RESEARCH ARTICLE

Exploring the Link Between Climate Change and Farming in Rural and Peri-Urban Communities in Sierra Leone

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Abstract

Climate change has been impacting farming and livelihood outcomes around the world. In Sierra Leone, limited studies have been done in this direction; therefore, this study was undertaken to understand and explain what has been happening. The objectives of the study were to identify the main crops grown and animals are reared by the farmers; the trend in the yield of crops and the number of animals produced between 2014 and 2023 and to assess farmers' perception on how climatic parameters been impacting farming and find out the coping strategies adopted by the farmers to reduce the impact of climate change on farming in the study area

Data was collected from 315 respondents selected using purposive and simple random sampling techniques, and a semi-structured questionnaire was administered to them. Climatic data was also collected from 3 weather stations as ancillary data. Data was analysed using the Statistical Package for the Social Sciences, version 26 (SPSS).

Results reveal that farmers grow mainly food crops like rice, cassava, and vegetables and reared animals like poultry, cattle, and goats. The yield of the main food crops was increasing between 2014 and 2017 but remained the same between 2017 and 2020, but increased between 2021 and 2023. The reasons for the increase in yield include using more fertilizer and expansion of farmlands. Reasons for the decline in yield are erratic and low rainfall at the start of the rainy season, inadequate land for farming and flooding. Animals reared in the communities are increasing in number, though climate change has some impact on them. Further findings show that temperature, rainfall, and wind speed have been contributing significantly to climate change and that has been impacting farming in the study area. Coping strategies adopted by farmers include adjusting planting and harvest times, watering the plants regularly, adding mulch to the seed beds.

It is recommended that farmers need to be trained to build on the knowledge and skills they already have in order to promote sustainability and food security in their communities.

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1. Introduction

Climate change has been affecting the whole world. These effects range from high temperatures and evaporation, which have resulted in the depletion of the soil structure and its resultant effects on crop failures and the health and productivity of farm animals[1][2][3]. There has also been flooding of farmlands which has resulted in the wiping out of entire cultivated fields, decreased yields of cereals[4][5]. Long or intermittent periods of drought and heat stress, as a result of increases in temperature, have affected farming all over the world, and as such, their impact on food availability is becoming acute[6][7][8]. A report by the World Bank[9] clearly states that increasing temperatures, water availability, shifting agro-ecosystem boundaries, invasion of pests and diseases, and more extreme weather events are posing food security challenges and have put about 690 million people, especially in Sub-Saharan countries, at the mercy of hunger and starvation[9]. Studies by[10][11] have predicted that climate change will impact farming, which can lead to an increase in food prices and eventually food insecurity and increased poverty. Evidence of the effects of climate change on agricultural production has shown that heat and humidity have been affecting the health and productivity of animals raised for meat, milk, and eggs[3]. Temperature increases and changes in precipitation regimes can also affect the occurrence and number of insects, weeds, and diseases that will infest farmlands[2]. This eventually will lead to reduced crop yields, lower nutritional quality of cereals, and lower livestock productivity[8][9][12]. In a study by Habib-ur-Rahman, et al.,[12] in Asia, it is stated that as a result of climate change, it is predicted that there will be a yield reduction of rice by 15.2% and 14.1% in wheat production. Wang et al.,[13], stated that climate change had affected four main crops grown in India: maize, rice, wheat, and soybeans. This assertion was also supported by Azad, et al.,[7], who had earlier reported that as a result of rising temperatures which promote crop evapotranspiration, there will be a reduction in wheat yield. Furthermore, other studies have shown that climate change will affect the length of the growing periods of certain crops in many parts of the world[14][3].

Notwithstanding the negative impact of climate change on agriculture, climate change has been reported to have some positive impacts, as reported by the United States Environmental Protection Agency (EPA), that an increase in temperature and carbon dioxide (CO_2) can lead to a resultant increase in some crop yields in some places, though water should be available to release soil nutrients[15].

In Africa, climate change has negatively impacted food crop and livestock production, thus worsening the already food insecurity situation experienced by low investments in agriculture by governments[16]. African farmers are more vulnerable to climate change (high temperatures and fluctuations in rainfall, etc.) than farmers in other parts of the world, especially in Europe, the U.S.A., and other developed countries[16], where farmers can mitigate the effects of drought by irrigating farmlands and using more resistant varieties of seeds, along with innovations, fertilizers, pest and disease control mechanisms[15][16].

In order to mitigate the effects of climate change around the world and boost food production, and thus reduce food insecurity and hunger around the world, studies have shown that some agricultural practices have been developed and adopted, and these include climate-smart agriculture. Climate-smart agriculture is an integrated approach which enables farmers to manage their environments (cropland, rangeland for livestock, forests, wetlands, and water bodies) in a sustainable linkage that will promote food production and slow climate change[9]. Others have recommended alternating planting times and planting density of crops, crop rotations with legumes, agroforestry, mixed farming, using climate-resilient plants, livestock, and fish breeds in order to reduce the effects of climate change on farming[1][12][9].

In Sierra Leone, where the study was done, there have been incidents of climate change-related issues, stemming from flooding, intermittent drought (especially in the dry seasons), blowing of strong winds in the early and late parts of the rainy season, and changes in the rainfall pattern[17][18][19][20]. Unprecedented rainfall in March and April, which concise with the early part of the rainy season has often led to the disruption of the burning of brushed farm lands, thus leading to changes in the crops that will be eventually cultivated[17]. On the other hand, a late start to the rainy season as perceived by farmers had also disrupted the cultivation certain crops[20]. This has led to a decline in agricultural productivity over the years, especially in food crop production[17][21][22]. A similar report of climate impact on animal farming was made by Sesay[23], though in one district in the north of the country. Studies on the link between climate change and farming in the four geographic regions of the country are still not clear, as researches undertaken so far have not been adequate e.g. a study by Yila et al.,[20] who had tried to established the impact of rainfall and temperature on crop production in Moyamba District had only concentrated on one district and had not looked at the impact on animal rearing and more so had not clearly linked the impact of climate change on farming based on the perception of farmers themselves who had been practicing farming over the years This study was therefore undertaken to understand the link between climate change and farming in rural and peri-urban communities in four regions of Sierra Leone based on what the farmers experience and practices. This was done by asking the following research questions:

What are the main types of crops grown in the selected communities in the four regions? What are the main types of farm animals reared in the study areas? In which agro-ecologies are these crops grown and animals reared? What are the estimated yields of the main food crops in the study area over the past 10 years (2014-2023)? Is there a relationship between the decline in yields of crops cultivated and climate change? What climatic parameters or elements are seriously affecting or impacting crop production and animal rearing? What have been the coping strategies farmers have employed to reduce the effects of climate change on farming in their communities in the study area?

2. Methodology

The study employed a mixed-method research design, which involved the collection of data from household heads involved in farming. Climatic data for the past 10 years for the study communities was also collected and analysed. The climatic data was used to triangulate with the household survey data. The household data was collected from household heads involved in farming in seven districts in rural and peri-urban communities in Sierra Leone. The districts were the Western Rural District in the west, Bombali and Tonkolili districts in the north, Kenema and Kono districts in the east, and Bo and Moyamba districts in the south (Figure 1).

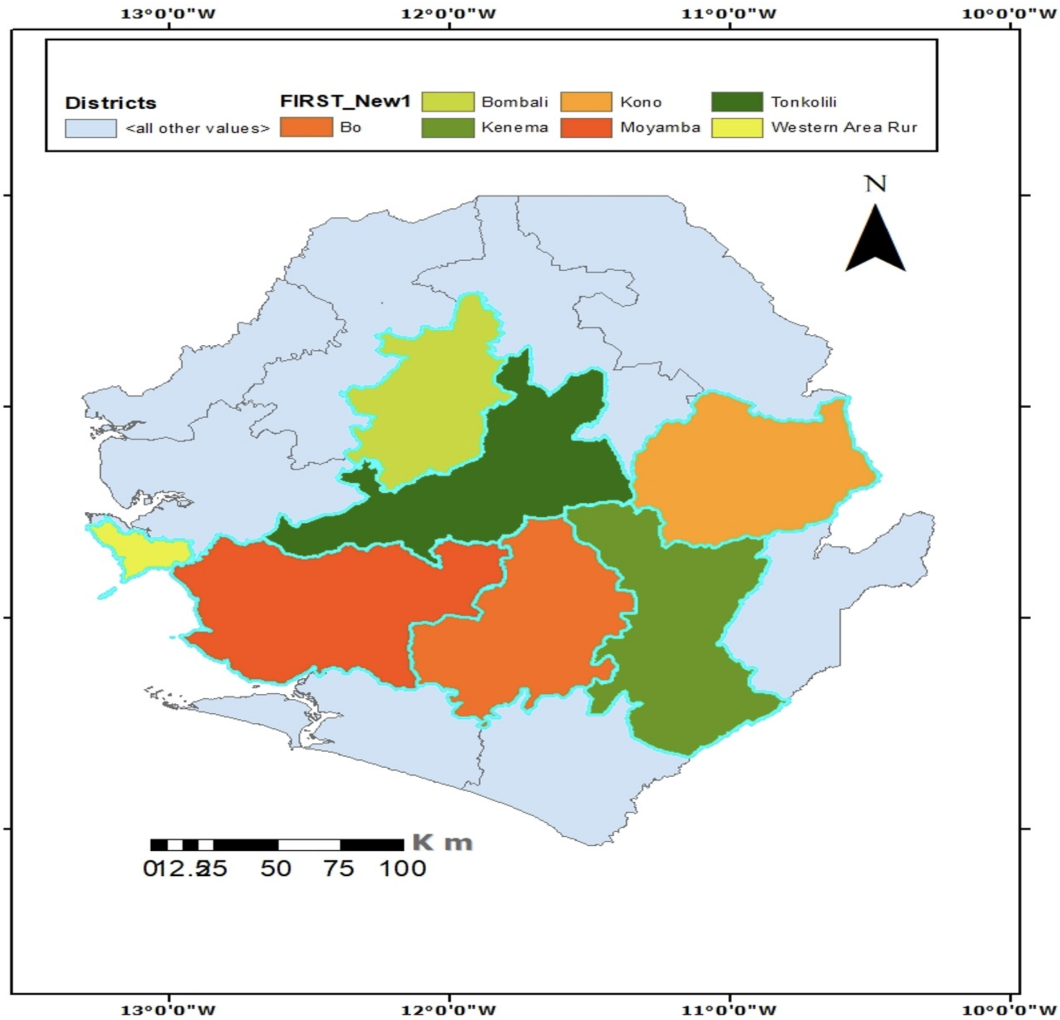

Figure 1. Map of Sierra Leone showing study districts.

The Western Rural district is closer to Freetown, the capital city of Sierra Leone. It has several peri-urban and rural communities, and a good number of the residents are engaged in vegetable, poultry, and piggery farming. Bombali and Tonkolili districts are two districts in the north and share boundaries; they have a large grassland area (boli-land) and are renowned for rice cultivation as well as animal rearing. Kono and Kenema districts are the two large districts found in the east which have large tracks of forest cover[22]. The main crops cultivated in these two districts are food crops like rice, cassava, and yam, etc. The districts are also renowned for tree crops farming. The Bo and Moyamba districts are located in the Southern region, with fallow bush as the dominant vegetation, though there are flooded plains known as “baati” in Bo districts and mangrove swamps on the coastal areas of Moyamba districts. A total of 315 semi-structured questionnaires were administered to household heads, who were purposively selected, based on having been engaged in farming for the past ten years in the sampled rural and peri-urban communities in the seven districts. A total of 45 questionnaires were administered in each district, thus bringing the total to 315. The questionnaires sought farmers' perceptions of climate change and crop and animal production over the past 10 years to find out whether the climatic elements, especially temperature, rainfall, humidity, and wind velocity, have impacted their farming activities and if so, to what extent. The data was collected over a period of one month in the seven districts; at least a minimum period of 4 days was allocated to each district. Ethical procedures for social science data collection were followed, and permissions were granted by community leaders and household heads before semi-structured questionnaires were administered.

Climatic data (rainfall, temperature, and humidity) from weather stations that were accessible (mainly from Mile 91, Njala University, Kenema, and the Western area) were collected and analysed. This information is presented in Figure 2 as a combined rainfall and temperature graph.

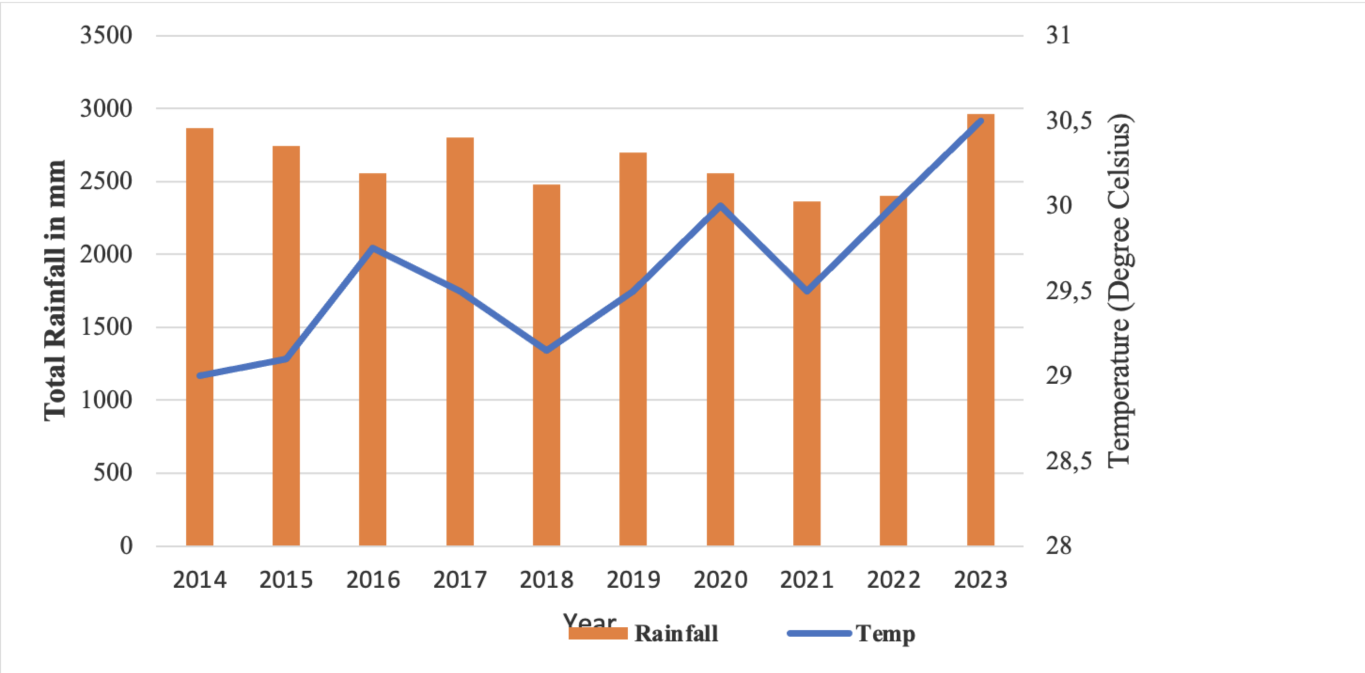

Figure 2. Average temperature and combined average total rainfall from 2014-2023 for the study areas

Source: Njala University Weather Station, Daru Weather Station, and Mile 91 SLARI Weather Station.

The weather data collected from these weather stations, as shown in the graph, were used for verification of the farmers' perception of the climatic phenomena over the past 10 years (2014-2023).

The data from the semi-structured questionnaires were assigned codes and inputted into the Statistical Package for Social Sciences (version 26) spreadsheet. The data collected from weather stations were inputted into the Excel spreadsheet and analysed and developed into graphs. Some of the data from the survey was presented in tables and graphs and then reported. Correlation and regression analyses were done to show the relationship between climatic elements and farming, and further analysis, mainly multi-linear regression, was done to predict the impact of climate change on farming in the study areas.

The variables used for the correlation analyses include farmers' perception on climatic change impacts (this comprises of the following variables; crop yield, income level, water unavailability during crop growth, food insecurity and ability of farmers to work during extreme weather conditions) with the farmers' perception on temperature, rainfall, humidity and wind. The variables that make up the climate change impact were given a value of 1 for yes, and 0 for no. Hence for each farmer the answers provided were aggregated to determine the total score for the climate change impact suffered by that household in relation to farming.

The multiple linear regression analyses done by using the farmers perception on the impact of climate change as the dependent or response variable, while impact of temperature, rainfall, humidity, wind speed, main crops cultivated (whether increasing or decreasing), animals reared (whether increasing or decreasing in number) and actions taken to minimize impact of climate change as independent or predictor variables. This equation for the regression is given below:

$$Y = a + bx_1 + cx_2 + dx_3 + ex_{4 \ldots \varepsilon}$$

where Y is the dependent variable- in this case Climate Change Impact; X_1, X_2, X_3 and X_4 are the independent variables – in this case they include farmers' perception of impact of temperature, rainfall, humidity, wind speed, main crops cultivated (whether yield increasing or decreasing), animals reared (whether number increasing or decreasing) and actions taken to minimize impact of climate change.

- a = intercept
- b, c, d, e – slopes
- ε - residual (error)

3. Results and Discussion

3.1. Socio-economic and Demographic Profile of Farmers

Over half (55%) of the farmers interviewed are males, and 45% are females. Less than two-fifths (39.7%) have no formal education, 25.4% have secondary education, 18.3% had primary education, and about 16.3% hold a diploma, high teacher's certificate, or a first degree. More than sixty percent (60.7%) are married; others are single (18.0%), widowed (10.7%), or separated/divorced (7.3%). Majority (73.3%) are engaged in farming as their main livelihood activity, while others do trade (10.0%), teaching (5.0%), work in the civil service (6.0%), and the rest do artisan works (6.7%). It therefore indicates that those engaged in other activities do farming as a part-time activity (26.7%). Over two-thirds of the households in the study areas are headed by men (67.7%), and just under one-third (32.3%) are headed by women. Their average income earned per day is about Le 70 ($ 3 U.S. dollars). The findings show that majority of households in rural and peri-urban communities in Sierra Leone are engaged in farming as their main livelihood activity, and that resonates with the 2015 Housing and Population Census (Statistics Sierra Leone, 2015)[24] and FAO (2018)[25]. The findings also show that the average income earned by most household heads per day in the study areas is above the national average household income reported by the World Bank for Sierra Leone in 2020, which was $1.90 for less than fifty percent (44.2%) of the population (World Bank, 2020)[26].

3.2. Main crops grown and animals reared by farmers

3.2.1. *Main crops grown*

Figure 3 presents the main crops grown by the farmers in the study area.

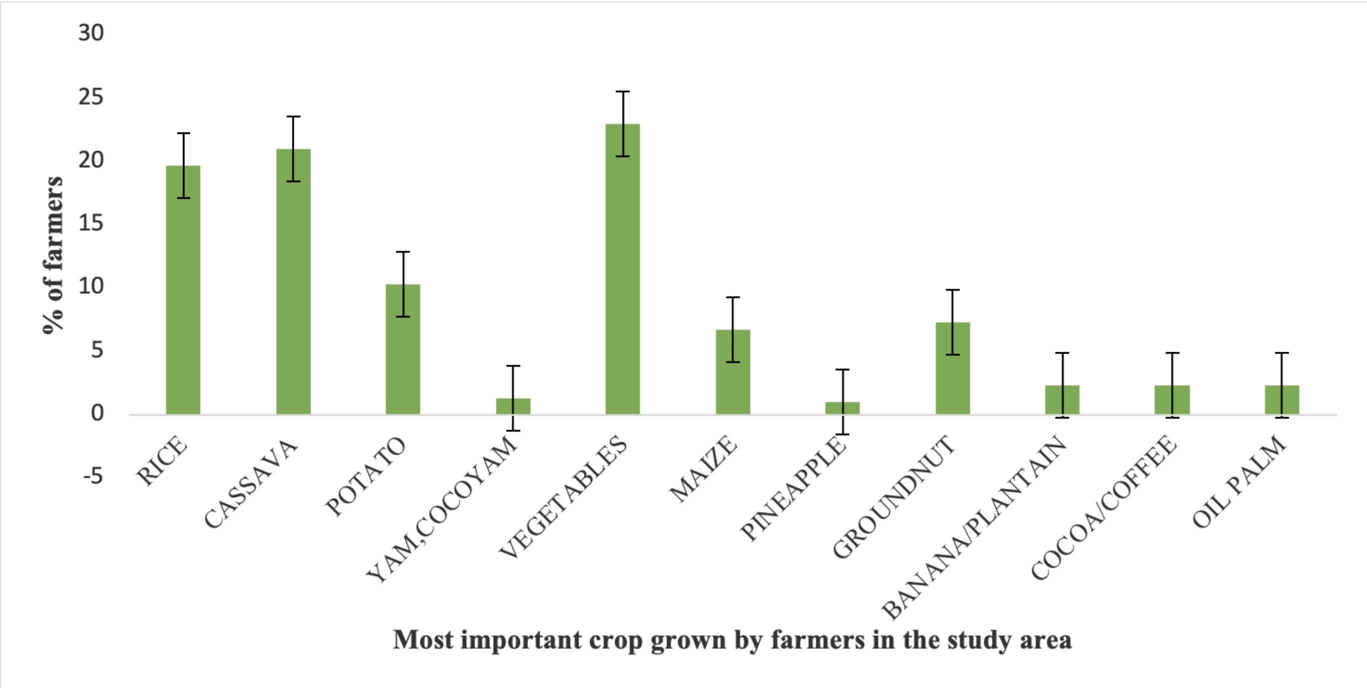

Figure 3. Distribution of farmers by the most important crop they grown in the study area.

Figure 3 shows that the farmers in the study area grow varieties of crops, but the most important ones are vegetables (23%), cassava (21.3%), and rice (19.7%). A few farmers grow pineapple (1.0%), cocoa yam (3.3%), and oil palm (2%). This finding is in agreement with that of the FAO (2018) report, which stated that many households in Sierra Leone depend on agriculture for their food and income and that the loss of crops and seeds can result in food and nutrition insecurity.

3.2.2. *Main animals reared*

Figure 4 shows the main animals reared by farmers in the study area.

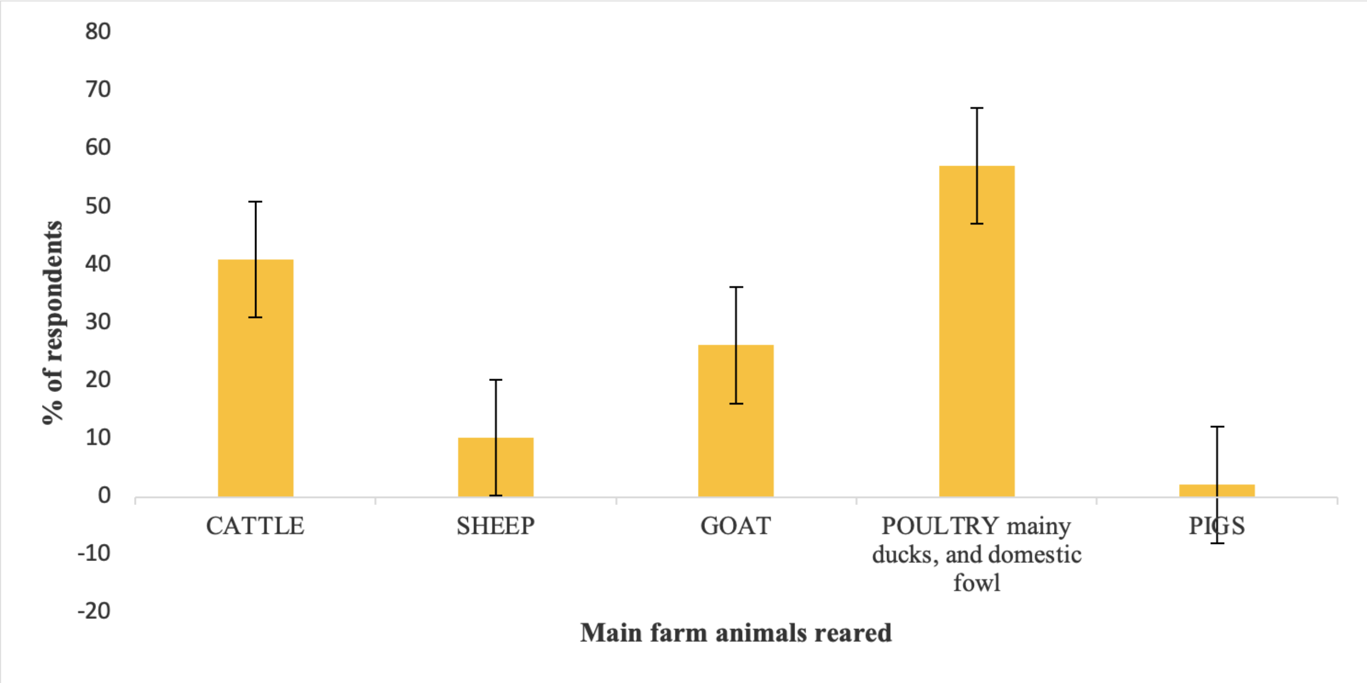

Figure 4. Distribution of respondents by types of main animals reared in the study area.

Figure 4 indicates that over half (57.2%) of the farmers in the study communities are rearing poultry (domestic fowls and ducks), and only a few are rearing pigs as their main farm animals. This finding resonates with that of Mcgahey et al., (2019)[27], who reported that domestic fowls are the main farm animals reared in Moyamba District in Southern Sierra Leone.

3.3. Farmers' perception of the trend in the yield of main crops and number of main animals reared by farmers since 2014

3.3.1. *Farmers' perception of the trend in the yield of main crops*

Figure 5 shows the farmers' perception of the trend in the yield of crops grown in the study areas since 2014.

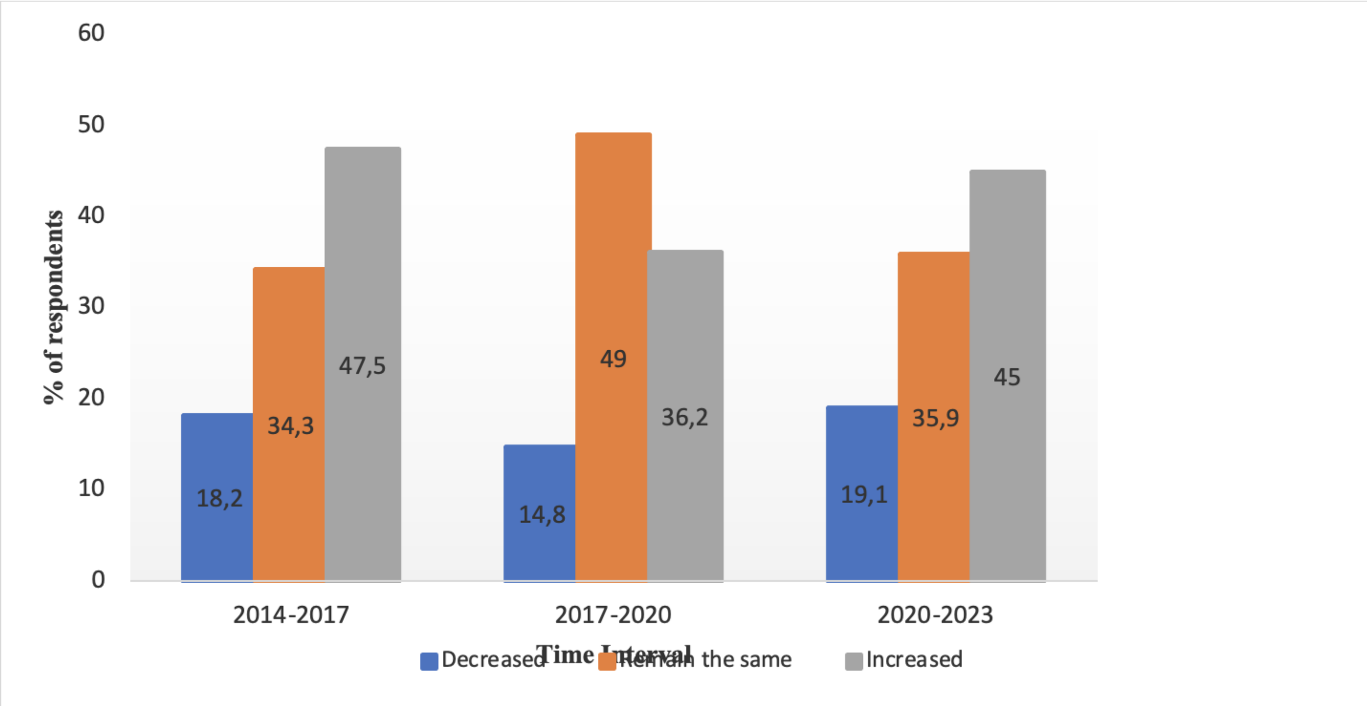

Figure 5. Farmers' perception of the trend in yield in their main food crop production since 2014 to 2023.

It is noted in Figure 5 that between 2014-2017, slightly less than eight percent (47.5%) of the farmers stated that there had been an increase in yield in their main crop, while less than twenty percent (18.2%) agreed that the yield in their main crop had decreased. However, between the period 2017-2020, slightly less than half (49%) of farmers agreed that the yield in their main crop grown during that period had remained the same, and only a small percentage (14.8%) agreed that it had decreased. It is also shown on the graph that forty-five percent (45%) of the farmers stated that they had an increase in the yield in their main crop produced between the periods 2020-2023, while less than one-fifth (19.1%) agreed that they had experienced a decrease in yield. This finding somehow agrees with that made by Mansaray et al.,[21] which indicated that 40% of farmers in their study have reported yield loss.

The farmers were asked to state whether there were reasons for the increase or decrease in the yield so as to ascertain the reasons for the change in yield between the time periods indicated in Figure 5. The findings are presented in Figures 6 and 7.

Figure 6 presents the reasons advanced by farmers for the increase in the yield of their main crops between 2014 and 2023.

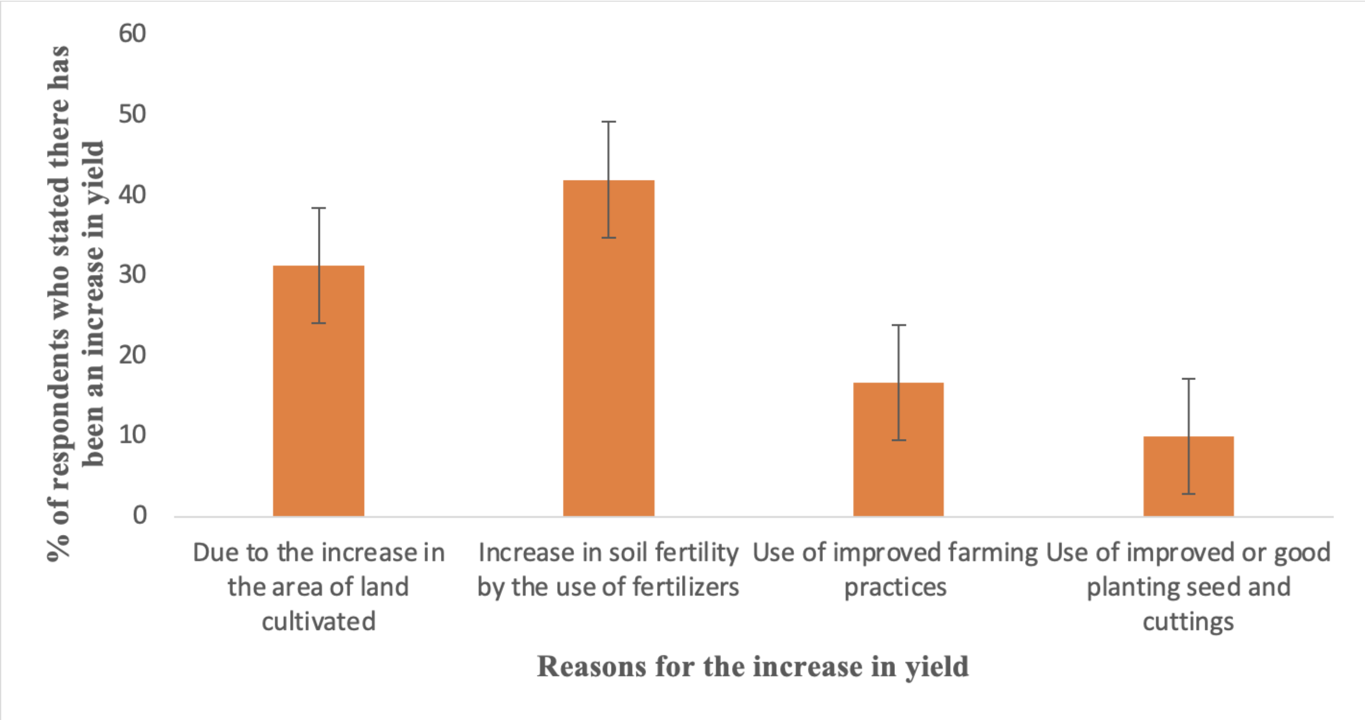

Figure 6. Distribution of respondents by main reasons for increase in main crop produced between 2014-2023

Figure 6 shows that the main reason advanced by farmers who stated that they realized an increase in their main crop was due to increased use of fertilizers (42%), and a small number (10%) stated that it was due to the use of improved planting materials. This finding is in agreement with that of Morton (2007)[28], who stated that farmers use shortcut methods of cultivation by using chemical and artificial fertilizers as a way of mitigating ecosystems and climate change conditions.

Figure 7, on the other hand, presents the reasons given by farmers who had stated that they had experienced a decline in the yield of their main crop between 2014 and 2023.

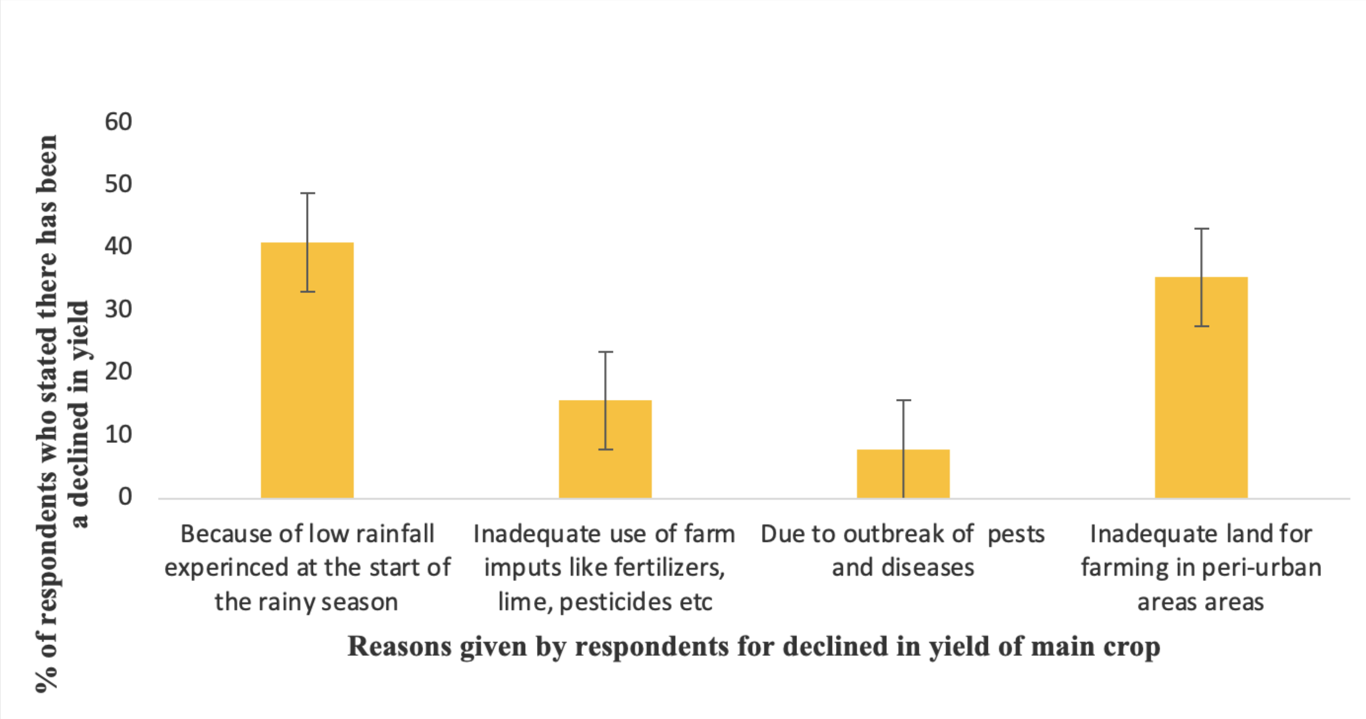

Figure 7. Distribution of respondents by main reasons for decrease in main crop produced between 2014-2023

Figure 7 shows that slightly over two-fifths (41%) of respondents who stated that there has been a decline in the yield of their main crop grown between 2013-2023 noted that this was as a result of low rainfall experienced at the start of the rainy season, especially for the growth of crops like rice. On the other hand, a small number (7.9%) stated that the decrease in main crop production is as a result of outbreaks of pests and diseases on their farms. This finding resonates with that of the World Bank Report[9] and Ziska et al.,[2], who also stated that, as a result of climate change, pests and diseases can multiply, which can eventually lead to low yields of most staple crops. A similar report was made by the United States Fourth National Climate Assessment[1], which stated that agricultural productivity was expected to decline in the United States as a result of increases in temperature, water stress, drought, and wildfires.

3.3.2. *Farmers' perceptions of the trend in the number of animals produced or reared by farmers between 2014-2023*

The finding is presented in Figure 8.

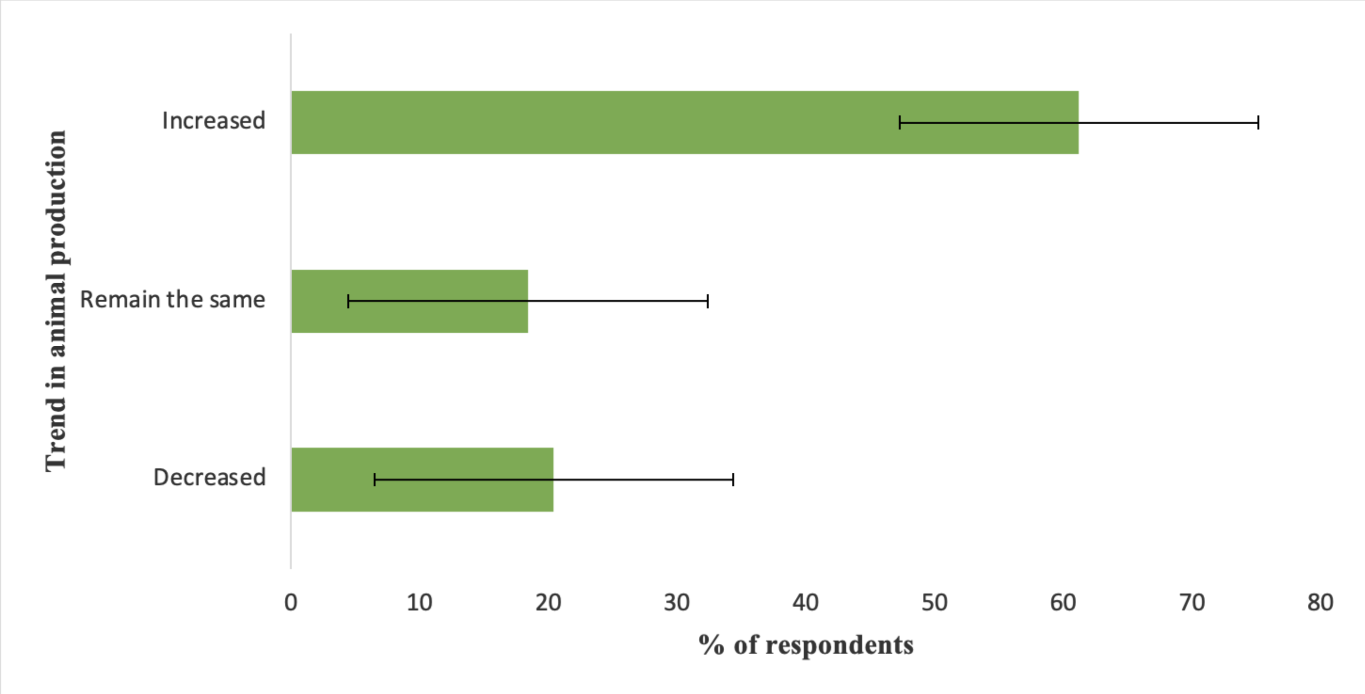

Figure 8. Farmers' perception of the trend in animal production in the study areas between 2014-2023

Figure 8 reveals that slightly above six-tenths (61.2%) of the farmers who rear animals agreed that there has been an increase in the total number of animals produced in the study areas between 2014 and 2023. On the other hand, less than two-tenths (18.4%) of the farmers said the total number of animals reared had remained the same. As the finding shows, climate change does not have much negative impact on the animals reared; this could be as a result of the breed of animals reared in most of the areas selected for the survey. The main breeds of animals reared include local domestic fowl, ducks, the West African Dwarf goats and sheep, and the Ndama cattle, etc. These animals can withstand some of the adverse effects of climate change. This finding contradicts that of the study by Digesa (2024)[29], who reported from Southern Ethiopia that feed shortage, reduced water availability, higher heat stress, and increased diseases are direct impacts of climate change on livestock production in terms of increased livestock mortality.

3.4. Farmers' perception of the impact of climate change on farming

This section tries to explore farmers' perceptions of major climate elements on farming in the study areas. The findings are discussed in the subsections below.

3.4.1. *Impact of rainfall on farming*

3.4.1.1. Whether the rains have been coming early, late, or normal since 2014

The finding is presented in Figure 9 below.

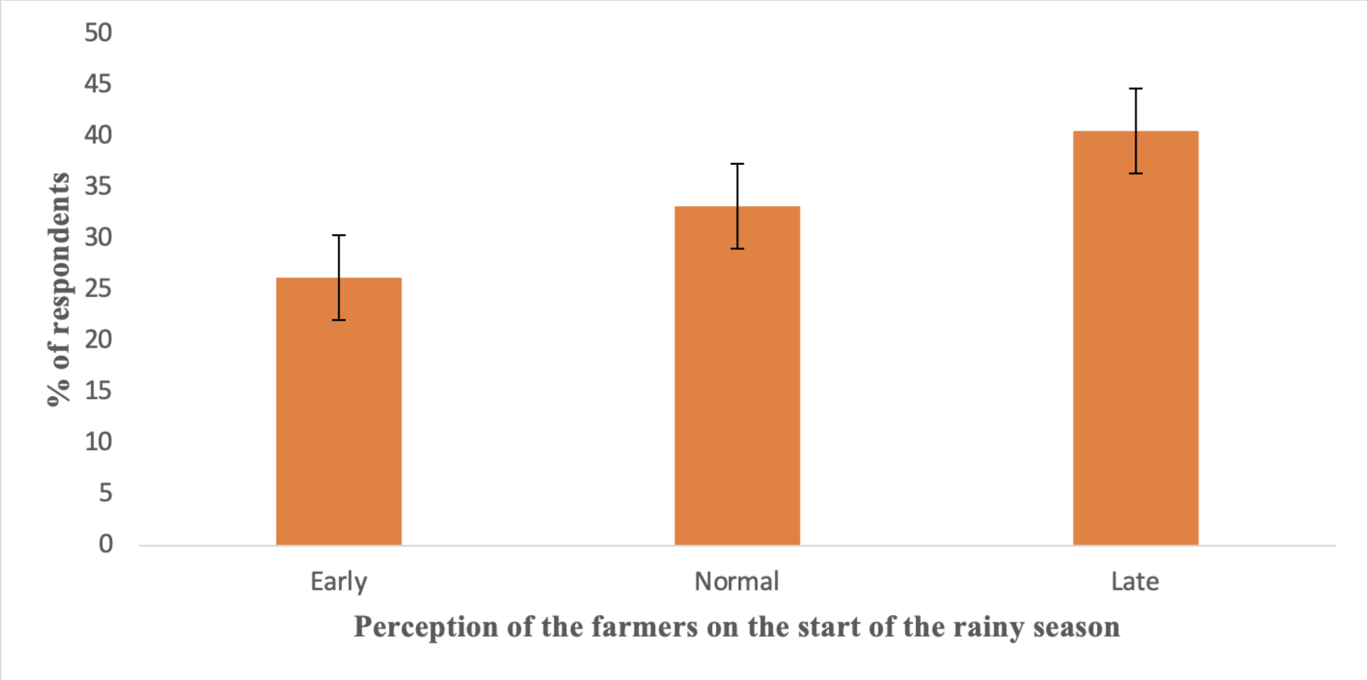

Figure 9. Farmers' perception of the start of the rainy season for the past 10 years

It is indicated in Figure 9 that slightly over two-fifths (40.6%) of the respondents perceived that the rains are late in coming as compared to the period 10 years ago, when the rain used to come at the start of April or sometimes in March. However, over a quarter (26.2%) of the respondents agreed that the rain is still coming early as usual. They further said the rainy season starts in mid-April in their study area, and this has still continued. This finding is in agreement with the WFP[30] report, which stated that rainfall (one month) and (three months) anomaly variations at the start of the rainy season enhances crop development. However, the finding contradicts that of Johnson et al.[17], who reported that there used to be unprecedented rainfall in March and April that prevented farmers from burning the brushed farmland and that at that time most farmers would not be able to cultivate the main staple food, which is rice. They would instead plant other crops, thus leading to food insecurity.

The farmers stated that if the rains come late instead of the normal time, that can result in several impacts, including reduction in the growing period of crops like rice and other major crops, including cassava, pepper, beans, pumpkin, and others, diseases prevalence, pest infestation, invasion of weeds on uncultivated farmlands, and sustainability of domestic farm animals, since most of them are reared on free range. This, they say, will lead to low yields of crops and poor meat.

The farmers also stated that periods of late rains have coincided with a decrease in low rainfall. They stated that when the total annual rainfall in their study area is low, they experience poor harvest and eventually low income, as most of the crops don't do well. However, as seen in Figure 2, the total rainfall has started increasing again in 2023; maybe if the trend continues, the farmers may expect a better harvest or better yields.

3.4.1.2. Coping strategies to mitigate early/late and low annual rainfall in farming

A good number (N=65) in the study area stated that one of the major steps taken to mitigate late rainfall is to adjust their planting time, which is becoming difficult as the rainy season is becoming unpredictable for them. Some (N =20) said they irrigate or water the plants if the farm is not large. Others have said they can only plant crops that can withstand dry weather. A few (N= 9) said they use the swamp for crop production because there is always some amount of water there, which can be used for irrigation or watering.

3.4.2. *Impact of temperature on farming*

3.4.2.1. Farmers' perception of the temperature since 2014

Figure 10 presents the farmers' perception of temperature in the study area since 2014.

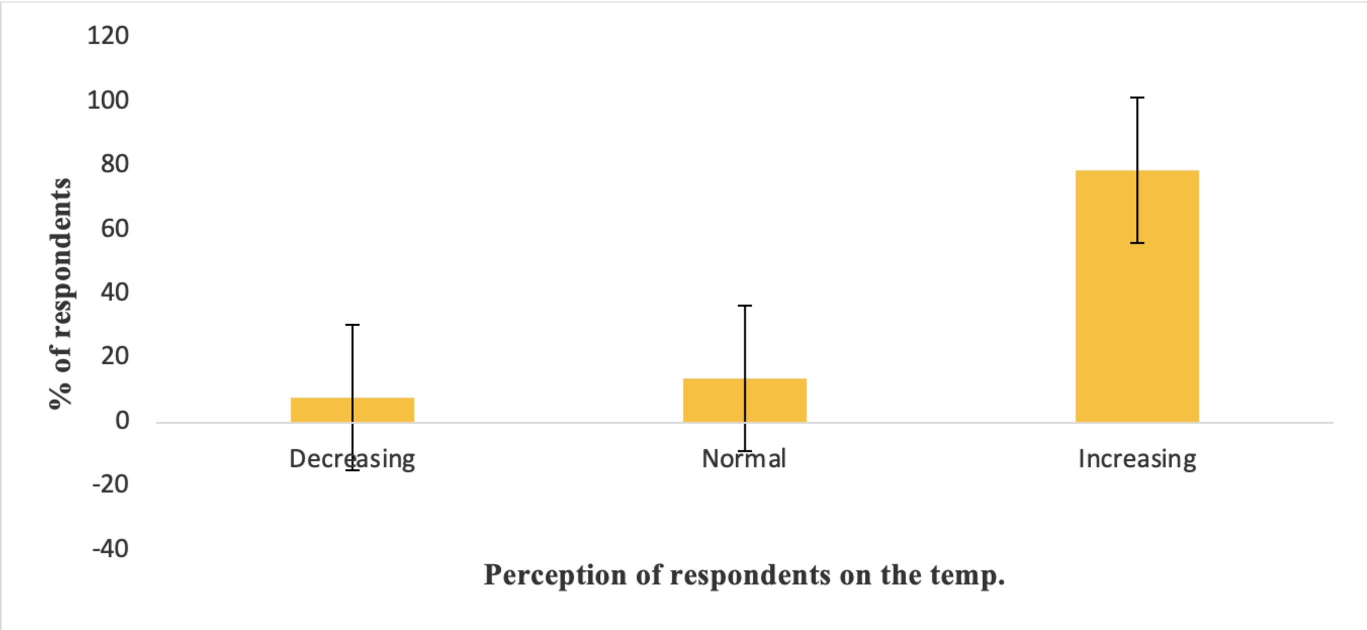

Figure 10. Farmers' perception of the temperature in the study area for the past 10 years

Figure 10 shows that over three quarters (78.6%) of the respondents agreed that the temperature has been increasing in the study area, and only a very small number (7.7%) said that it has been decreasing. This finding is in agreement with the climate data shown in Figure 2, which clearly shows that the temperature has been increasing slowly over the past few years. In similar vein, Yila et al.[20], also stated that farmers in Moyamba District in Southern Sierra Leone perceived that temperature have been increasing over the years.

3.4.2.2. Farmers' perceptions of the effect of high temperature on farming

Further discussions with the farmers on the effect of high temperature on farming reveal that high temperature causes abnormal growth of plants and sometimes death; it affects seed germination, reduction in yields, or sometimes crop failure; and it can affect animals like cattle by causing heat stress and restlessness among them.

3.4.2.3. Coping strategies adopted by farmers to mitigate the effect of high temperature on farming

The farmers identified the following as the coping strategies adopted to mitigate the effect of high temperature on farming. Some of the farmers (N= 15) had been adjusting their planting and harvesting times. A good number (N= 78) of the farmers had been watering their plants regularly in order to reduce the heat and drying of the soil. A moderate number (36) had been practicing mulching of their vegetable gardens. A few (6) planted their crops in between trees, while others (4) have moved to the swamp, which tends to be cooler.

3.4.3. Impact of humidity on farming

The finding is presented in Figure 11.

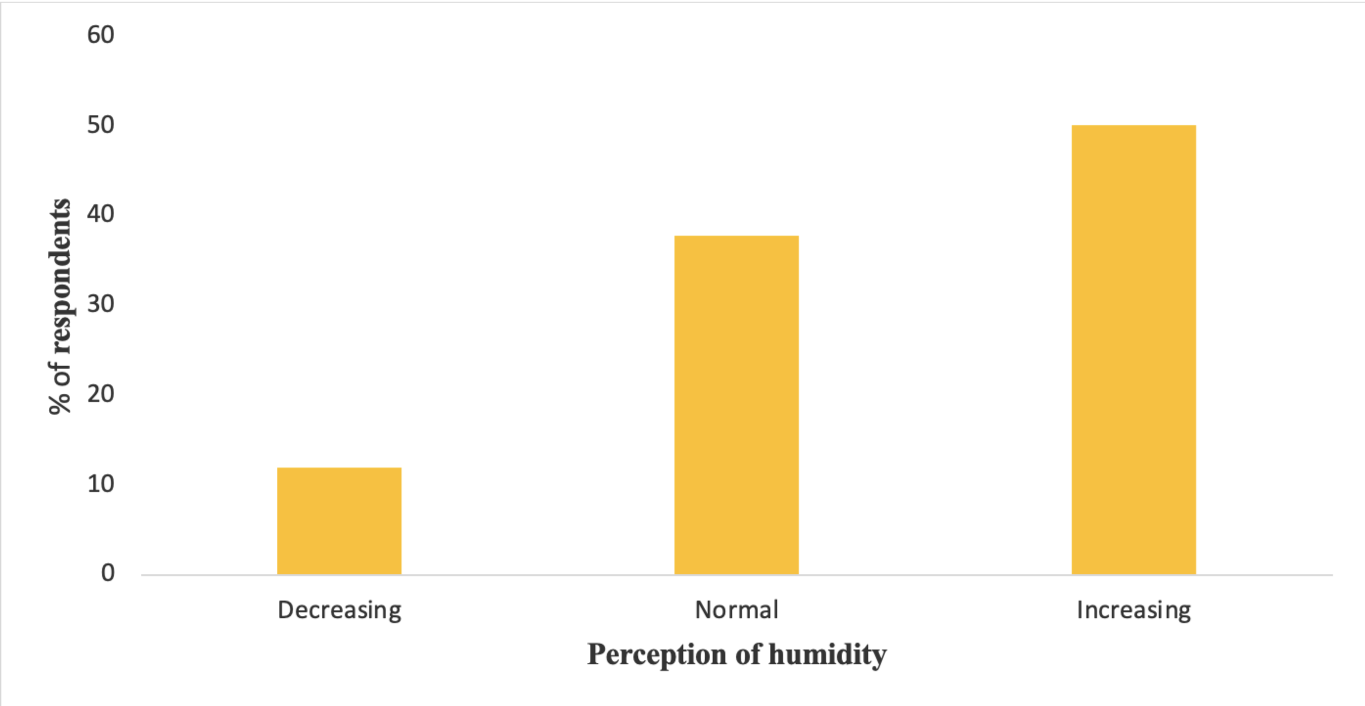

Figure 11. Farmers' perception of relative humidity in the study area since 2014.

Figure 11 reveals that slightly above half (50.2%) of the respondents hold the perception that humidity has been increasing in the study area in the past 10 years, while a small number (12%) of respondents noted that it has been increasing. However, when the farmers were asked if humidity has been affecting farming in their community, 35.6% of the farmers agreed that it has been affecting, while 30.5% said it has not been affecting their farming activities; on the contrary, 33.9% of the respondents stated they can't tell because they don't have the knowledge.

To better understand those farmers that stated that humidity has been affecting farming in the study area, the farmers were asked to describe the effects. The findings are discussed below:

They stated that high humidity brings more rain for farming, while low humidity brings less rain and that affects their farming. They further stated that low humidity drains water from the leaves, making them weak, and they eventually die. Finally, they noted that high humidity increases diseases in both plants and animals, thus leading to death. This finding somehow agrees with that of Walsh et al.[3] who reported that agricultural productivity of animals reared for meat, milk and eggs are affected by heat and humidity.

To mitigate the effects of low or high humidity on farming, the farmers gave some practices that they have been doing; these include:

Planting more trees in their communities to increase evaporation, reducing bush burning and other wildfires, using seeds that can withstand low humidity, drying harvested crops before storage, and if diseases increase as a result of high humidity, using chemicals to kill the diseases.

3.4.4. *Impact of wind movement on farming*

3.4.4.1. Perception on wind movements

Figure 12 presents the perceptions of the respondents on wind movement in the study area since 2014.

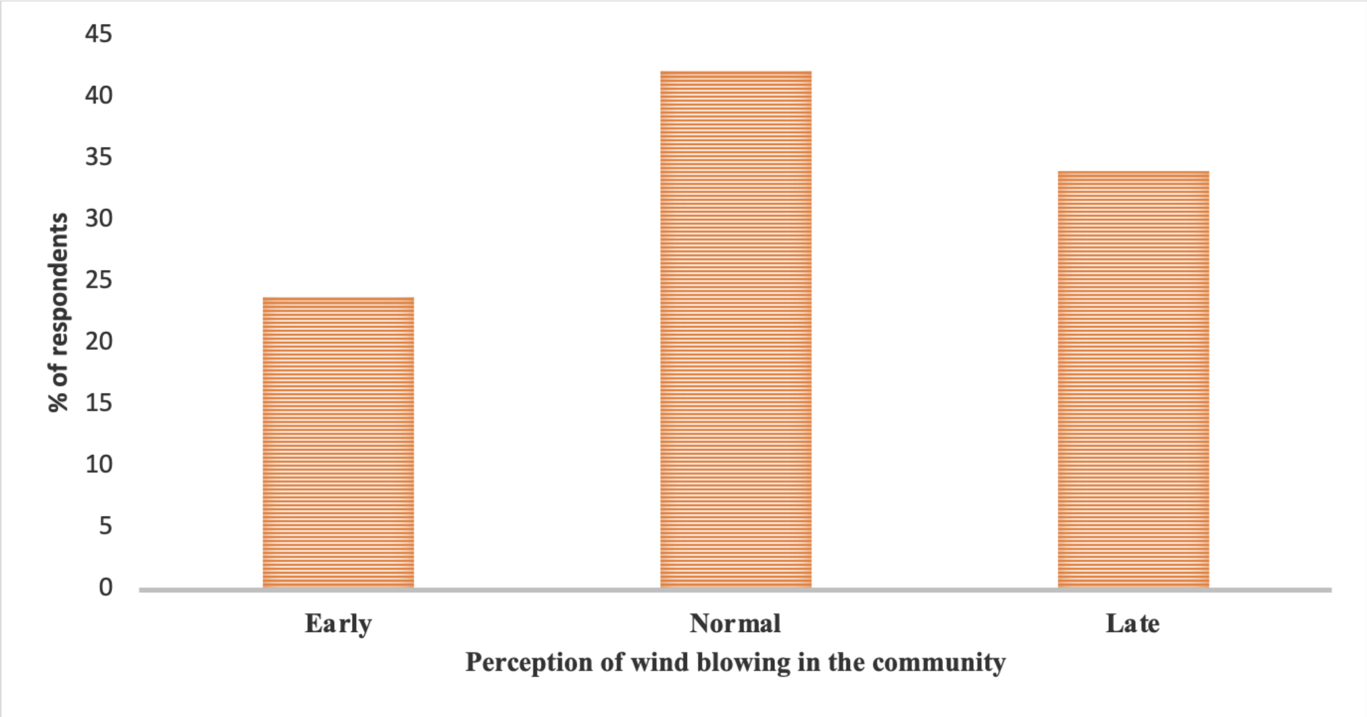

Figure 12. Farmers' perception of wind movement in the study area since 2014.

In Figure 12, slight over two-fifths (42.2%) of the respondents agreed that wind movement has been normal in the study areas, while slight over one-fifth (23.8%) of the respondents stated that the winds have been blowing early. Those who stated that the wind has been blowing as normal as before agreed that they have been getting the winds blowing during the dry season as well as during the rainy season. Those who said that the winds are late in coming said so because they now have late rains, as they believed that the winds bring the rains.

3.4.4.2. Effect of wind on farming

The findings on the effect of wind on farming are discussed below:

Most of the respondents (58.7%) agreed that they can tell whether wind movements have any effect on farming, while 2.1% agreed that it had an effect. The rest (39.3%) said there is no effect at all. Of the few who said wind movements had an effect on farming, some stated that it breaks the branches of their tree crops when the speed is very high. Others stated that it helps to damage their crops before harvesting by blowing them to the ground. This finding agrees with that of Gardinar et al.[31], who reported that wind damage can have a major economic impact on crops, forest and trees. A few stated that winds bring a lot of rain that can cause flooding in low-lying areas. Finally, some stated wind speed blowing with moderate or high speed can help to spread wildfires and dry up the soil during the dry season. It can be deduced therefore that wind speed can affect agricultural productivity[32][33]

3.4.4.3. Things that have been done to mitigate the effects of wind movements on farming

To mitigate the impact of wind movements and speed on farming, the farmers agreed that they have been doing the following.

A good number of them said they have been planting trees around their communities and farms to reduce the speed of the wind. Some stated that they have been harvesting their crops when they are ripe before the winds bring them down. A few said they have moved to swamps to plant their food crops and leave the upland for tree crop farming. Finally, some stated that they should educate and train them on climate change.

3.4.5. Correlation and regression analyses of farmers' perception of the impact of climate change on farming.

Table 1 presents the Pearson correlations coefficients between impact of climate change on temperature, rainfall, humidity and wind speed.

Table 1.

	Temperature	Rainfall	Humidity	Wind speed
Climate change impact	.614**	0.516**	-.647**	0.387**

*** Correlation significant at the 0.001 sig. level (2 tailed)*

It can be observed that there is a moderate positive and statistically significant relationship between temperature (0.616, p ≤0.01), rainfall (0.516, p≤0.01) and low or weak correlation between wind speed (0.387, p ≤ 0.01) and climate change impact while there is a moderate negative and statistically significant relationship between humidity and climate change (-.647, p ≤ 0.01). The positive correlations between temperature, rainfall and windspeed and climate change impact clearly indicates that as these climatic parameters changes the impact of climate change on farming also increases.

Table 2a, 2b and 2c presents the multiple regression analyses of Climate change impact as the dependent variable and impact of temperature, rainfall, wind speed, humidity, whether yields of main crops are increasing or decreasing, animals reared are increasing or decreasing and the action taken by farmers to minimize climate change as the independent or predictor variables.

Table 2a. Regression statistics between the dependent and independent variables

Multiple R	0.86
R Square	0. 73
Adjusted R Square	0. 72
Standard Error	0. 69
Observations	215
Durbin Watson	1.480

Table 2b. Analysis of variance (ANOVA) showing variability in the data set

Model	SS	df	MS	F	Significance F
Regression	249.82	7	35.61	80.02	0.001
Residual	92.91	207	.446		
Total	342.14	214			

Table 2c. Coefficients of the regression model.

	Unstandardized coefficients		Standardized coefficients	t-test	P- value	Collinearity statistics	
Intercepts	**B**	**Standard Error**	**Beta**			**Tolerance**	**VIF**
Intercepts	2.537	.368	-	6.897	.001	-	-
Rainfall Impacting	.539	.226	.150	2.384	.018	.328	3.045
Temperature Impacting	.574	.226	.162	2.543	.012	.322	3.107
Humidity Impacting	-1.115	.144	-.416	-7.759	.001	.454	2.201
Wind speeding impacting	1.038	.144	.273	7.198	.001	.909	1.101
Action taken to minimize climate change	-.068	.062	-.060	-1.085	.279	.422	2.371
Whether yield is high or low	.568	.248	.0.096	2.293	.023	.750	1.334

Table 2b shows that the independent or predictor variables (farmers perception of the impact of rainfall, temperature, humidity and wind speed, actions taken to minimize climate change impact, whether yields of crops are low or high used) for the prediction exhibit a statistically significant relationship with the dependent or response variable (impact of climate of climate change) at F (7, 207) = 80.2, $P < 0.001$. The model has explained 73.0% of the variance in impact of climate change as shown in table 2a. The model therefore shows that impact of climate change can be predicted by a combination of the following variables, include impact of rainfall, temperature, humidity, wind speed, the action taken by farmers to minimize climate change, yield of crops cultivated.

Table 2c shows the t-tests and their corresponding p- values. The tests are statistically significant for farmers perception of the impact of rainfall, p (.018) < 0.05, temperature, p (.012< 0.05, humidity, $p \leq 0.001$, wind speed, $p \leq 0.001$, farmers perception of crop yields, p (.023) < 0.05. On the other hand, the variable actions taken by the farmers to minimize impact of climate change are not statistically significant, p (0.279 > 0.05), meaning this variable is not useful in the model as it does not contribute to the overall prediction of the regression model.

The model also shows that the Watson Durbin value given in table 2a is 1.480, which is greater than 0 but less than 4, indicating no autocorrelation in the multiple regression. Furthermore, the Variance Inflation Factor (VIF) being < 10 and the tolerance being > 0.1 are sufficient for all the independent variables as shown in table 2c. Hence indicating that no multi-collinearity is involve in the model.

In conclusion, the multiple regression model used in this study shows a statistically significant relationship between the dependent and independent variables, F (7, 214) = 80.417, $P < 0.001$, R^2 =.730. Among the independent or predictor variables used in the model, 5 of them significantly contributed to the prediction, these are impact of rainfall, $p < 0.05$, impact of temperature, $p < 0.05$, humidity, $p \leq 0.001$, impact of wind speed, $p \leq 0.001$ and farmers' perception of crop yield, $p < 0.05$. In the model the best predictor of the impact of climate change on farming is impact of humidity (-0.416), followed by impact of wind speed (0.273), then impact of temperature (0.162), impact of rainfall (0.150) and farmers' perception of crop yield (0.096). The other predictor, actions taken by farmers to minimize impact of climate change is not statistically significant, p (0.279) >0.05 as it does not contribute to explaining impact of climate change, when the other predictors are in the model. These findings somehow agree with that of Bai et al.[33], who noted in their study that wind speed and temperature had a significantly adverse effect on agricultural productivity even though they reported that annual rainfall does not.

3.5. Conclusion

Findings reveal that farmers grew mainly food crops like rice, root crops like cassava, and vegetables. Few farmers grew tree crops like cocoa and oil palm. The main animals reared by farmers are poultry, cattle, and goats. The yield of the main food crops grown by farmers was increasing between 2014 and 2017 but remained the same between 2017 and 2020. However, yields started increasing again between 2021 and 2023. The increases for the yield, according to the farmers, are using more fertilizer to improve soil fertility and expansion of their farmlands, especially those in the rural areas. The reasons for the decline in yield of the main crops, according to other farmers, include erratic and low rainfall at the start of the rainy season, and inadequate land, especially in peri-urban areas, for farming. Animals reared in the study communities are increasing in number, though climate change in the form of high temperature and humidity has had some impact on them.

The study reveals that the rains have been coming late according to a good number of the farmers as compared to 10 years ago. This has led to a reduction in the growing periods of some varieties of rice and cassava. The farmers also agreed that diseases and pests are on the increase and strange weeds have invaded the farmlands when the rains are erratic. Some farmers have been experiencing poor harvests because of erratic rainfalls, and others have lost their crops when too much rain comes. The farmers have been mitigating late rainfall by adjusting the planting time, planting crops that can withstand drought, and some farmers have moved to the swamps if they have one to reduce the need for water, especially during the dry season.

Temperatures have been increasing according to the farmers' perception and data collected from three weather stations across the study areas. Farmers believed that high temperatures have been affecting the normal growth of their crops; it also affects seed germination. It also causes heat stress, especially in cattle. Coping strategies adopted by farmers include adjusting planting and harvest times, watering the plants regularly to reduce withering, adding mulch to the seed bed, planting crops among trees that do not have big branches, and finally, doing more farming in the swamps, which might be cooler.

Most farmers also agreed that humidity has been increasing and that it has been promoting diseases in both the plants they grow and the animals they rear. The farmers have been fighting the occurrence of wildfires and planting trees to mitigate the effect of humidity on their farms and the environment.

A good number of the farmers believed wind speed has not been seriously affecting farming as compared to other weathers like rainfall and temperature, but some believed rainstorms have been pulling their tree crops down. The farmers believed that wind brings rain and helps to spread wildfires and dry up the soil during the dry season. Some farmers agreed that they have been planting trees around their communities and farmland to mitigate the impacts of wind speed.

The findings from the multiple regression model based on the farmers perception on the impact of climate change on farming shows that climate parameters like temperature, rainfall, humidity and wind speed significantly affect farming in the study area.

The correlation and regression outputs also confirm that the views of people affected by certain phenomenon like climate change can be subjected to scientific tests and the result can be significant.

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