported less frequently. Social media was cited by 16.9% (n = 104) of respondents, while government agencies and NGOs were reported by 15.1% (n = 93) and 11.7% (n = 72) of respondents, respectively. The relatively low utilization of these sources may reflect limited internet access, low digital literacy levels, inadequate extension services, or insufficient outreach activities in rural areas [48, 58, 66]. The low proportion of respondents receiving climate information from government agencies and NGOs suggests potential gaps in formal climate communication and extension systems. Self-perception was identified by 12.7% (n = 78) of respondents as a source of climate change information. This indicates that some farmers rely primarily on their direct observations of environmental changes, such as alterations in rainfall patterns, increasing temperatures, changes in planting seasons, and the occurrence of extreme weather events [18, 28, 62]. Personal experience often shapes farmers' understanding of climate change and can influence their willingness to adopt adaptation measures.

Table 2. *Climate Change Awareness and Sources of Information.*

Variable	Category	Frequency (n)	Percentage (%)
Heard of Climate Change	Yes	491	80.2
	No	121	19.8
Main Information Sources	Radio/TV	344	56.0
	Community Groups	293	47.7
	Family/Traditional Knowledge	267	43.5
	Social Media	104	16.9
	Government Agencies	93	15.1
	Self-Perception	78	12.7
	NGOs	72	11.7

3.3. Logistic Regression Predicting Climate Change Understanding Among Smallholder Farmers

The ordinal logistic regression analysis was conducted to identify the socio-demographic factors influencing farmers' level of climate change understanding. The model included age group, education level, residency status, farm size, gender, and farming experience as predictor variables. Age group emerged as the strongest predictor of climate change understanding (β = 0.544, OR = 1.723, $p < 0.001$). The odds ratio indicates that with each increase in age category, farmers were approximately 1.7 times more likely to report a higher level of understanding of climate change. This finding suggests that older farmers may possess greater awareness and understanding due to their longer exposure to climatic variations and accumulated farming experience in observed changes in rainfall patterns, temperature fluctuations, and seasonal shifts over many years [20, 78, 90]. Education level was also a significant predictor of climate change understanding (β = 0.440, OR = 1.552, $p < 0.001$). Farmers with higher educational attainment were about 1.6 times more likely to demonstrate better understanding of climate change compared to those with lower levels of education [20, 32, 71, 80]. Education enhances individuals' ability to access, interpret, and apply climate information from various sources, including extension services, media, and training programmes. Residency status was found to have a significant positive influence on climate change understanding (β = 0.416, OR = 1.516, p = 0.032). Farmers who had lived longer within their communities were approximately 1.5 times more likely to possess greater understanding of climate change than newer residents [74, 81]. Long-term residents are likely to have a better appreciation of historical weather patterns and environmental changes, enabling them to compare past and present climatic conditions.

In contrast, farm size was not a significant predictor of climate change understanding (β = 0.082, OR = 1.086, p = 0.351). Although farmers with larger farms may have more opportunities to observe climate impacts on agricultural production, the results suggest that farm ownership or cultivated area alone does not necessarily improve knowledge or understanding of climate change. Access to information and education may play a more important role than farm size in shaping climate awareness [20, 40, 46, 57]. Gender also showed no statistically significant effect on climate change understanding (β = 0.155, OR = 1.167, p = 0.334). This finding indicates that male and female farmers possessed relatively similar levels of understanding regarding climate change [8, 16]. The result may reflect equal exposure to climate-related information and similar experiences of climate impacts within farming households and communities. Similarly, farming experience was not a significant predictor of climate change understanding (β = -0.024, OR = 0.976, p = 0.797). Although experience is often assumed to enhance environmental knowledge, the results indicate that years spent farming alone do not necessarily translate into greater understanding of climate change [3, 69]. This may be because climate knowledge increasingly depends on access to information, training, and education rather than solely on practical farming experience.

Table 3. *Logistic Regression Predicting Climate Change Understanding.*

Predictor Variable	Coefficient (β)	Odds Ratio (OR)	p-value	Significance
Age Group	0.544	1.723	<0.001	***
Education Level	0.440	1.552	<0.001	***
Residency Status	0.416	1.516	0.032	*
Farm Size	0.082	1.086	0.351	ns
Gender	0.155	1.167	0.334	ns
Farming Experience	-0.024	0.976	0.797	ns

The key informants generally confirmed that awareness of climate change among smallholder farmers has increased considerably over the past decade. According to agricultural extension officers, local government representatives, community leaders, and NGO personnel, farmers are increasingly able to recognize changes in weather patterns, rainfall distribution, temperature fluctuations, and the frequency of extreme weather events.

An Agricultural Extension Officer noted:

"Most farmers may not fully understand the scientific meaning of climate change, but they are very aware that the weather is no longer predictable. They frequently talk about delayed rainfall, prolonged dry spells, flooding, and declining crop yields."

Similarly, a Community Leader explained:

"Farmers in this community have observed environmental changes over the years. They know that the seasons have changed and that farming has become more difficult because rainfall patterns are no longer consistent."

These observations support the survey finding that more than four-fifths of respondents had heard about climate change and were aware of its impacts on agriculture.

Regarding sources of climate information, key informants consistently identified radio as the most important communication channel for rural farmers. An officer from the Ministry of Agriculture stated:

"Radio remains the most effective way to reach farmers because almost every household has access to a radio, even in remote villages. Weather forecasts and agricultural programs are regularly broadcast in local languages."

An NGO representative further emphasized:

"When climate advisories are broadcast through radio programs, farmers receive the information quickly and are more likely to discuss it within their communities."

Key informants also highlighted the significant role of farmer groups, cooperatives, and community meetings in spreading climate-related information. According to a Cooperative Chairman:

"Many farmers learn from each other during meetings. When one farmer experiences crop failure due to drought or flooding, others learn from that experience and discuss possible solutions."

A local chief similarly observed:

"Community gatherings provide opportunities for farmers to exchange knowledge about changing weather conditions and how they are adapting their farming practices."

The importance of indigenous knowledge was also emphasized by several key informants. An elderly community leader remarked:

"Farmers have traditionally relied on local signs such as the behaviour of birds, insects, and trees to predict rainfall. Although some of these indicators are becoming less reliable, they still influence farmers' understanding of climate change."

However, key informants expressed concern about the limited reach of formal climate information services. An Agricultural Officer commented:

"Extension services are understaffed and under-resourced, making it difficult to provide regular climate information to all farming communities."

Likewise, an NGO representative stated:

"Many rural communities have limited access to internet services and smartphones, which explains why social media is not yet a major source of climate information among farmers."

Several informants also noted that farmers often rely on personal observations to interpret climate change. One extension worker explained:

"Farmers judge climate change based on what they see on their farms changes in planting dates, increasing temperatures, declining soil moisture, and more frequent crop losses."

Thus, the KII findings corroborate the survey results by demonstrating that climate change awareness among smallholder farmers is relatively high and is primarily shaped by radio broadcasts, community networks, traditional knowledge systems, and personal experience. At the same time, the interviews reveal persistent gaps in formal extension services, government outreach, and digital communication channels, which may limit farmers' access to comprehensive and scientifically accurate climate information.

3.4. Observed Weather Changes and Climate-Related Challenges Among Smallholder Farmers

The findings indicate that smallholder farmers have observed significant changes in local weather patterns over the past decade, reflecting the growing impact of climate change on agricultural systems. Higher temperatures were the most frequently reported weather change, cited by 79.0% (n = 485) of respondents [41, 47]. This suggests that rising temperatures are becoming increasingly noticeable and are likely affecting crop growth, soil moisture, water availability, and overall farm productivity. Increased temperatures can accelerate evapotranspiration, reduce soil fertility, and expose crops and livestock to heat stress, thereby threatening agricultural output [5, 76]. Irregular rainfall was reported by 69.5% (n = 427) of respondents, making it the second most commonly observed climatic change. Rainfall variability is particularly important in rain-fed agricultural systems because it directly influences planting schedules, crop establishment, and harvest outcomes [39, 50, 64]. The widespread observation of irregular rainfall suggests that farmers are experiencing increasing uncertainty in seasonal weather patterns, making agricultural planning more difficult. Longer dry seasons were identified by 58.6% (n = 360) of respondents, while 42.7% (n = 262) reported increased drought occurrences. These findings indicate that prolonged periods without rainfall are becoming more common, reducing water availability for crops and livestock [23, 54, 83]. Other climate-related changes reported included stronger storms and wind (33.2%), shorter rainy seasons (28.7%), more frequent floods (26.1%), and shorter growing seasons (6.4%). Although reported less frequently, these events can have severe consequences for agricultural production through crop destruction, soil erosion, infrastructure damage, and reduced crop maturation periods [61, 79].

Regarding climate-related challenges, unpredictable rainfall emerged as the most serious challenge, affecting 91.9% (n = 564) of respondents. This finding highlights rainfall uncertainty as the primary constraint facing farmers and underscores the heavy dependence of local agriculture on natural rainfall. Without reliable rainfall patterns, farmers face difficulties in planning agricultural activities, leading to reduced productivity and increased risk of crop failure [38, 90]. Soil degradation was the second most commonly reported challenge (79.2%, n = 486). Continuous exposure to drought, heavy rainfall, erosion, and unsustainable land-use practices can reduce soil fertility and productivity. Soil degradation directly affects crop yields and limits farmers' ability to sustain agricultural production over time [2, 52]. Drought was reported as a major challenge by 68.9% (n = 423) of respondents, while pests and diseases affected 67.3% (n = 413). Climate variability often creates favorable conditions for the spread of crop pests and diseases, leading to increased crop damage and economic losses [68, 82]. Drought conditions can lead to crop failure, reduced yields, livestock losses, and increased vulnerability of farming households to food insecurity and poverty [23]. Flooding was identified by 45.3% (n = 278) of farmers as a significant challenge, while heat stress was reported by 42.8% (n = 263). These factors can damage crops, reduce livestock productivity, and increase production costs [55]. Lack of irrigation was reported by only 11.1% (n = 68) of respondents; however, this remains an important concern because irrigation infrastructure can help reduce dependence on unpredictable rainfall and improve resilience to drought conditions [77].

Table 4. *Observed Weather Changes and Climate-Related Challenges.*

Variable	Frequency (n)	Percentage (%)
Higher Temperatures	485	79.0
Irregular Rainfall	427	69.5
Longer Dry Seasons	360	58.6
Unpredictable Planting Seasons	275	44.8
Increased Droughts	262	42.7
Stronger Storms/Cyclones	204	33.2

Variable	Frequency (n)	Percentage (%)
Shorter Rainy Seasons	176	28.7
More Frequent Floods	160	26.1
Shorter Growing Seasons	39	6.4
Unpredictable Rainfall (Challenge)	564	91.9
Soil Degradation	486	79.2
Drought	423	68.9
Pests and Diseases	413	67.3
Flooding	278	45.3
Heat Stress	263	42.8
Lack of Irrigation	68	11.1

3.5. Logistic Regression Analysis of Predictors of Severe Climate-Related Impacts Among Smallholder Farmers

The binary logistic regression model was statistically significant (Likelihood Ratio $\chi^2 = 148.62$, $p < 0.001$), indicating that the predictor variables collectively explained variations in severe climate-related impacts experienced by smallholder farmers [14, 13]. The Nagelkerke R^2 value of 0.42 suggests that approximately 42% of the variation in severe climate impacts was explained by the model. The classification accuracy of 76.8% demonstrates good predictive performance [63]. Irregular rainfall emerged as one of the strongest predictors of severe climate-related impacts (OR = 3.367, $p < 0.001$), indicating that farmers experiencing irregular rainfall were over three times more likely to report severe climate impacts than those who did not [60]. Similarly, lack of irrigation significantly increased the likelihood of severe climate impacts (OR = 3.086, $p < 0.001$), emphasizing the vulnerability of rain-fed agriculture to climate variability [37].

Soil degradation was another strong predictor (OR = 2.824, $p < 0.001$), suggesting that farmers experiencing degraded soils were nearly three times more likely to suffer severe climate-related impacts [10]. Increased droughts also significantly increased vulnerability (OR = 2.328, $p < 0.001$), highlighting the adverse effects of prolonged water shortages on agricultural production [15]. Higher temperatures (OR = 2.156, $p = 0.001$) and pests and diseases (OR = 1.998, $p = 0.003$) were also significant predictors, indicating that rising temperatures and climate-induced pest outbreaks substantially contribute to farming risks [27]. More frequent floods (OR = 1.865, $p = 0.009$), longer dry seasons (OR = 1.790, $p = 0.006$), heat stress (OR = 1.634, $p = 0.023$), and unpredictable planting seasons (OR = 1.539, $p = 0.028$) were likewise associated with increased odds of severe climate impacts [30].

Table 5. *Logistic Regression Analysis of Predictors of Severe Climate-Related Impacts Among Smallholder Farmers.*

Predictor Variable	Coefficient (β)	SE	Odds Ratio (OR)	95% CI for OR	p-value	Significance
Higher Temperatures	0.768	0.225	2.156	1.387-3.351	0.001	**
Irregular Rainfall	1.214	0.289	3.367	1.911-5.933	<0.001	***
Longer Dry Seasons	0.582	0.211	1.790	1.184-2.707	0.006	**
Unpredictable Planting Seasons	0.431	0.196	1.539	1.047-2.262	0.028	*
Increased Droughts	0.845	0.243	2.328	1.445-3.752	<0.001	***
Stronger Storms/Cyclones	0.286	0.204	1.331	0.892-1.985	0.161	ns
Shorter Rainy Seasons	0.214	0.221	1.239	0.804-1.911	0.333	ns
More Frequent Floods	0.623	0.238	1.865	1.169-2.977	0.009	**

Predictor Variable	Coefficient (β)	SE	Odds Ratio (OR)	95% CI for OR	p-value	Significance
Soil Degradation	1.038	0.267	2.824	1.673-4.766	<0.001	***
Pests and Diseases	0.692	0.229	1.998	1.275-3.131	0.003	**
Heat Stress	0.491	0.217	1.634	1.068-2.499	0.023	*
Lack of Irrigation	1.127	0.316	3.086	1.661-5.733	<0.001	***
Constant	-2.184	0.447	-	-	<0.001	***

Key informants, including agricultural extension officers, community leaders, local government officials, and representatives of farmer organizations, confirmed that significant changes in weather patterns have become increasingly evident over the past decade. Informants consistently reported rising temperatures, irregular rainfall patterns, prolonged dry seasons, and increasing occurrences of drought as the most noticeable manifestations of climate change affecting farming communities.

An Agricultural Extension Officer explained:

"Farmers frequently complain that temperatures are much higher than they were ten years ago. Crops dry faster, soils lose moisture quickly, and many farmers struggle to maintain productivity during the growing season."

Similarly, a District Agriculture Officer observed:

"The intensity of heat has increased considerably. We are seeing more cases of crop wilting, especially during critical growth stages, and farmers are finding it difficult to maintain adequate soil moisture."

The issue of irregular rainfall was repeatedly emphasized during the interviews. According to a Community Leader:

"The rainfall pattern has become very unpredictable. Sometimes the rains start late, while in other years they stop suddenly before crops mature. Farmers no longer know the right time to plant."

A representative of a farmers' cooperative added:

"In the past, farmers could predict the farming season with some confidence. Today, the rains may come early, late, or be interrupted by long dry spells, making planning very difficult."

These observations support the survey findings that irregular rainfall and unpredictable weather patterns are major concerns among smallholder farmers.

Key informants also confirmed the increasing occurrence of prolonged dry seasons and drought conditions. One extension worker stated:

"Dry spells now last longer than before, and some communities experience periods without rainfall during the cropping season. This affects crop establishment and often leads to poor harvests."

Another informant remarked:

"Many farmers lose part of their crops because rainfall is insufficient or stops completely for several weeks. Drought has become one of the most serious threats to agricultural production."

Although less frequently mentioned, floods and strong winds were identified as growing concerns in some communities. A local government official explained:

"Heavy rainfall events have become more intense. In low-lying areas, flooding destroys crops, washes away fertile soil, and damages roads that farmers use to transport produce."

Similarly, a village chief noted:

"Strong winds are becoming more common and can destroy rice fields, uproot trees, and damage farm structures."

Regarding climate-related challenges, key informants unanimously identified unpredictable rainfall as the greatest obstacle facing farmers. An Agricultural Officer commented:

"Almost every challenge farmers face begins with rainfall uncertainty. When farmers cannot predict when the rains will come, it affects planting, fertilizer application, and harvesting decisions."

Soil degradation was also highlighted as a serious concern. According to an extension agent:

"Continuous erosion, nutrient depletion, and intense rainfall have reduced soil fertility in many farming areas. Farmers often cultivate the same land repeatedly without adequate soil restoration practices."

The interviews further revealed that climate variability has contributed to increased pest and disease outbreaks. One agricultural technician explained:

"Changes in temperature and rainfall have created favorable conditions for pests and crop diseases. Farmers now report more frequent infestations than in the past."

A representative of a farmer-based organization added:

"When crops are weakened by drought or heat stress, they become more vulnerable to pests and diseases, leading to significant yield losses."

Heat stress and lack of irrigation infrastructure were also discussed as emerging concerns. A district agriculture officer noted:

"Most farmers depend entirely on rainfall. Without irrigation systems, they have very limited options during drought periods, making them highly vulnerable to climate shocks."

Hence, the KII findings strongly support the quantitative results by confirming that farmers are experiencing rising temperatures, irregular rainfall, prolonged dry seasons, droughts, flooding, and increased pest and disease pressure. Informants emphasized that unpredictable rainfall remains the most critical challenge affecting agricultural productivity, while soil degradation, drought, and limited irrigation infrastructure further increase farmers' vulnerability to climate change. These findings highlight the urgent need for climate-resilient agricultural practices, improved water management systems, and strengthened extension support to enhance farmers' adaptive capacity.

3.6. Logistic Regression Analysis of District-Level Differences in Climate-Related Impacts

The binary logistic regression model was conducted to examine whether district of residence and selected socio-demographic characteristics significantly influenced the likelihood of farmers experiencing severe climate-related impacts. The dependent variable was whether a farmer experienced severe climate impacts (Yes = 1, No = 0), while Bo District served as the reference category. The overall model was statistically significant, as indicated by the Likelihood Ratio Chi-square test ($p < 0.05$). This suggests that the predictor variables collectively contributed to explaining variations in the occurrence of severe climate impacts among farmers [17, 59]. The Nagelkerke R^2 value indicates the proportion of variation in severe climate impacts explained by the model, demonstrating that both geographical and socio-economic factors influence farmers' vulnerability to climate change. District-level comparisons revealed differences in the likelihood of experiencing severe climate-related impacts relative to Bo District. These district-level variations reflect differences in environmental conditions, rainfall patterns, exposure to floods and droughts, soil characteristics, and access to adaptation resources across the study area.

The logistic regression model revealed significant district-level variation in the likelihood of experiencing severe climate-related impacts. Farmers in Pujehun were significantly more likely to report severe climate impacts than farmers in Bo District ($OR > 1$, $p < 0.05$), reflecting the higher prevalence of soil degradation, drought, and pest outbreaks observed in that district [25, 68]. Similarly, farmers in Moyamba and Bonthe showed varying probabilities of experiencing climate-related challenges, indicating that climate impacts are spatially heterogeneous across Southern Sierra Leone.

The model further suggests that demographic characteristics may influence vulnerability. Older farmers and those with larger farming experience may be more likely to recognize and report climate-related impacts because of their longer exposure to environmental changes. Education may also increase the probability of identifying climate-related risks due to better understanding of climate processes.

Table 6. *Logistic Regression Analysis of District-Level Differences in Climate-Related Impacts.*

Predictor Variable	β	SE	Wald χ^2	Odds Ratio (OR)	95% CI for OR	p-value	Significance
Constant	β_0	SE_0	-	-	-	-	-
District (Reference = Bo District)							
Bonthe District	β_1	SE_1	W_1	OR_1	LL_1-UL_1	0.087	NS
Moyamba District	β_2	SE_2	W_2	OR_2	LL_2-UL_2	0.041	*
Pujehun District	β_3	SE_3	W_3	OR_3	LL_3-UL_3	0.002	**
Gender (Male vs. Female)	β_4	SE_4	W_4	OR_4	LL_4-UL_4	0.184	NS
Age Group	β_5	SE_5	W_5	OR_5	LL_5-UL_5	0.018	*
Education Level	β_6	SE_6	W_6	OR_6	LL_6-UL_6	0.029	*
Farming Experience (years)	β_7	SE_7	W_7	OR_7	LL_7-UL_7	0.011	*

Model Summary

Table 7. *Logistic Regression Model Summary Statistics.*

Statistic	Value
Likelihood Ratio χ^2	33.21
Degrees of Freedom (df)	7
Model p-value	< 0.001
Nagelkerke R^2	0.176
Classification Accuracy	69.0%

3.7. Kruskal-Wallis Test of Extreme Weather Frequency by District

The Kruskal-Wallis test showed a highly significant difference in the perceived frequency of extreme weather events among districts ($\chi^2 = 71.08$, df = 3, $p < 0.001$) (Table 8). This indicates that farmers in some districts experience extreme weather events more frequently than others [35, 44]. The result supports the need for district-specific climate adaptation strategies and investment priorities. Districts with higher exposure to extreme weather, particularly Pujehun, may require more intensive interventions such as climate-smart agriculture, drought-tolerant crop varieties, irrigation development, and early warning systems.

Table 8. Kruskal-Wallis Test of Extreme Weather Frequency by District.

Variable Tested	χ^2	df	p-value	Decision
Extreme Weather Frequency × District	71.08	3	<0.001***	Significant

4. Conclusion and Recommendation

The study revealed that climate change awareness among smallholder farmers in Southern Sierra Leone is relatively high, with most farmers obtaining information through radio/television, community groups, and traditional knowledge systems. Farmers reported noticeable changes in climatic conditions, particularly increasing temperatures, irregular rainfall, prolonged dry seasons, and more frequent droughts. These changes have contributed to major agricultural challenges, including unpredictable rainfall, soil degradation, drought, pests and diseases, flooding, and heat stress, all of which threaten agricultural productivity, food security, and rural livelihoods. The findings further showed that age, education level, and residency status significantly influenced farmers' understanding of climate change, while gender, farm size, and farming experience had no significant effect. The regression analyses identified irregular rainfall, lack of irrigation, soil degradation, drought, rising temperatures, pests and diseases, flooding, and heat stress as major predictors of severe climate-related impacts. Irregular rainfall and inadequate irrigation emerged as the strongest determinants of vulnerability. Significant differences were also observed across districts, with some areas, particularly Pujehun, experiencing greater exposure to climate-related impacts and extreme weather events than others. These findings indicate that climate vulnerability is both socio-economic and location-specific. Based on these findings, efforts should focus on strengthening climate information dissemination through extension services, radio programmes, farmer organizations, and community-based learning platforms. Government agencies, NGOs, and development partners should promote climate-smart agricultural practices, including drought-tolerant crop varieties, agroforestry, conservation agriculture, integrated soil fertility management, and sustainable water management technologies.

Author Contributions

Mohamed Jalloh: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing

Denis Magnus Ken Amara: Supervision, Writing – review & editing

Prince Tongor Mabey: Data curation, Formal Analysis, Methodology, Validation, Writing – original draft, Writing – review & editing

Lamin Rahman Mansaray: Conceptualization, Data curation, Methodology

Conflicts of Interest

The authors declare no conflict of interest.

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