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Cash crop farmers' perceptions of, and adaptation to climate change: A preliminary study of Black Bush Polder, Guyana

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Abstract

Farmers Black Bush Polder, Guyana, have been experiencing changes in weather variability and climate parameters as well as the impacts of those changes on their livelihoods. Understanding farmers' perception of climate change and their adaptation strategies is crucial to assisting with efforts for developing suitable intervention strategies to combat the effects of climate variability and climate change. In this non-experimental research engaging fifty (50) randomly selected farmers the aim was to: (1) examine how cash crop farmers in Black Bush Polder perceived the effects of climate change; (2) identify adaptation strategies used by farmers in combating the effects of climate change; (3) identify the factors that influence the adaptation strategies chosen by farmers; (4) identify perceived barriers in the implementation of adaptation measures; and (5) make recommendations in light of the difficulties encountered by farmers. A self-administered structured questionnaire survey was used to collect primary data and the responses to the items using a modified Likert scale. Descriptive statistics, and Pearson Correlation Coefficient were used to analyze the data. The results showed that there was variation in both temperature and rainfall in the Black Bush Polder Area. Overall, farmers had a general perception that these variations had an impact on their farming activities as well as on their choice of adaptation measures. Key recommendations made were: planting improved, or more resistant varieties of crops, changing planting times as dictated by rainfall, collection of water in furrows near plants, utilizing drip irrigation systems and techniques for preparing crop beds, and using of shade houses and greenhouses to lessen the effects of climate change.

Keywords: Cash Crop Farmer; Adaptation; Climate Change; Black Bush Polder; Guyana

1. Introduction

Agriculture is a significant contributor to Guyana's economy. However, it is negatively impacted by the effects of climate variability and climate change and impacts appear to affect the farmers in Black Bush Polder, Lower Corentyne, Guyana. In spite of the numerous challenges that farmers encounter, Black Bush Polder still remains one of the prominent farming areas, and a bread-basket for surrounding communities. Climate change perception includes a variety of psychological constructs, such as knowledge, beliefs, attitudes, and concerns about how the climate is changing [33]. The characteristics of the individuals, their experiences, the information they receive, and the cultural and geographic context in which they live all have an impact on and shape perception [32] [33].

It is possible to view awareness of climate change as a prerequisite for the adoption of agricultural adaptation strategies [20] [25]. Additionally, the cooperation and participation of the intended beneficiaries are necessary for the successful implementation of public policies meant to promote adaptation. This study explored farmers' perceptions of climate change in Black Bush Polder as a means of identifying perceived adaptation barriers, comparing farmer's perception of

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climate change with meteorological data, examining the factors that influence the choice of adaptation strategy, and identifying adaptation strategies farmers used to combat the negative effects encountered.

This study explored farmers' perceptions of climate change in Black Bush Polder as a means of comparing farmer's perception of climate change with meteorological data, identifying adaptation strategies, identifying perceived adaptation barriers and examining the factors that influence the choice of adaptation strategy

1.1. Climate change policies, adaptation initiatives and agriculture in Guyana

In Guyana, the temperature is expected to rise 1°C– 4°C, and sea level by 1-3 feet by the end of the 21st century. Intense periods of rainfall and longer dry periods are also expected [34]. Additionally, with a large percentage of the population, living on the coast, where the majority of the agriculture and food production is located, sea level rise and high intensity rainfall will severely impact food security [34]. It has been evident that persons living on the coast are affected by persistent flooding and occasional periods of droughts have impacted agriculture, and the economy as a whole [3].

Guyana is committed to implementing various international multilateral climate change agreements, treaties, protocols, and regional strategies, and in some cases, has done so by developing and implementing domestic policies and legislation. Guyana is obligated under Article 4 of the UNFCCC as a ratified signatory to both the Convention and its Kyoto Protocol and the country is also committed to taking national-level action to achieve the Sustainable Development Goals.

A framework for addressing the problems Guyana is currently facing and will encounter in the future as a result of climate change is provided by the National Climate Change Policy and Action Plan (NCCPAP). This policy's overarching goal is to ensure that climate change adaptation and mitigation follow the UNFCCC guidelines. The policy's objectives are to: control, reduce, or prevent anthropogenic greenhouse gas emissions in all relevant sectors, such as the energy, transportation, industry, agriculture, forestry, waste management, and health sectors; conduct vulnerability assessments of sectors and communities and identify adaptation measures required to address the impacts of climate change; implement measures to facilitate climate change mitigation and adaptation; and implement measures to reduce the negative impacts of climate change on vulnerable sectors and communities.

The Policy incorporates knowledge from earlier national documents, including the Nationally Determined Contribution (2015), Initial National Communication (2002), Second National Communication (2012), Low Carbon Development Strategy (2009 and 2013), Climate Change Action Plan (2001), Climate Change Adaptation Policy and Implementation Plan (2001), Draft Climate Resilience Strategy and Action Plan (2015), policymaker interviews, and national consultations. This National Climate Change Policy and Action Plan consolidates current efforts and builds on prior ones to lay the groundwork for Guyana's future climate change initiatives. On a larger scale, this entails improving the green state's appeal from an economic, environmental, and social standpoint.

The Low Carbon Development Strategies (LCDS) is used by the Government of Guyana to combat the effects of climate change. Additionally, the Ministry of Agriculture (MOA) has increased the Grow More Food Campaign, a market-oriented program to increase food production for both domestic and international markets. Guyana can use these following adaptation techniques to combat climate change: conserving energy and cutting greenhouse gas emissions (which will boost revenue and lessen the impact on the environment); increasing soil organic matter (this not only enhances soil health and productivity, but also reduces atmospheric CO_2 concentrations because organic matter is primarily carbon derived from atmospheric CO_2 [via plant photosynthesis]); increasing the effectiveness of nitrogen (N) use (Synthetic N fertilizers are energy-intensive to produce, transport, and apply, and soil emissions of nitrous oxide, a greenhouse gas increase as more N fertilizer is applied to the soil); breaking into the growing market for renewable energy (such as wind energy, biomass fuels), using marginal land as a source of N [17].

Construction of seed storage facilities, establishment of gene banks, implementing programs for rural diversification and the use of alternative energy are all ways of combatting effects of climate change faced by farmers. Some farmer adaptation strategies include: altering planting and harvest dates; altering crop varieties; using more water, fertilizer, pesticides, and herbicides; altering crop species; and installing new irrigation or drainage systems or making other significant investments [17].

Measures and adaptations at the crop-level are expected to be key in minimizing future yield losses, changing crop cultivars, sowing time, cultivation techniques, and/or irrigation practices [17]. To do this, adaptation measures can be planned using local coping strategies and indigenous knowledge as a starting point. Despite the fact that local communities already have a wealth of knowledge about coping with climatic variability and extreme weather events, rapidly changing climate conditions will require updating local knowledge with more scientific observations and establishing collaboration between neighbors and neighboring countries to transfer knowledge from areas already experiencing these changes [10].

More so, national agricultural research that is pertinent, should be encouraged. Research on cultivars that are resistant to new pests and diseases, heat, drought, and salinity should be prioritized. This will aid in creating methodologies and resources that can adapt to quickly changing circumstances [10]. Farmers should be encouraged to support institutions and procedures that cross disciplinary and sectoral boundaries since broadly based institutions and processes can support adjustments in resource access and use, resolve disputes, and protect groups' and individuals' rights to land and natural resources [10].

Farmers should collectively strive to create inexpensive strategies that offer a range of advantages. This may entail putting in place significant monetary incentives like microcredit, paying for environmental services, and lessening the marketing sway of the agricultural supply sector. Crop mitigation measures include those that reduce fertilizer use in soil and increase crop diversity, encourage the use of legumes in crop rotations, boost biodiversity, make high-quality seeds more readily available, and implement integrated crop/livestock systems; Promoting low-energy production methods, enhancing wildfire suppression efforts, preventing crop residue burning, and encouraging commercial agriculture and agro-industries to use energy efficiently are all recommended [10].

In Guyana, the agricultural industry dominates in terms of both job creation and foreign exchange earnings. Future national and regional development will still depend heavily on agriculture due to rising consumer demand for increased agricultural productivity, agribusiness investment opportunities, etc. As a result, agriculture must play a significant part in reducing the effects of climate change and adjusting to them. In order to combat the effects of climate change, our farmers must be aware of potential solutions [6]. Farming has many facets, and each practice has a significant impact and is connected to the others. Farmers in Guyana also tackle the effects of climate change faced by practicing composting; which enriches the soil, aids in proper waste management, reduces the likelihood of flooding, and helps to remove and reduce greenhouse gases [14].

Some farmers practice Agroforestry (permaculture) which is the self-sufficient and sustainable expansion of agricultural ecosystems. Typically, this kind of system will stabilize soil, offer shade, and offer protection from excessive rainfall. Alternately, other farmers maintain the conventional model while adopting and adapting to the needs of a specific farmer or the dangers they face, such as by installing drip irrigation systems or rainwater harvesting systems to safeguard and store water [14].

Drip irrigation systems are particularly being used in areas that are prone to drought, and farmers are encouraged to use raised beds in open field. Farmers also utilize shade house farming since it aids in the control of pests and diseases, and only a little manual labour is needed. Additionally, there are more innovative techniques, such as temperature-controlled vertical greenhouses, container farming, and hydroponics systems which farmers employ [16]. Failure to mitigate and adapt to climate change is serious risk facing communities globally. As climate change transforms global ecosystems, it impacts our homes, businesses, livelihoods, and infrastructure [35].

Vendors in Region 6, Guyana, who source their produce from farmers in Black Bush Polder have reported that the amount of cash crop produce supplied to them has declined. One reason alluded to is that there has been an increase in rainfall and a rise in temperature which has affected the crops grown. Farmers have attributed these effects to “climate change”. As a result of increases in the market prices for cash crops, the researchers sought to investigate the perceptions of farmers about climate change and their choice of adaptation strategies. The objectives of this study are: i) to investigate farmers' perceptions and knowledge of ‘climate change’; ii) to ascertain if farmers have been affected by any impacts of climate change and if this has affected the yield of their cash crops; iii) to determine which cash crops, in the opinion of farmers, are most affected by climate change impacts and iv) to identify the adaptation strategies used by farmers to mitigate the effects of climate change.

The outcome of this study can provide a basis for better understanding the perception of farmers regarding climate change and adaptation strategies, and also help raise awareness on the effects of climate change on ‘cash crop’ farmers residing in Black Bush Polder, Region #6 (East Berbice -Corentyne) while offering recommendations to alleviate challenges faced by "cash crop" farmers.

2. Methodology

2.1. Study Location

This study was undertaken in Black Bush Polder in Region Six (East Berbice-Corentyne), Guyana, an area that is known for its cash crop production. There are five villages along the 22-mile Black Bush Polder Road: Yakusari, Mibicuri, Johanna, Zambia, and Lesbeholden (Figure 1). Given that this agricultural activity represents a significant livelihood aspect of farmers in Black Bush Polder, it was felt that if the knowledge base of farmers as it relates to climate change and its impacts is known, then appropriate measures and policies could be recommended to alleviate any likely impacts that they may face as a result of climate change.

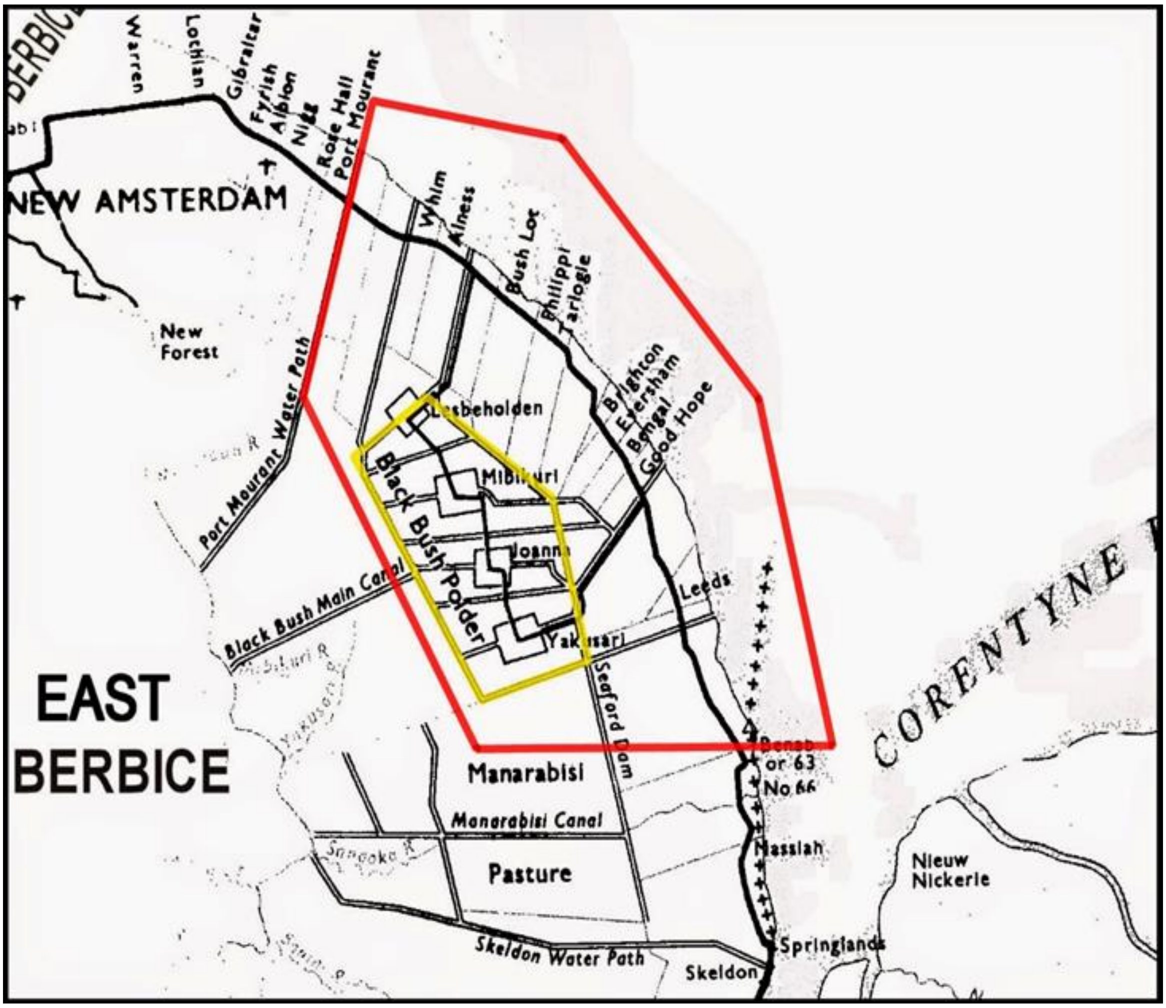

Figure 1 Black Bush Polder area outlined in Yellow (MykenLara, 2014).

2.2. Sampling procedures and methods of data collection

This preliminary study employed a non-experimental cross-sectional study design. Data was collected from fifty (50) randomly selected cash crop farmers from the Black Bush Polder, Region Six (East Berbice-Corentyne) area. Ten (10) farmers were chosen from each village: Yakusari, Mibicuri, Johanna, Zambia, and Lesbeholden.

Data was collected using a self-administered structured questionnaire which was distributed to farmers over a duration of five days. This questionnaire was divided into sections with questions that sought to investigate the perception of farmers about various aspects of climate change, how this phenomenon may have impacted their agricultural activity and the various types of adaptation strategies they would have employed in addressing the impacts of climate change.

The farmers were briefed on the purpose of the study and completed questionnaires were collected and the data was analyzed using the SPSS software. The study's findings were used as the basis to develop recommendations for potential adaptive strategies farmers can use to reduce the impacts of climate change to which they were exposed.

2.3. Data Analysis

2.3.1. Descriptive statistics, mean and standard deviation, were used to analyze the data

Pearson's Correlation Coefficient was done to determine the relationship between rainfall and temperature. The results were expressed in tables, figures and charts to indicate among others, mean, frequencies and percentages. In addition to primary data collected using the questionnaires, rainfall and temperature data was obtained from the Hydrometeorological Department for the Black Bush Polder area. This data was then analyzed to provide a descriptive data set of the weather and climate variability and climate change for the Black Bush Polder area.

3. Results and Discussion

3.1. Meteorological Data analysis

Meteorological data from the Hydrometeorological Department was used to assess the climate variability within the Black Bush Polder area and establish trends of the overall intensity and variability of temperature and rainfall over a period of forty (40) years.

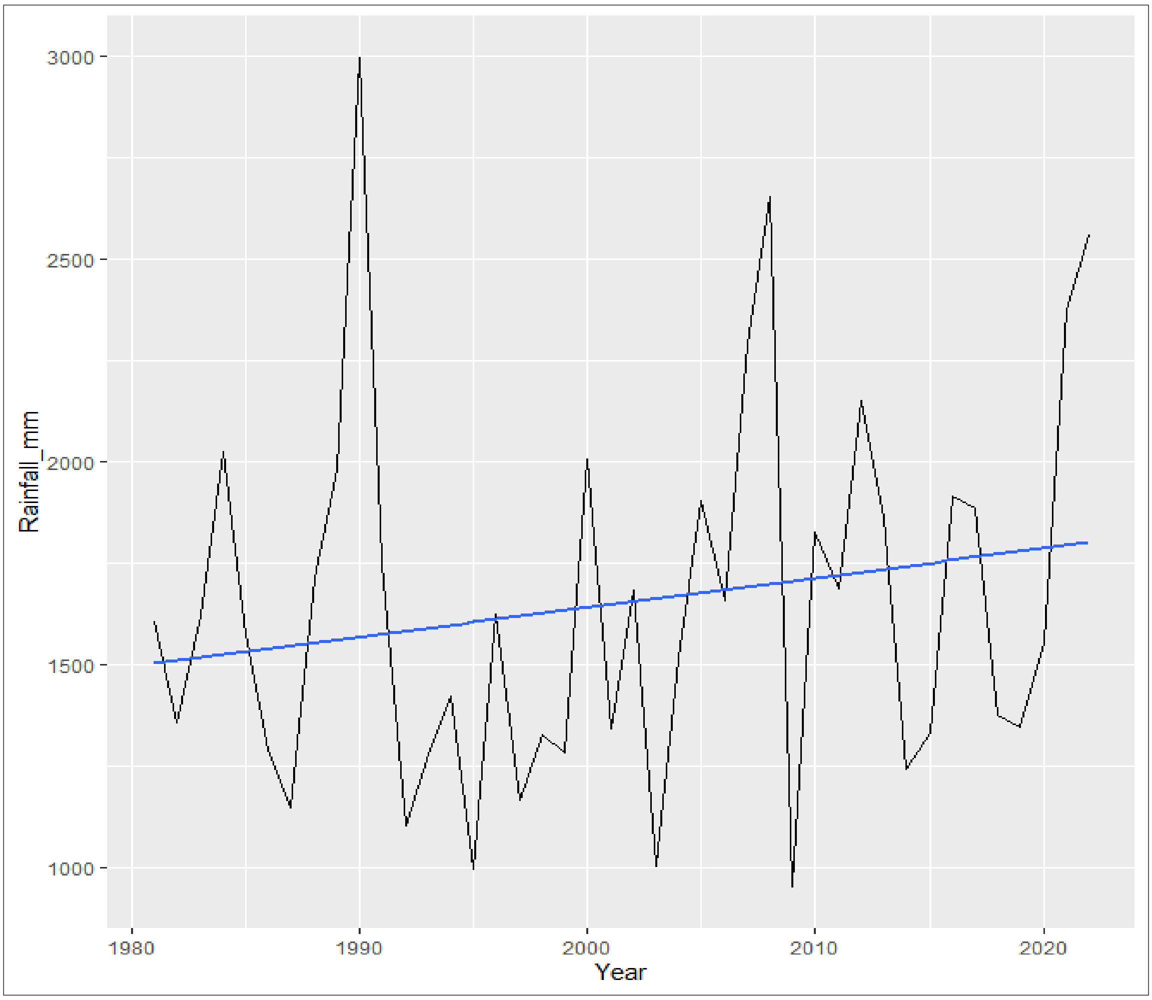

Figure 2 Summary of Annual Rainfall 1980 to 2022

(Chart adapted from Hydrometeorological Department)

The Annual Rainfall graph for the period 1980-2022, (Figure 2), shows a slow but gradual increase in the amount of rainfall. The highest annual rainfall was recorded in the year 2022.

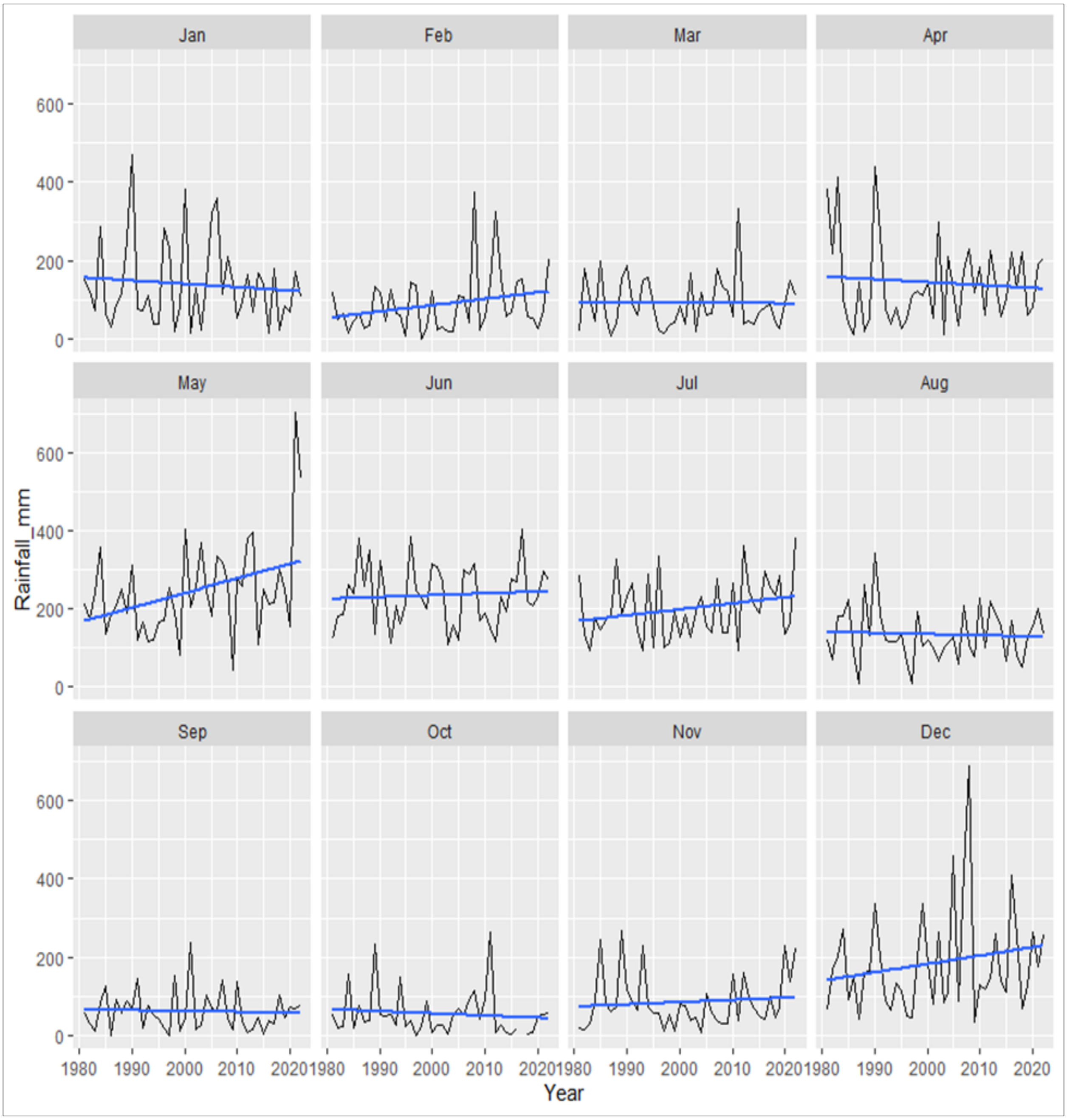

Figure 3 Summary of Average monthly rainfall for the period 1980-2022

(Chart adapted from Hydrometeorological Department)

The analysis that was conducted using data on average monthly rainfall from 1980 to 2022, (Figure 3), reveal that the month of May recorded the highest average rainfall followed by the months of December, June, and July. For the month of May, there was a sharp rise in average rainfall.

The months of September and October recorded the lowest average rainfall. A slow but gradual decrease in rainfall was seen. An increase in the average monthly rainfall were seen for the months of February, May, June, July, November and December. A decrease in average monthly rainfall was seen January, March, April, August, September and October. These findings suggest that there is a fluctuation in the rainfall patterns, exhibiting late onset in some months and early cessation in others. For the annual average rainfall for the period 1980 to 2022, (Figure 2), it was observed that there was a slow but gradual increase in the intensity of rainfall.

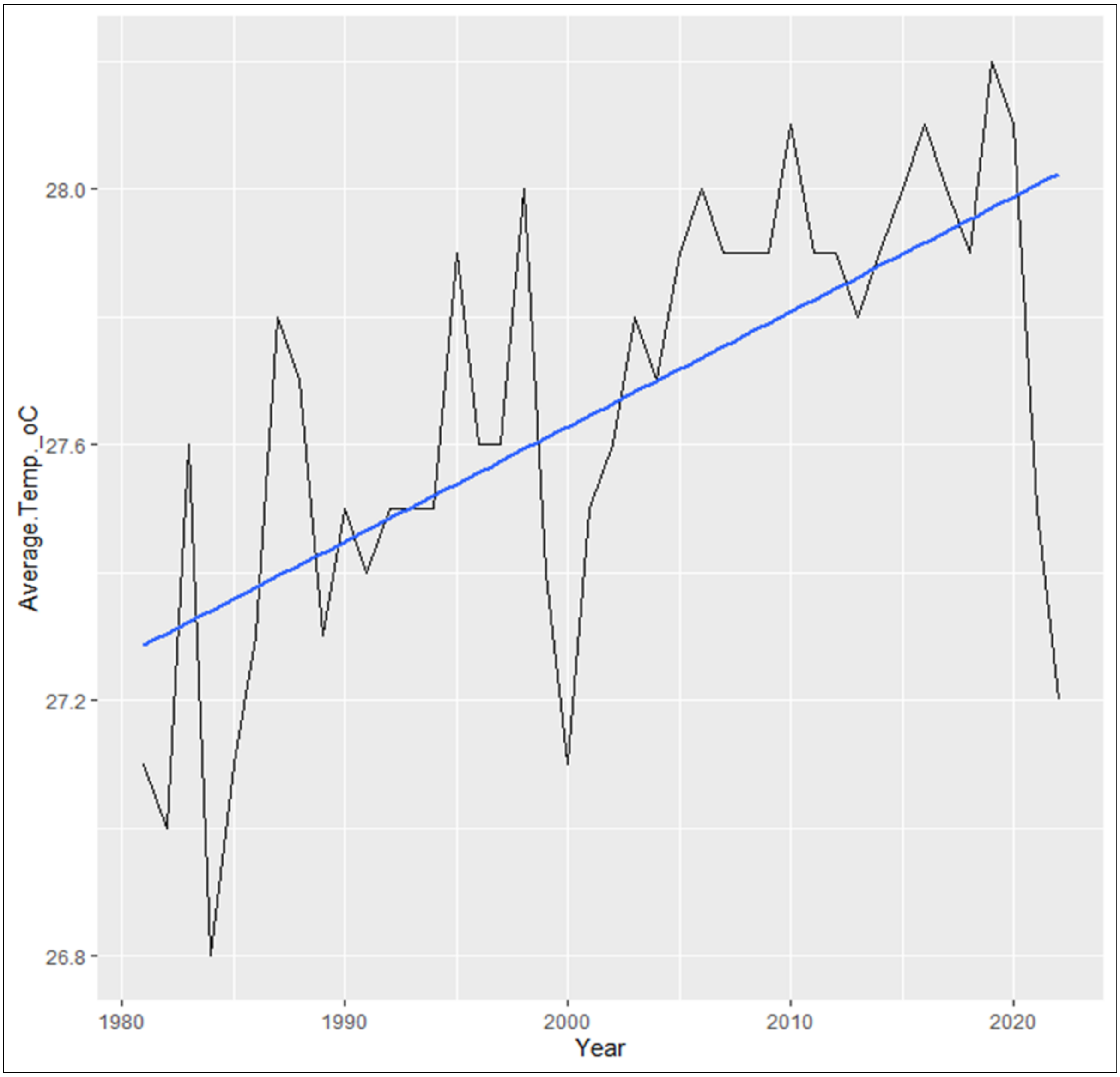

Figure 4 Summary of Annual Average Temperature for the period 1980-2022

(Chart adapted from Hydrometeorological Department)

The Annual Average Temperature graph for the period 1980-2022, (Figure 4), shows the gradual rise in temperature. The highest temperature was recorded in the year 2022. It was observed that there was a sharp and steady increase in temperature surpassing 28^{o}C. These results imply that the temperature is gradually rising.

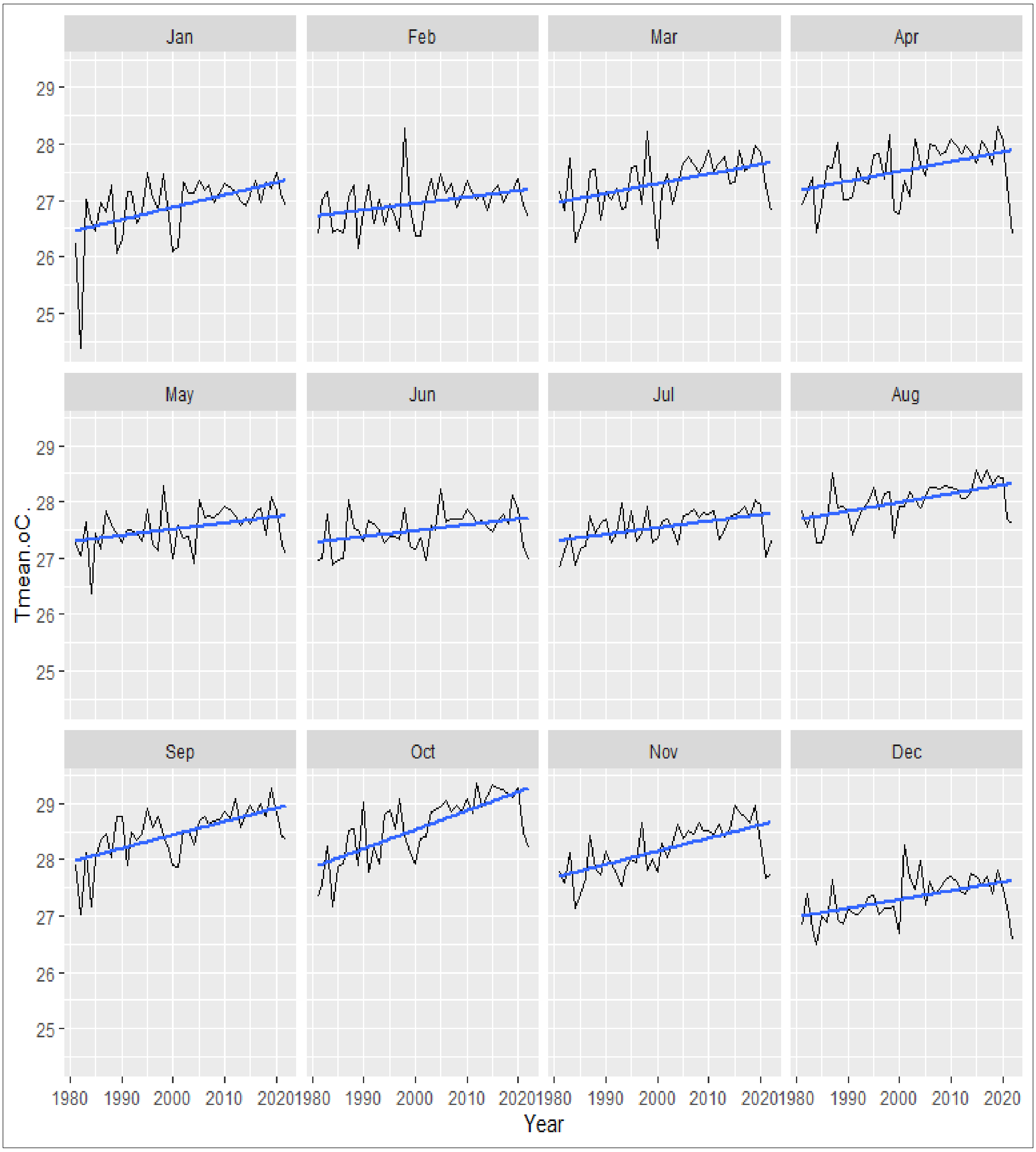

Figure 5 Summary of Average monthly temperature for the period 1980-2020

(Chart adapted from Hydrometeorological Department)

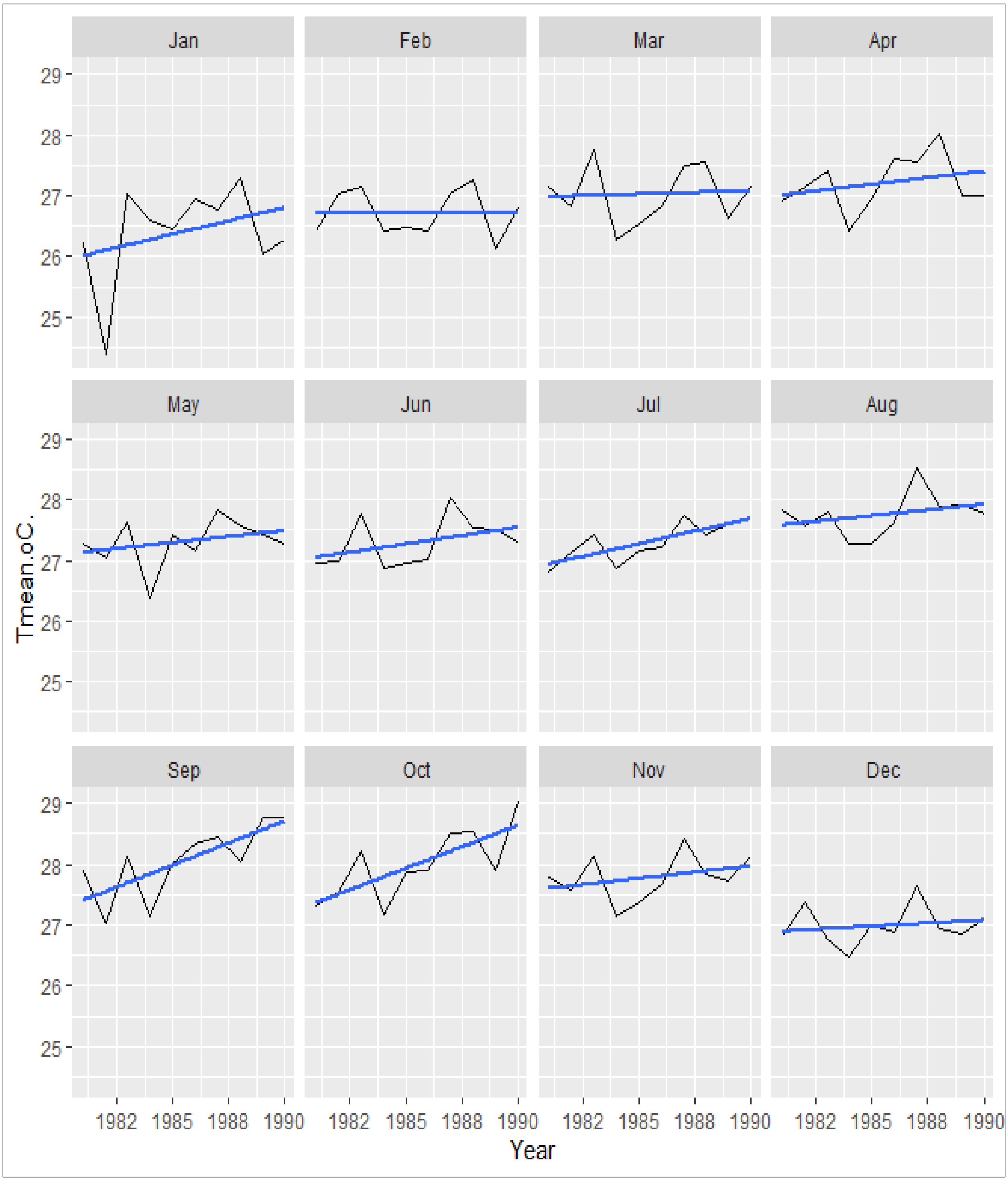

Figure 6 Summary of Average monthly temperature for the period 1980-1990

(Chart adapted from Hydrometeorological Department)

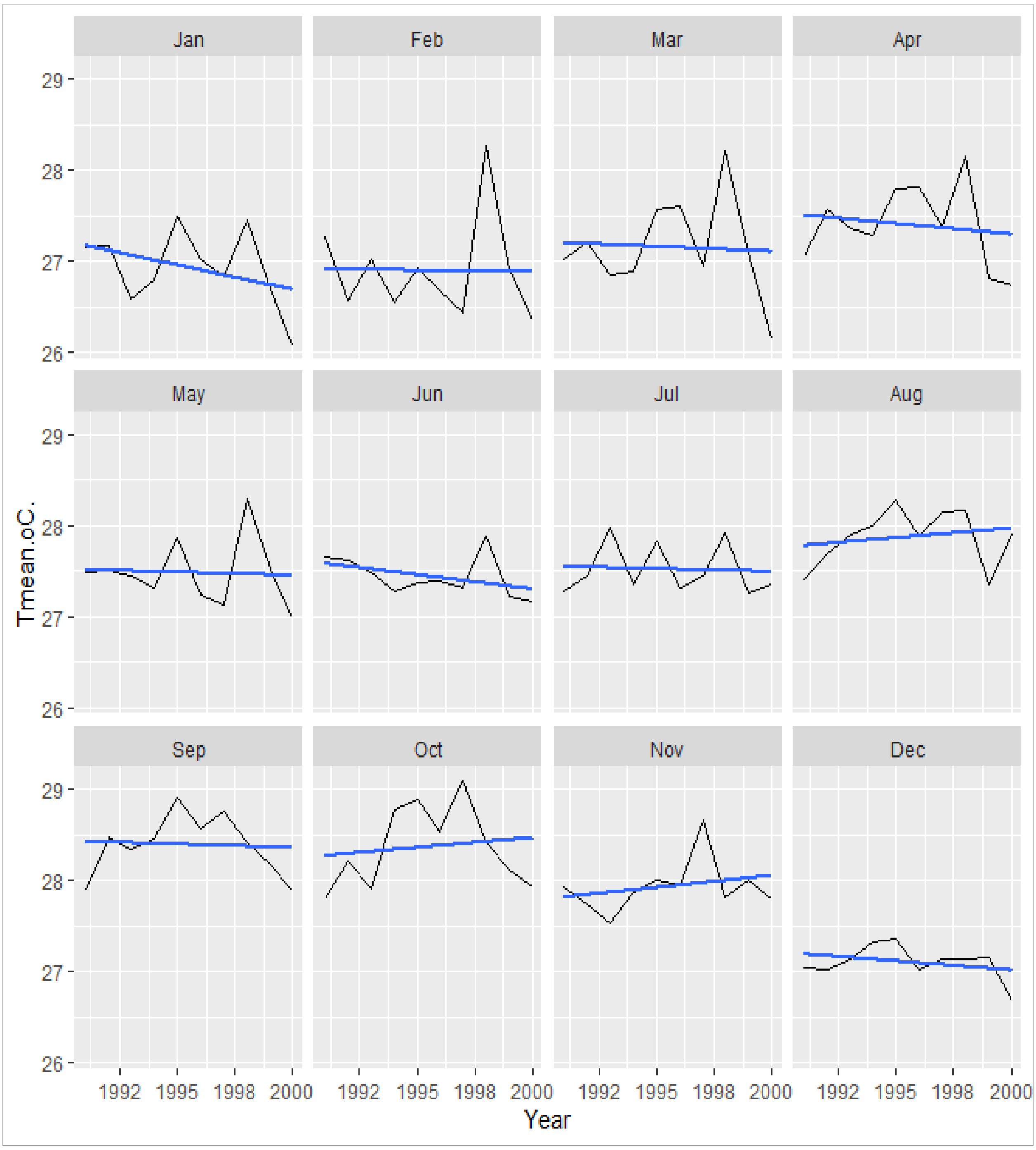

Figure 7 Summary of Average monthly temperature for the period 1990-2001

(Chart adapted from Hydrometeorological Department)

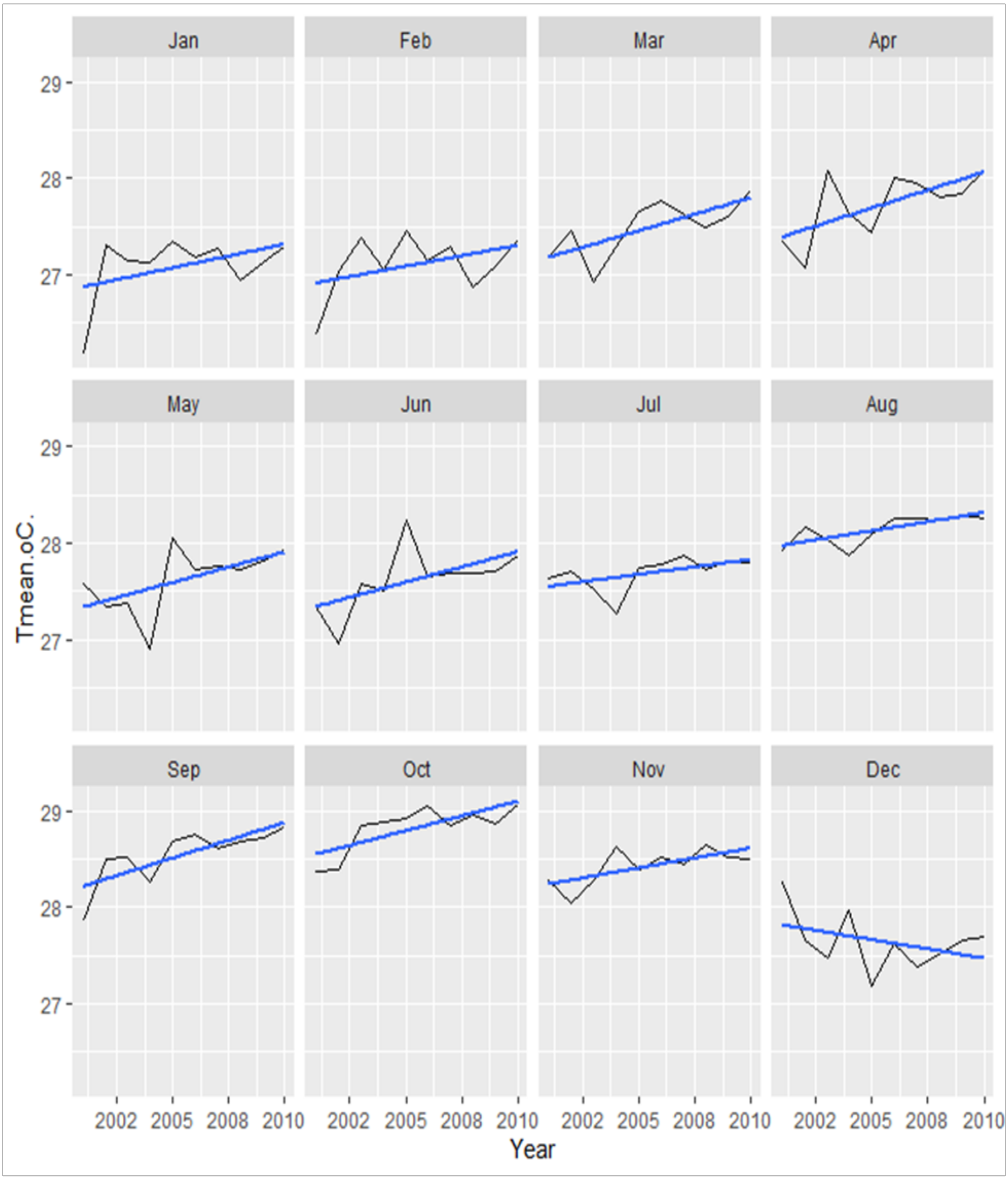

Figure 8 Summary of Average monthly temperature for the period 2001-2010

(Chart adapted from Hydrometeorological Department)

Figure 9 Summary of Average monthly temperature for the period 2021 and 2022

(Chart adapted from Hydrometeorological Department)

The analysis was conducted using data on average monthly temperature from 1980 to 2022. The results of the 10-year moving average 1980-1990, (Figure 6), show that the hottest month was September and October, whilst the month of January recorded the lowest average temperature. For the period 1990-2001, (Figure 7), there was an increase in the average monthly temperature. The period from (September-November) recorded the highest temperatures. For the period 2001-2010, (Figure 8), the results of the 10-year moving average show that the average monthly temperature continued to increase. The months (August, September, October and November) recorded the highest temperatures. For the period (2011-2022), (Figure 9), the average monthly temperature continued to increase. The month of September and October recorded the highest temperature, whilst December was the only month with a decline in temperature.

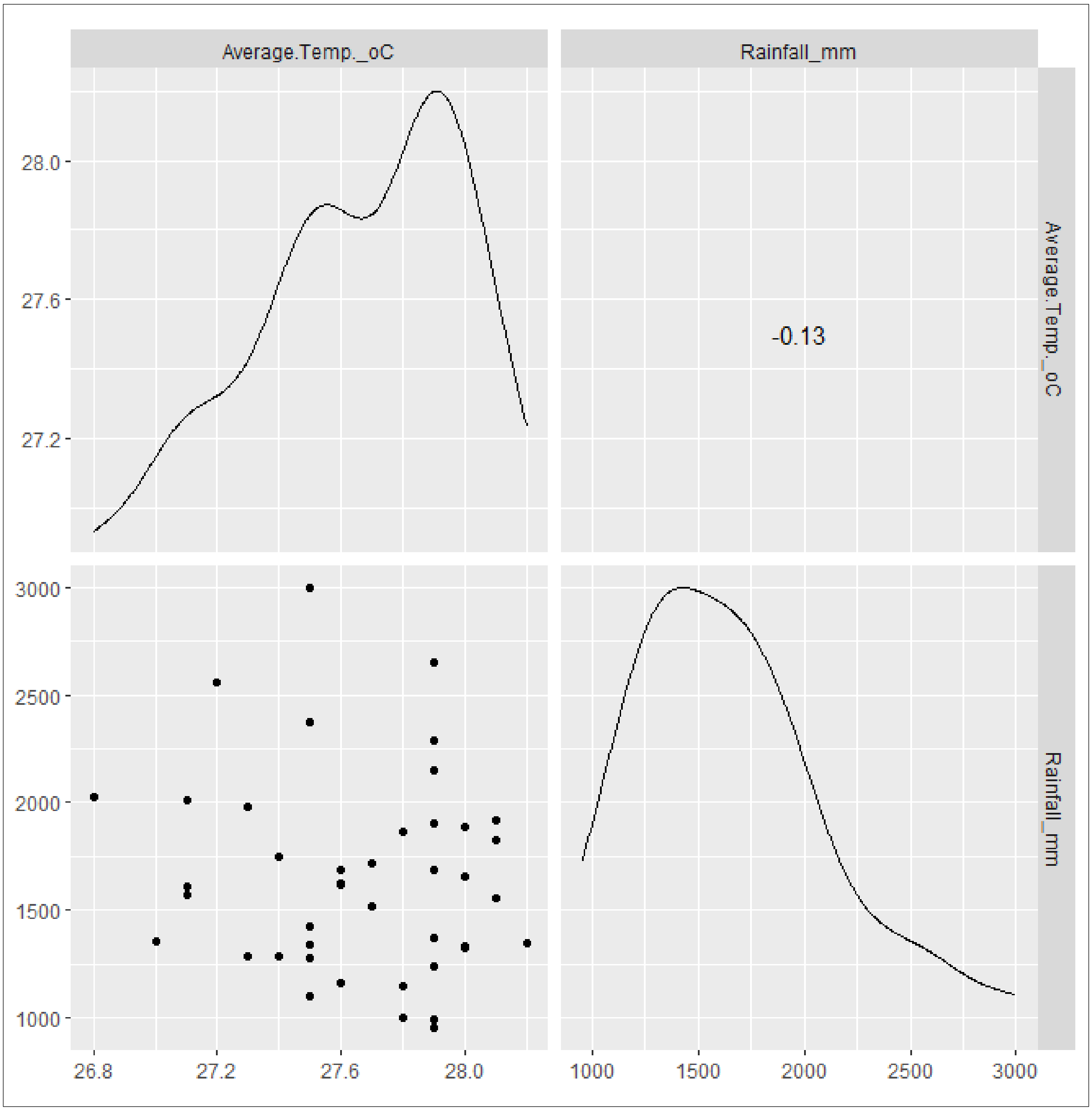

Figure 10 Rainfall distribution for the period 1880-2022

The rainfall distribution graph for the period 1880-2022, (Figure 10), shows the correlation between rainfall and mean temperature. The correlation coefficient between rainfall and mean temperature, as depicted in the scatter plot, is -0.13. Since, the value is below zero, it expresses a negative correlation. This indicated that an increase in one variable reliably predicts a decrease in the other.

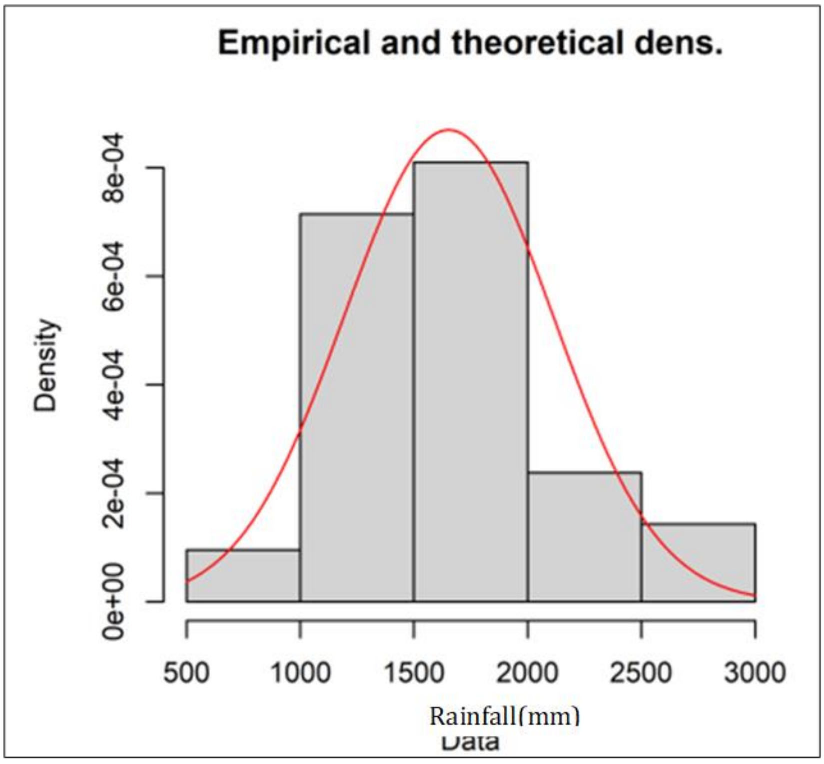

Figure 11 Density distribution of mean rainfall

The density distribution graph of mean rainfall for the period 1880-2022, (Figure 11), shows that the highest recorded rainfall was 3000mm, the average rainfall was 1700mm and the lowest recorded rainfall was 500mm.

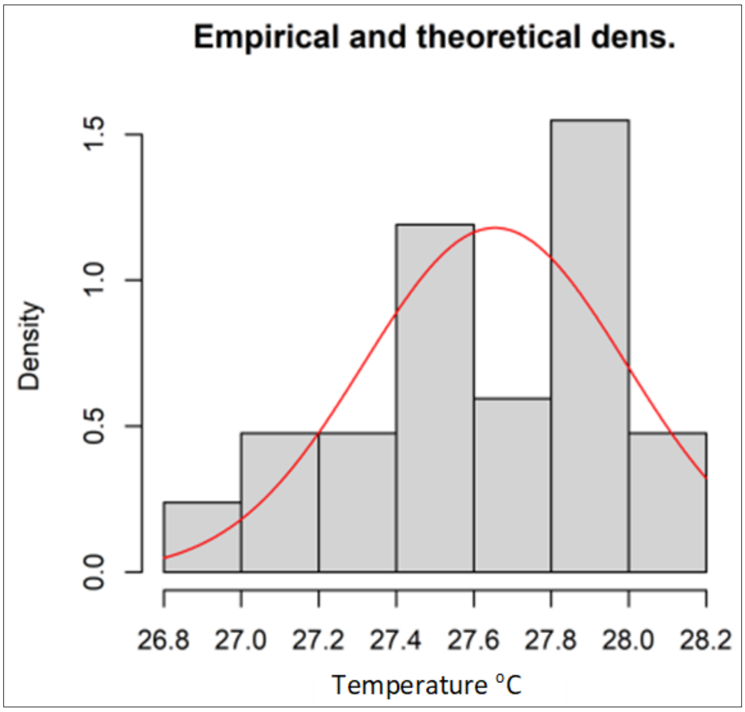

Figure 12 Density distribution of mean temperature

The density distribution graph of mean temperature for the period 1880-2022, (Figure 12), shows that the highest recorded temperature was 28.2^{o}C, the average temperature was 27.7^{o}C, and the lowest recorded rainfall was 26.8^{o}C.

Guyana has an equatorial climate with two dry seasons (January to April and mid-August to mid-November) and two wet seasons (May to mid-August and mid-November to mid-January [5]. Meteorological data obtained from the Hydrometeorological Station for a duration of 42 years (1980-2022) confirmed the findings that the temperature is gradually increasing; surpassing 280^{o}C, and rainfall is becoming more prevalent and irregular with early onset and late cessation.

Similar studies carried out in Ethiopia by Tesfaye & Seifu (2016) revealed that 86% of respondents perceived a change in rainfall while 95% of respondents perceived a change in temperature. According to the study's findings, farmers have gone through protracted dry spells. These results corroborated the findings of Asrat & Simane in 2018 which reveals that farmers' perceptions of climate change are influenced when they would have previously experienced more frequent droughts.

The density distribution graph of mean rainfall for the period 1880-2022, (Figure 11), shows that the highest recorded rainfall was 3000mm, the average rainfall was 1700mm and the lowest recorded rainfall was 500mm. The density distribution graph of mean temperature for the period 1880-2022, (Figure 12), shows that the highest recorded temperature was 28.2^{o}C, the average temperature was 27.7^{o}C, and the lowest recorded rainfall was 26.8^{o}C.

The rainfall distribution for the period 1880-2022 from meteorological data indicates that as the temperature increases, the amount of rainfall decreases. The correlation coefficient between rainfall and mean temperature, as depicted in the scatter plot, (Figure 10), is -0.13. Since, the value is below zero, it expresses a negative correlation. This indicated that an increase in one variable reliably predicts a decrease in the other.

3.2. Questionnaire data analysis

Table 1 Overview of farming and demographic traits

Variables	**Percentage**
Duration of Farming experience in years	
1-5	6
6-10	14
11-15	24
16-20	22
>20	34
Level of education	
Primary	32
Secondary	16
Tertiary	4
Others	48
Major Cash crops cultivated	
Pepper (Sweet & hot varieties)	14
Tomato	14
Pumpkin	4
Bora	12
Boulanger (Egg plant)	16
Squash	4

Leafy vegetables (Cabbage, lettuce, poi	8
Okra	10
Cassava	4
Seasonings (Shallot, celery, thyme)	8
Legumes (Pigeon peas, red beans, blackeye beans)	6
Major Crops affected by Climate Change	
Tomatoes	30
Leafy vegetables (cabbage, lettuce, poi)	26
Pepper (Sweet & hot varieties)	20
Boulanger	16
Squash	8

Table 1 presents the demographic characteristics of the farmers in Black Bush Polder that were studied. Eighty – percent (80%) of the farmers were males and 20% of the farmers were females. The farmers had varied years of farming experiences ranging between 1-5 years (six percent-6%); 6-10 years (fourteen percent-14%); 11-15 years (twenty-four percent-24%); 16-20 years (twenty-two percent-22%) and >20 years (thirty-four percent-34%).

Primary education is the highest level of education held by thirty-two percent (32%) of farmers, followed by secondary education in sixteen percent (16%) of cases, tertiary education in four percent (4%) of cases, and no education in forty-eight percent (48%) of cases.

The major cash crops cultivated by the farmers are peppers; including both hot and sweet varieties wiri-wiri peppers (*Capsicum frutescens*), ball-of-fire (*Capsicum chinense*) and sweet peppers (*Capsicum annuum*) accounting for fourteen percent (*14%*); tomatoes for fourteen percent (*14%*); pumpkin for four percent (*4%*); bora for twelve percent (*12%*); boulanger for sixteen percent (*16%*); squash for four percent (*4%*); cabbage and lettuce for eight percent (*8%*); okra for ten percent (*10%*); cassava for four percent (*4%*); seasonings for eight percent (*8%*); and legumes (pigeon peas, red beans and blackeye beans) accounting for six percent (*6%*).

Most farmers cultivated boulanger, followed by peppers (both sweet and hot varieties), tomatoes and bora. The least number of farmers cultivated cassava, squash and pumpkin. The crops which are most affected by the changing weather patterns as a result of climate change are tomatoes (thirty percent-30%), Leafy vegetables-cabbage, lettuce, poi (twenty-six percent-26%), Pepper-Sweet & hot varieties (twenty percent-20%), Boulanger (sixteen percent-16%), and Squash (eight percent-8%).

The largest percentage of farmers who participated in the study had greater than twenty (20) years of farming experience. Almost half of the farmers, accounting to forty-eight percent (48%) had no form of education. However, those farmers who had education, mainly received the Primary level of education, followed by the Secondary level, and finally a very small percentage received Tertiary education. Choice of adaptation strategy depends on farmers' ability to access, realize and interpret climate information to make essential decisions that are directly related to farmers' education level. The outcome is consistent with earlier research [2].

Nineteen major crops were cultivated by the farmers. The major crops are: pepper (sweet and hot varieties), tomato, pumpkin, bora, boulanger, squash, leafy vegetables (cabbage, lettuce and poi), okra, cassava, seasonings (shallot, celery, thyme), and legumes (pigeon peas, red beans, blackeye beans). A large percentage of the farmers cultivated boulanger, tomatoes and pepper. The smallest percentage of farmers cultivated squash and pumpkin. The major crops affected by climate change are tomatoes, leafy vegetables (cabbage, lettuce, poi), pepper (sweet and hot varieties), boulanger and squash. Tomatoes and leafy vegetables were the crops that were most susceptible to the effects of climate change.

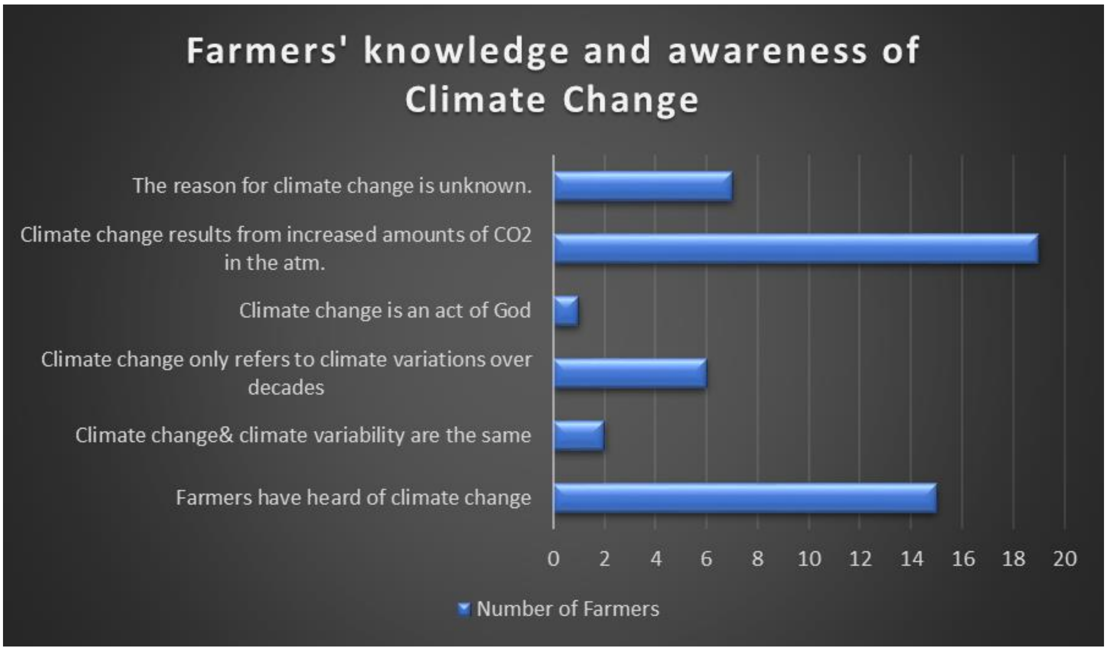

Figure 13 Farmers' knowledge and awareness of Climate Change

Figure 13, shows farmers' knowledge and awareness of climate change. Most of the farmers (accounting for thirty-eight percent-38%) indicated that climate change results from increased amounts of CO_2 in the atmosphere, whilst one (1) farmer indicated that Climate Change is an act of God. Six (6) farmers indicated that climate change only refers to climate variations over decades, two (2) farmers said that climate change and climate variability are the same, seven (7) indicated that the reason for climate change is unknown, and fifteen (15) farmers have never heard of climate change.

Table 2 Major perceptions, and insights from questionnaires

Perception investigated	**Years of farming experience**		
Perceived climate changes (%)	A (1 – 10 Yrs)	B (11 – 20 Yrs)	C (>20 Years)
Recent alterations in rainfall onset	20%	28%	52%
Precipitation fluctuations in the early and late growing seasons	27%	32%	41%
Extended dry spell	24%	45%	31%
Recent temperature increase	31%	35%	34%

Table 2 summarizes farmers' perceptions of climate change based on frequent observations and the length of their farming careers. The majority of the farmers, with greater years of farming experience noted recent changes in the timing of rainfall (fifty-two percent-52%, category C), fluctuations in the amount of precipitation during the early and late growing seasons (forty-one percent-41%, category C), extended dry spell (thirty-one percent-31%, category B), and a recent rise in temperature (thirty-five percent-35%, category B).

The majority of farmers perceived that the climate change is responsible for the negative effects they experienced. Some perceptions of farmers that is evident that climate change is happening are: recent alterations in rainfall onset, precipitation fluctuations in the early and late growing seasons, extended dry spell, and recent temperature increase.

Table 3 Impacts of climate change experienced by farmers

Impacts	%
Crop failure due to water shortages/increased temperature	22
Loss of crops during flooding	28
More pests and diseases attack the crops	10
Financial losses experienced due to impacts of climate change	18
The price of produce had decreased	6
The price of produce has increased	16

Table 3 shows the impacts of climate change experienced by farmers. The majority of the farmers, (twenty-eight percent-28%), indicated that they are greatly impacted due the loss of crops by flooding, followed by crop failure due to water shortages/increased temperature (twenty-two percent-22%), financial losses amounting to eighteen percent (18%) increase in the price of crops (16%), increase in pests and diseases (ten percent-10%), and the least impact being a reduction in the price of crops grown.

The largest percentage of farmers in Black Bush Polder, amounting to twenty-eight percent (28%) experienced loss of crops during flooding, crop failure due to water shortages/ increased temperature and financial losses due to the impacts if climate change. Other farmers experienced increased in price of crops, increased prevalence of pests and diseases, and a decreased price of crops.

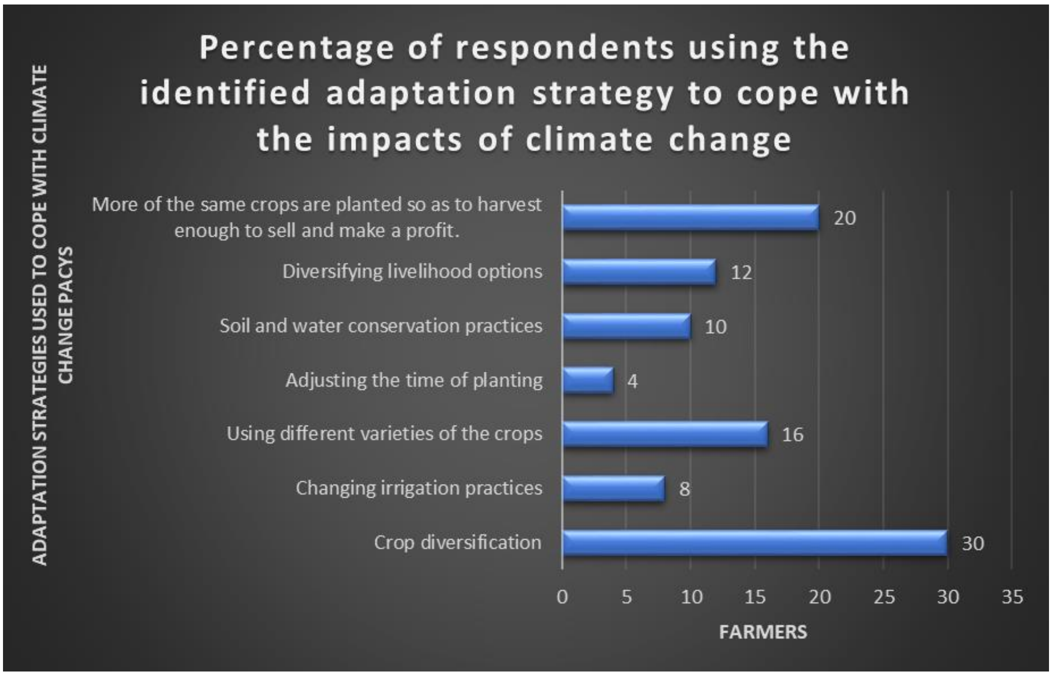

Figure 14 Adaptation strategies used in coping with the impacts of climate change

Figure 14, shows the adaptation strategies used in coping with the impacts of climate change. Thirty percent (30%) of the farmers diversified their crops as a means of combatting the effects faced, sixteen percent (16%) of the farmers planted different varieties of the same crops, whilst twenty percent (20%) of the farmers planted the same crops, but increased the quantity that they planted with aim of having enough to sell, make a profit and improve their livelihood. Twelve percent (12%) of the farmers diversified their livelihood options with the intention of earning more income, ten percent (10%) adjusted their soil and water conservation practices, whilst eight percent (8%) changed their irrigation practices, and four percent (4%) adjusted their planting time with the aim of having a greater yield.

Farmers residing in Black Bush Polder implemented different climate change adaptation strategies. Thirty percent (30%) of the farmers adopted the strategy of crop diversification. This high percentage was because the farmers had reduced yield, damage to crops, and increased prevalence pest and diseases, increased temperature, and early onset and late cessation. Some farmers, however, chose to plant the same crops; but at a larger scale with the aim of harvesting a greater yield. Other farmers were forced to use improved crop varieties-early maturing and drought-resistant., whilst other chose diversify their livelihood options so as to earn additional income.

On the other hand, the result indicated that only a few farmers chose to use small-scale irrigation, soil and water conservation practices, and adjusting their time of planting, as an adaptation strategy compared to other adaptation strategies. The findings of [8] are supported by the findings of this study, which attested that the use of required and recommended types of fertilizer, variation in planting dates, and changing crop varieties were the primary adaptation strategies used by cotton farmers.

A study done by Ledger, NARI and Mc Gill University in 2012 found that drip irrigation systems with holes that are positioned directly on the roots of plants aided in water conservation, and time conservation. Additionally, plastic mulch (preferably white) also significantly reduced the number of weeds, and the prevalence of pest and diseases. More specifically, techniques for preparing crop beds as well as the use of shade houses and greenhouses helped to lessen the effects of climate change.

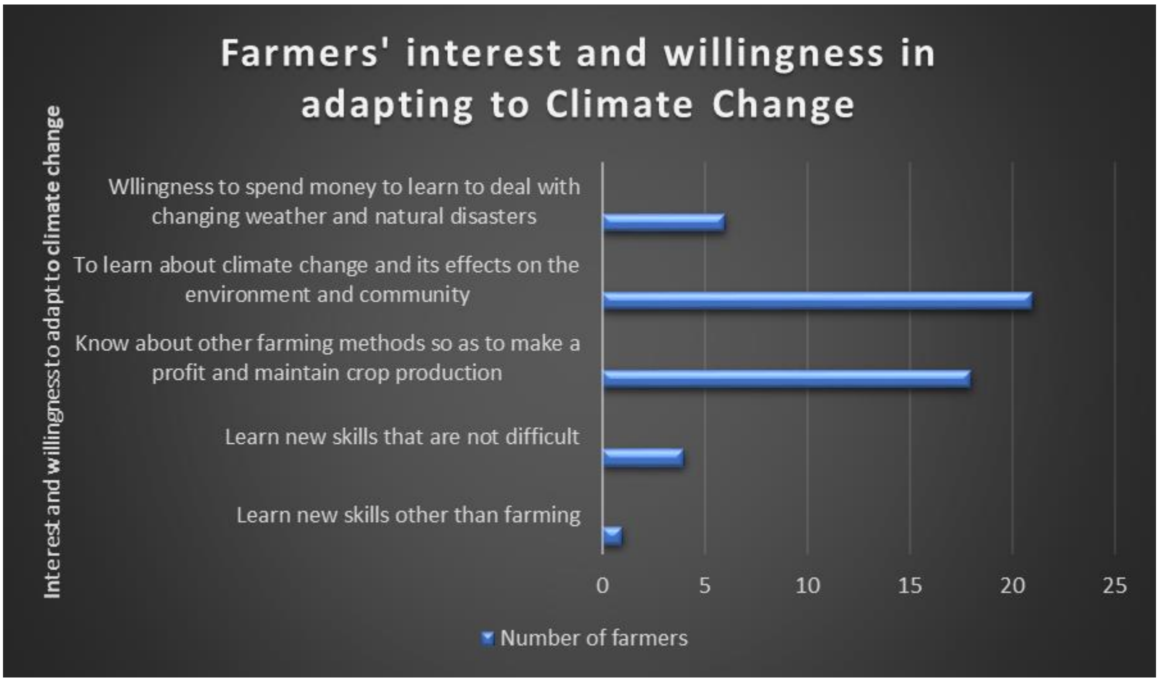

Figure 15 Farmers' interest and willingness in adapting to Climate Change

Figure 15, shows farmers' interest and willingness in adapting to Climate Change. Majority of the farmers indicated that they are willing to learn about climate change and its effects on the environment and the community. Eighteen (18) farmers indicated a willingness to familiarize themselves with other farming methods to as to make a profit and maintain their yield. Six (6) farmers indicated a willingness to expend extra money so as to deal with the changing weather, four (4) farmers wanted to learn new skills that are not difficult and one percent (1%) indicated a willingness to learn skills other than farming.

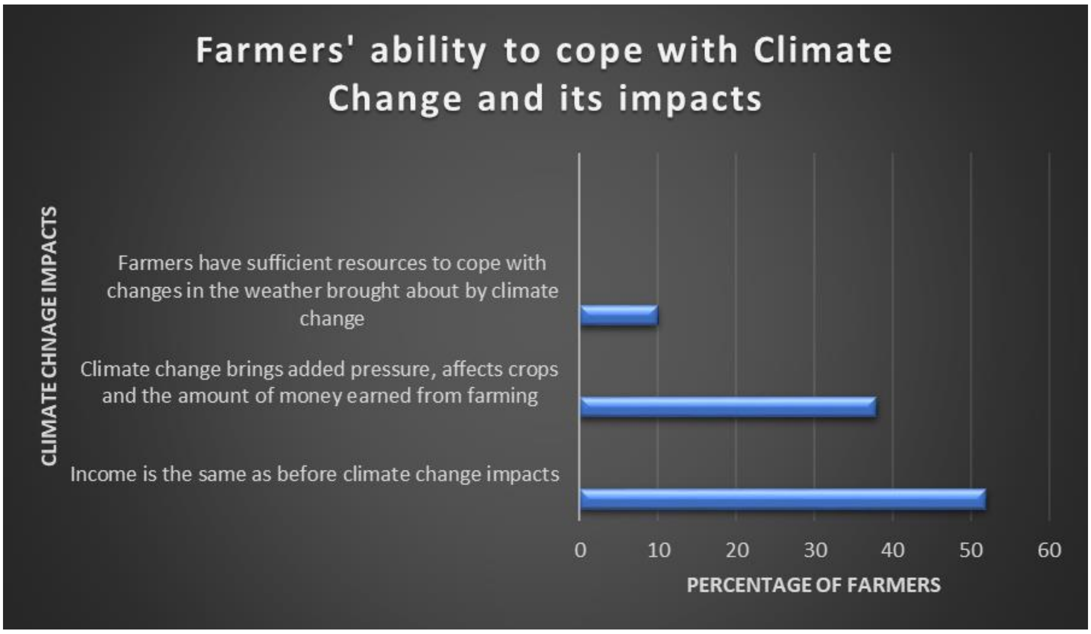

Figure 16 Farmers' ability to cope with climate change and its impacts

Figure 16, shows farmers' ability to cope with Climate Change and its impacts. Fifty-two (52%) of the respondents indicated that climate change adds pressure, affects crops and the amount of the money earned from farming, thirty-eight percent (38%) of the farmers said that the income that they earned is the as before climate change impacts and ten percent (10%) of the farmers indicated that they have sufficient resources cope with the changes in the weather patterns.

The major challenge perceived by farmers in applying climate change adaptation measures is lack of money and access to credit facilities. Other challenges faced by farmers are lack of relevant skill/ qualification, lack of information, lack of interest, and no available off-farm jobs. Farmers will be more aware of adaptation strategies after receiving training about climate change, its effects, and potential solutions [7]. This could be the possible explanation for a possible correlation between changing planting dates and taking part in climate change training. The outcome confirms what Ajao *et al*. (2011) and Seid (2018) found. Additionally, the study by Legesse *et al*. (2012) found that the lack of climate training programs makes it more difficult for people to adopt adaptation strategies. Seventy-six percent (76%) of the farmers' most needed services/ support for climate change adaptation is access to credit facilities. Other farmers most needed services are: improved crops, seeds/ varieties, climate information, alternative income earning opportunities, and agricultural extension services. The findings imply that expanding access to agricultural extension services can assist farmers in utilizing a variety of adaptation tactics. The current conclusion is in line with those of Atinkut & Mebrat (2016) and Bryan *et al*. (2013), but it is in direct opposition to those of Tazeze *et al*. (2012), who claimed that access to extension services lowers the likelihood of adopting crop diversification adaptation strategies.

Table 4 Support received by farmers from the Government to cope with the impacts of climate change

Support from the Government to cope with the impacts of climate change	**Percentage of Farmers**
The Government has provided me with financial support to offset the impact of climate change	80%
The Government has held meetings and introduced programs and activities to update farmers on climate change and the impacts of climate change	48%
The Government has not provided any form of support to offset the impact of climate change.	0%
The Government has been helpful in assisting farmers to adapt to the impacts of climate change.	44%
Extension agriculture workers have visited my farm to give advice on adaptation measures I can put in place.	26%

Table 4 shows the support received by farmers from the Government to cope with the impacts of climate change. Eighty percent (80%) of the farmers indicated that the Government has provided them with financial support to offset the impact of climate change, forty-eight percent (48%) indicated that the government has held meetings and introduced programs and activities to update farmers on climate change and its impacts, twenty-six percent (26%) of farmers have had Extension agriculture workers visit their farm to give advice on adaptation measures they can employ to counteract the climate impacts, and forty-four percent (44%) have indicated that the Government has been helpful in assisting farmers to adapt to the impacts of climate change.

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Globally, extension is a crucial pillar of agricultural development. The extension and outreach systems in the majority of developing countries remain weak and are frequently damaged, underfunded, and disconnected from research and education systems despite significant investments made over the past few decades to strengthen agricultural research, extension, and advisory services. However, they are not effectively reaching farmers and end users to produce the desired impacts [4].

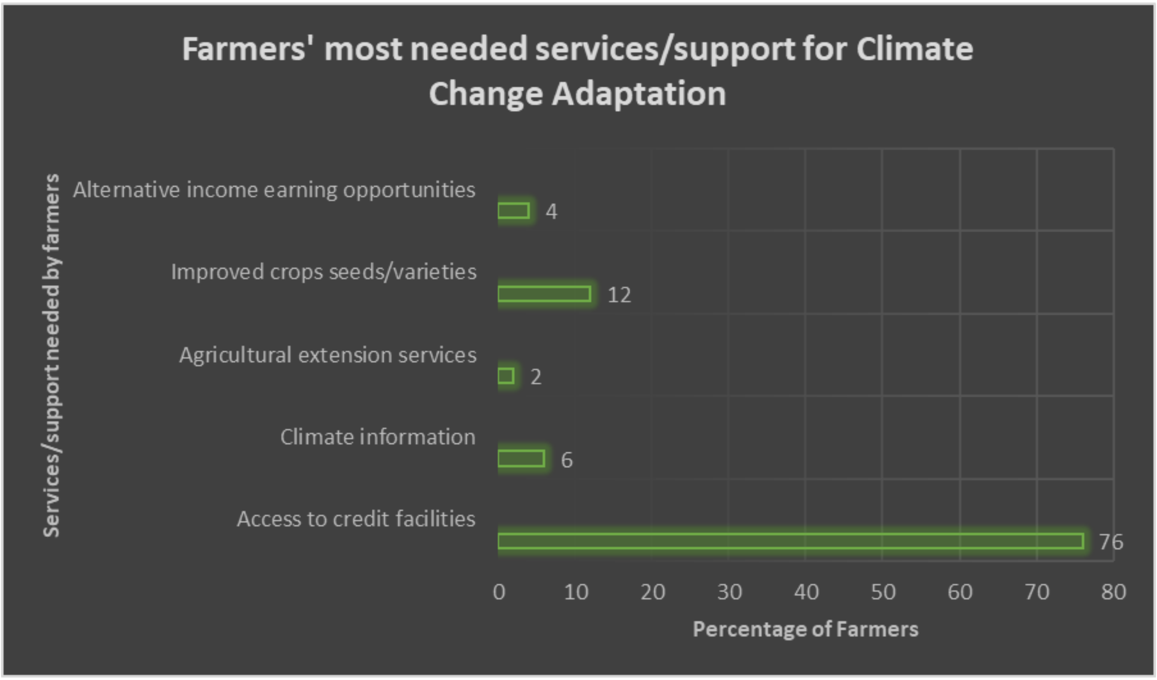

Figure 17 Farmers' most needed services/support for Climate Change adaptation

Figure 17, shows farmers' most needed services/support for Climate Change Adaptation. Approximately three-quarter (¾) of the respondents indicated that they need access to credit facilities to mitigate the effects of climate change, twelve percent (12%) said that they needed improved crop seeds/ varieties, six percent (6%) said that they needed climate information, four percent (4%) indicated the need for other opportunities for earning money, and two percent (2%) indicated the need for Agricultural extension services.

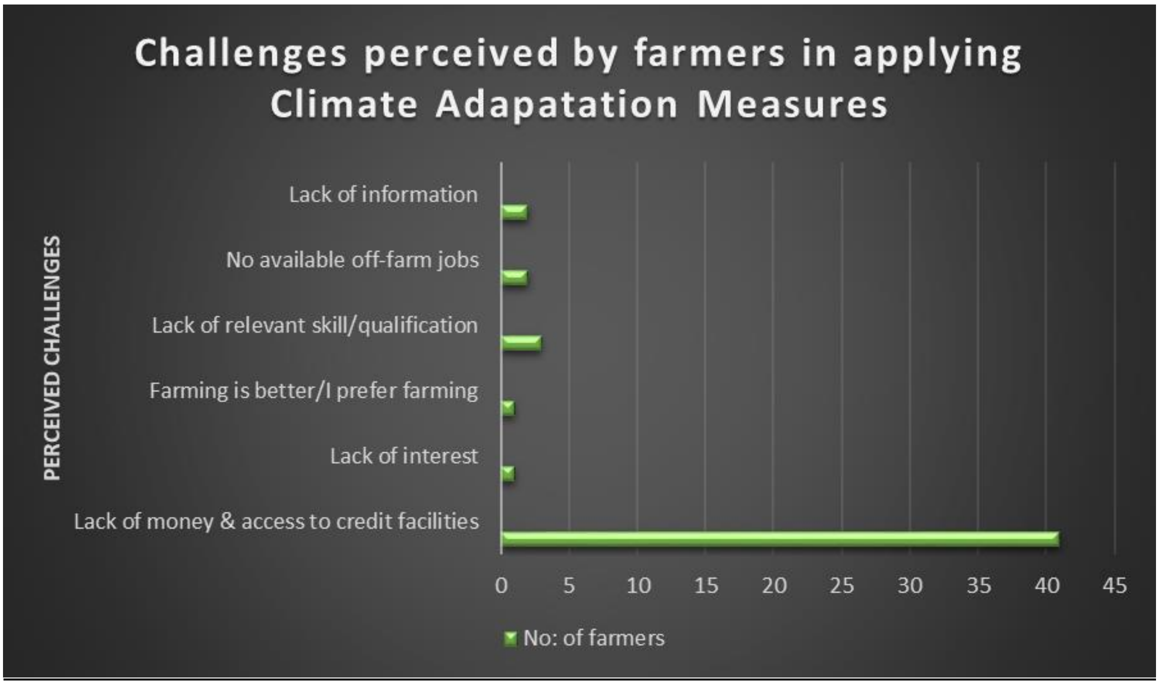

Figure 18 Challenges perceived by farmers in Appling Climate Adaptation Measures

Figure 18, shows challenges perceived by farmers in applying Climate Adaptation Measures. Forty-one (41) of fifty (50) farmers indicated that they lack money and access to credit facilities, three (3) farmers said that they lack relevant skills/ qualification, two (2) farmers each indicated that they have no-available off-farm jobs, and lack information, whilst one (1) farmer each indicated that they prefer farming and that they lack interest.

4. Conclusions

Adaptation to climate change is a two-step process which requires that farmers first perceive climate change and then respond to the changes in the second step (Asrar, 2018). This study explored "Cash crop farmers' perceptions of, and adaptation to climate change in Black Bush Polder, Lower Corentyne, Guyana." It is evidenced by the insights gained from the study that the climate has indeed changed, and is continuing to change. Meteorological data has confirmed that the temperature is increasing, surpassing 28^{o}C, and rainfall is becoming more irregular, with late onset and early cessation. Data collected from questionnaires also confirms that the climate is indeed changing. Hence, the perceptions adopted by the farmers in the study that the climate is gradually changing, is confirmed. Nineteen (19) major crops were cultivated by the farmers. A large percentage of the farmers cultivated boulanger, tomatoes and pepper. The results revealed tomatoes and leafy vegetables were the crops that were most susceptible to the effects of climate change. Additionally, the majority of the farmers reported a decreased yield in crops at the time of harvest. Due to the many impacts faced because of climate change, farmers were forced to implement adaptation strategies to counteract the effects. Some adaptations measures employed were crop diversification, replanting the same crops at a larger scale, using improved crop varieties, diversifying their livelihood options, using small-scale irrigation, soil and water conservation practices, and adjusting their time of planting. The results of this study indicated that limited experience, lack of access to information on climate change, a low level of education, lack of interest, lack of relevant skill/ qualification, and no available off-farm jobs influenced the perception and adaptation decisions of farmers in the Black Bush Polder area. Hence, facilitating effective and reliable access to information and improving farmers' awareness of potential benefits of adaptation would be important policy intervention measures. Additionally, policies should work to encourage farm-level adaptation by ensuring that farmers effectively contribute to the development and implementation of pertinent adaptation strategies.

Recommendations

Based on the preliminary study conducted, the following recommendations are made:

Agricultural Extension Officers, National Agricultural Research and Extension Institute (NARI), the Environmental Protection Agency (EPA) and other climate related agencies should be involved in the study so that they would be knowledgeable on the issues the farmers encounter, and can take steps to remedy the effects.

Additionally, if further work is to be done on this preliminary study; a larger sample size should be used. This will give a better, more accurate representation of the perceptions, effects and adaptation strategy of the given population. Future studies should focus on the need for soil and water testing to optimize farm inputs in the agricultural lands in Black Bush Polder Region 6, Guyana.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors hereby declare that this manuscript does not have any conflict of interest.

Statement of informed consent

All authors declare that informed consent was obtained from all individual participants included in the study.

References

[1] Asrat & Simane. (2018). Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. https://ecologicalprocesses.springeropen.com/articles/10.1186/s13717-018-0118-8#ci.

[2] Belay, A.; Recha, J. W.; Woldeamanue, T. & Morton, J. F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agric & Food Secur (2017) 6:24. DOI 10.1186/s40066-017-0100-1.

[3] Bristol, M. (2019). How Guyana fights climate change. https://www.ndcs.undp.org/content/ndc-support-programme/en/home/impact-and-learning/ideas-and-insights/20190/how-guyana-fights-climate-.

[4] Buehren, N., Goldstein, M., Molina, E. & Vaillant, J. (2017). The impact of strengthening agricultural extension services evidence from Ethiopia (Policy Research Working Paper 8169). https://bit.ly/2K870M4.

[5] Bynoe, P. (2009). Impact of Climate in Guyana. https://www.undp.org/sites/g/files/zskgke326/files/migration/latinamerica/UNDP_RBLAC_ImpactofClimateChangeGuyana.pdf.

[6] Climate Smart Agricultural Practices. (2023). Climate Smart Agriculture: Practices And Their Adoption. https://eos.com/blog/climate-smart-agriculture/.

[7] Diallo, A.; Donkor, E. & Owusu, V. (2020). Climate change adaptation strategies, productivity and sustainable food security in southern Mali. Climatic Change 159(3). DOI: 10.1007/s10584-020-02684-8.

[8] Dilshad & Muhammad. (2020). Climate change adaptation impact on cash crop productivity and income in Punjab province of Pakistan. https://pubmed.ncbi.nlm.nih.gov/32474785/.

[9] Eakin, H.; Lemos, M. C. & Nelson, D. (2014). Differentiating capacities as a means to sustainable adaptation. Global Environmental Change 27(1):1–8. DOI: 10.1016/j.gloenvcha.2014.04.013.

[10] Food and Agriculture Organization [FAO]. (2008). Climate Change, Water and Food Security. https://www.fao.org/3/i2096e/i2096e.pdf.

[11] Government of Guyana. (2002). Guyana: Initial National Communication in Response to its Commitments to the UNFCCC. http://hydromet.gov.gy/.

[12] Guyana National Climate Unit. (2008). Support initiatives that strengthen Guyana's capacity to address Climate Change [Brochure].

[13] Hawkins, E. (2022). What You Need to Know About Food Security and Climate Change. https://www.worldbank.org/en/news/feature/2022/10/17/what-you-need-to-know-about-food-security-and-climate-.

[14] Hugh, M. (2022). For Farmers in Guyana, climate change means loss of funds. https://climatetracker.org/for-farmers-in-guyana-climate-change-means-loss-of-funds/.

[15] Intergovernmental Panel on Climate Change [IPCC]. (2007). Climate Change 2007 Impacts, Adaptation and Vulnerability. https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf.

[16] Intergovernmental Panel on Climate Change [IPCC]. (2008).4th Assessment Reports on Climate Change 2008. www.ipcc.ch.

[17] Intergovernmental Panel on Climate Change [IPCC]. (2014). AR5 Synthesis Report: Climate Change 2014. https://www.ipcc.ch/report/ar5/syr/.

[18] Ivanchuk, N, (2020). Climate Change and Agriculture: Adaptation Tips. https://eos.com/blog/climate-change-and-agriculture/.

[19] Maizland, L. (2021). China's Fight against Climate Change and Environmental Degradation. Council on Foreign Relations. https://www.cfr.org/backgrounder/china-climate-change-policies-environmental-degradation.

[20] Makuvaro, V.; Walker, S.; Masere, T. P. & Dimes, J. (2018). Smallholder farmer perceived effects of climate change on agricultural productivity and adaptation strategies. Journal of Arid Environments 152. DOI: 10.1016/j.jaridenv.2018.01.016.

[21] NASA. (2023). Global Warming vs. Climate Change. https://climate.nasa.gov/global-warming-vs-climate-change/.

[22] Nullis, C. (2022). Eight warmest years on record witness upsurge in climate change impacts. https://public.wmo.int/en/media/press-release/eight-warmest-years-record-witness-upsurge-climate-change-impacts.

[23] Porter, J. *et al*. (2014). Food security and food production systems. https://www.google.com/search?q=et+al+in+referncing&sxsrf=AJOqlzXdkJ1Vh_Vvu7N7n8ORx5NlAu571w%3A1675354987437&ei=a-PbY6WvGu-IwbkPmvyT-Ao&ved=0ahUKEwjlkJjXn_f8AhVvRDABHRr.

[24] Raja, A. *et al*. (2016). A Statistical Survey of Knowledge, Attitude and Practice of Cash Crop Farmers in Black Bush Polder Region of Guyana. https://www.researchgate.net/publication/296477569_A_Statistical_Survey_of_Knowledge_Attitude_and_Practice_of_Cash_Crop_Farmers_in_Black_Bush_Polder_Region_of_Guyana.

[25] Simelton, E.; Quinn, C. H.; Batisani, N.; Dougill, A. J.; Dyer, J. C.; Fraser, E. D. G.; Mkwambisi, D.; Sallu, S. & Stringer, L. C. (2013). Is rainfall really changing? Farmers' perceptions, meteorological data, and policy implications, Climate and Development, 5:2, 123-138. DOI: 10.1080/17565529.2012.751893.

[26] Shah, K. (2019). National Climate Change Policy and Action Plan 2020-2030 draft 2.0. https://climatechange.gov.gy/en/index.php/resources/documents/50-draft-national-climate-change-policy-and-action-plan-2020-2030/file.

[27] Tesfaye, W. & Seifu, L. (2016). Climate change perception and choice of adaptation strategies: Empirical evidence from smallholder farmers in east Ethiopia. International Journal of Climate Change Strategies and Management, Vol. 8 Issue: 2, pp.253-270, Doi: 10.1108/IJCCSM-01-2014-0017. http://dx.doi.org/10.1108/IJCCSM-01-2014-0017.

[28] United Nations. (2019). Green State Development Strategy: Vision 2040. https://observatoriop10.cepal.org/en/instruments/green-state-development-strategy-vision-2040

[29] United Nations Climate Action. (2022). Climate Action- What is climate change? https://www.un.org/en/climatechange/what-is-climate-change.

[30] United Nations Framework Convention on Climate Change and the Kyoto Protocol to the UNFCCC. http://unfccc.int/2860.php.

[31] USC libraries. (2023). General Reference & Research Help. https://libguides.usc.edu/writingguide/discussion.

[32] van der Linden, S. (2018). The social-psychological determinants of climate change risk perceptions: Towards a comprehensive model. Journal of Environmental Psychology 41:112-12. DOI: 10.1016/j.jenvp.2014.11.012.

[33] Whitmarsh, L. & Capstick, S. (2018). Perceptions of climate change. In S. Clayton & C. Manning (Eds.), Psychology and climate change: Human perceptions, impacts, and responses (pp. 13–33). Elsevier Academic Press. https://doi.org/10.1016/B978-0-12-813130-5.00002-3.

[34] Wilburg, K. (2020). EPA's key role in monitoring emissions from oil sector. https://climatechange.gov.gy/en/index.php/news-and-events/press-releases/181-office-for-climate-change-epa-to-play-key-role-in-monitoring-emissions-from-oil-sector.

[35] World Economic Forum. (2023). Agenda Articles. https://www.weforum.org/agenda/climate-change/.

[36] Zeleke, T. *et al*. (2022). Smallholder farmers' perception of climate change and choice of adaptation strategies in East Hararghe Zone, Eastern Ethiopia. ISSN: 1756-8692. https://www.emerald.com/insight/content/doi/10.1108/IJCCSM-01-2022-0014/full/html.