Perceived Effects of Rainfall and Temperature Variability on Yields of Cereal Crops in the Mion District of Northern Ghana

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Abstract

Climate variability has been a major threat to achieving sustainable food production in many countries, including Ghana. This is attributable to insufficient and erratic rainfall coupled with increasing temperature. This study examined the perceived effects of rainfall and temperature variability on yields of cereal crops in the Mion District of the Northern Region. The study reveals that farmers in the Mion District have experienced changes in climatic conditions evident in high temperatures and low rainfall. The study also reveals that rainfall and temperature variability adversely affect the yields of cereal crops such as rice, maize, and millet. The effect could manifest in either yield reduction or total crop failure of cereals. The study also showed that factors that enable farmers to respond to impacts of rainfall and temperature variability are Agric extension services, application of fertilizer, irrigation farming, use of improved seeds, and favourable government policies such as subsidies and credit facilities. The study, therefore, concludes that yields of cereal crops are adversely affected by rainfall and temperature variability. However, farmers resort to Agric extension services, application of fertilizer, irrigation farming, use of improved variety of seeds, and favourable government policies in response to the impacts of rainfall and temperature variability. The study recommends that government should employ more extension agents and construct more irrigation facilities in the Mion District to reduce the adverse effects of climate variability on yields of cereal crops.

Keywords: Perceived, Effects, Climate Variability, Cereal Crops, Rainfall, Temperature, Yields.

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Background

Globally, the average temperature has increased to 1 degree Celsius above the pre-industrial baseline (Kapelle, 2020). This increase in temperature is projected to negatively impact food sufficiency, adequate water supply, and the frequency and intensity of extreme climatic events (Willis, 2014). Global warming has been attributed to the higher concentration of Atmospheric Greenhouse Gases (GHG) (IPCC, 2014). The consequences of this higher concentration can be seen through extreme events, including drought and frequent floods, as well as crop failure leading to food insecurity (Antwi-Agyei, 2012). Conservative estimates show a temperature increase of 1.7^{o}C to 2.04^{o}C by 2030 in northern Ghana, with an average temperature increase of 41^{o} C (MESTI, 2013).

The evidence of climate variability, such as extreme climatic events, has affected many countries (IPCC, 2014). In Ghana, many parts of the country have experienced increased temperatures and a decline in rainfall patterns. Ghana's climate has become difficult to predict because of the negative effects of climate variability and change, which may lead to extreme climatic events, including torrential rains, severe dry winds, and excessive heat (MESTI, 2012). The agricultural sector of Ghana has been experiencing decreasing contribution to GDP, although the sector employs about 47 percent of Ghanaians (GSS, 2014). The mean annual production of the major staple cereal crops shows a declining growth rate from 2005-2016. For instance, maize recorded a growth rate of 11.37 percent from 2005 to 2010, which declined to -1.34 percent from 2011-2016 seasons (MoFA-SRID, 2017). Paddy rice recorded a growth rate of 20.59 percent from 2005-2010, which declined to 8.38 percent from the 2011-2016 seasons. Millet also recorded a growth rate of 14.86 percent from 2005-2011 and declined to -3.12 percent during the 2011-2016 periods, and Sorghum also recorded a growth rate of 10.30 percent from 2005-2010 which declined to -2.98

percent from 2011-2016 seasons (MoFA-SRID, 2017). The decline in yields of cereal crops can be attributed to many factors. For instance, there is about a 10-16 percent annual reduction in crop yields globally due to pests, estimated to cost 220 billion US Dollars (Chakraborty & Newton, 2011). In Africa, about 30-60 percent reduction in crop yield can also be attributed to insects (Tadele, 2017). Agricultural inputs, including fertilizers, certified seeds, irrigation, pesticides, machinery, and credit and extension services, influence crop productivity (Tadele, 2017). Several studies have estimated the likely effects of climatic factors on the productivity of food crops. However, the effects of historic climatic trends on global agricultural productivity are yet to be widely investigated (Lobell & Gourdji, 2012). In Ghana, few studies highlight the effects of rainfall and temperature variability on yields of cereal crops. This study, therefore, aims at filling the gap in existing literature and serves as a guide to providing useful information on perceived effects of rainfall and temperature variability on yields of cereal crops Northern Ghana. This study examined climate-crop relationship as well as the effects of the historic trends of the climatic factors on yields of cereal crops (Paddy rice, Maize and Millet) in the Mion District of Northern Ghana. The study provides information for informed decisions on farming to help farmers adapt to rainfall and temperature variability. It will also assist in policy formulation on climate variability to develop adaptation measures including livelihood diversification and climate-smart agriculture in order to reduce farmer's vulnerability to extreme events.

There are previous studies on the effects of rainfall and temperature variability on yields of food crops. For instance, Baffour-Ata et al., (2021) examined the effects of climate variability on yields of selected staple food crops in Northern Ghana. In addition, Kyei-Mensah et al., (2019) focused on the impact of rainfall variability on crop production within the Worobong Ecological Area of Fanteakwa District in Ghana. More so, Bekuma Abdisa et al., (2022) looked at the impact of climate variability on rain-fed maize and sorghum yields among small-holder farmers in Ethiopia. However, there is still a lot to be done. It is in line with this background that this study sought to provide answers to the following research questions: (i) What are the perceived changes in climate conditions in the Mion District? (ii) How do rainfall and temperature variability impact yields of cereal crops? (iii) What factors enable or constrain farmers' responses to impacts of rainfall and temperature variability in the Mion District? and (iv) Which cereal crops are affected by rainfall and temperature variability in the Mion District?

Conceptual Framework

The study is guided by the conceptual framework in Figure 1, which is based on the logic of environmental possibilism. Environmental possibilism justifies that the environment sets certain constraints or limitations, but social conditions determine culture. In other words, man is not entirely free from the influence of the environment. Still, there is room for the effort of man such as technology, attitudes, habits, and values, which influence man’s action and his environment (Fekadu,2014). Possibilism holds that both factors (man and nature) are equally important to make influence on each other (Fekadu, 2014). The conceptual framework depicts that environmental factors such as climate (rainfall and temperature) variability are not solely responsible for the yields of cereal crops.

By implication, apart from climate (rainfall and temperature) variability, other factors such as the application of fertilizer, agricultural extension services, irrigation farming, improved variety of seeds, and government policies have an influence on the yields of cereal crops. The conceptual framework is adapted from (Selvaraju et al., 2006). The conceptual framework of Selvaraju et al. (2006) is based on the logic of environmental determinism, which holds that adaptation to environmental factors such as temperature and rainfall variability is the only panacea for improving livelihood security and sustainable livelihoods. Selvaraju et al. (2006) fail to acknowledge the fact that, apart from environmental factors such as temperature and rainfall variability, socio-economic factors such as application of fertilizer, extension services, irrigation farming, improved variety of seeds, and favourable government policies, are instrumental in improving livelihood security and sustainable livelihoods. Figure 1 is a modification of Selvaraju et al. (2006). From Figure 1, it is observed that, holding other factors constant, rainfall and temperature are instrumental in the cultivation of cereal crops. Rainfall is an important climatic factor that influences temperature of a particular place, as well as evapotranspiration and soil moisture. For instance, insufficient rainfall will lead to increase in temperature which will in turn result in demand for water for evapotranspiration by crops leading to reduction in soil moisture which consequently leads to poor crop yield. In addition, human-induced factors such as the application of fertilizer, extension services, irrigation farming, the use of improved variety of seeds and government policies have positive influence on output of cereal crops.

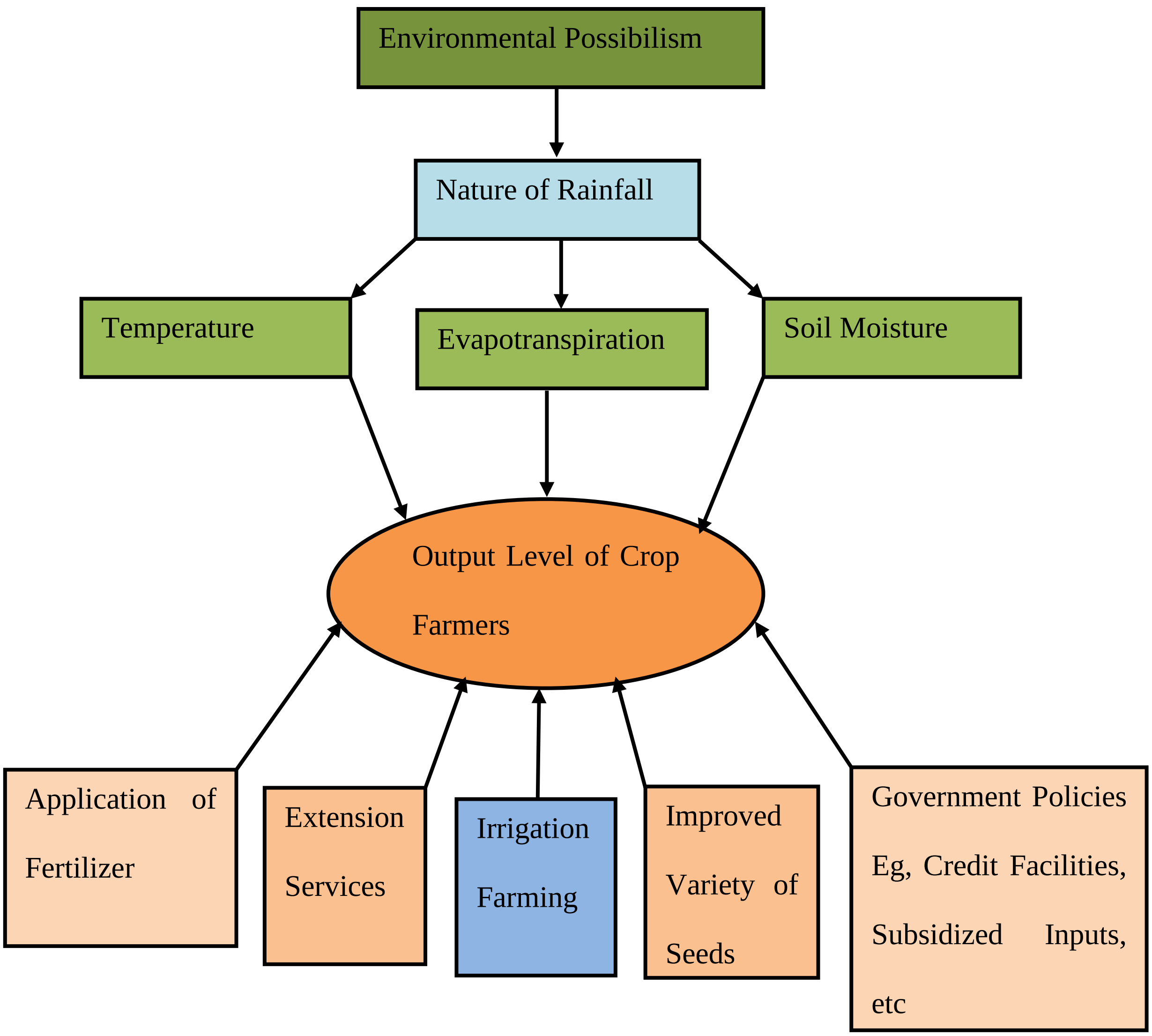

Figure 1: Conceptual framework on factors influencing food crop production

Source: Modified from Selvaraju et al. (2006).

Study Area and Methodology

Profile of the Mion District

The Mion District has a population of 81,812 of which 7,278 (8.9%) live in urban areas while 74,534 (91.1%) live in rural areas (GSS, 2014).

The District is found at the eastern part of the Northern Region of Ghana between latitude 9^{o} - 35’’ north and 00^{o} - $30^{''}$west and 00^{o} – $15^{''}$east. Mion District shares boundaries with Savelugu Municipality, Nanton District and Tamale Metropolis to the west, to the east with Yendi Municipality, to the south with East Gonja and Nanumba North Districts as well as Gushegu and Karaga Districts to the North. The District covers a surface area of 2,714.15 sq km and has a population density of 30.1 persons per square kilometer (GSS, 2014). Figure 2 is the district map of Mion.

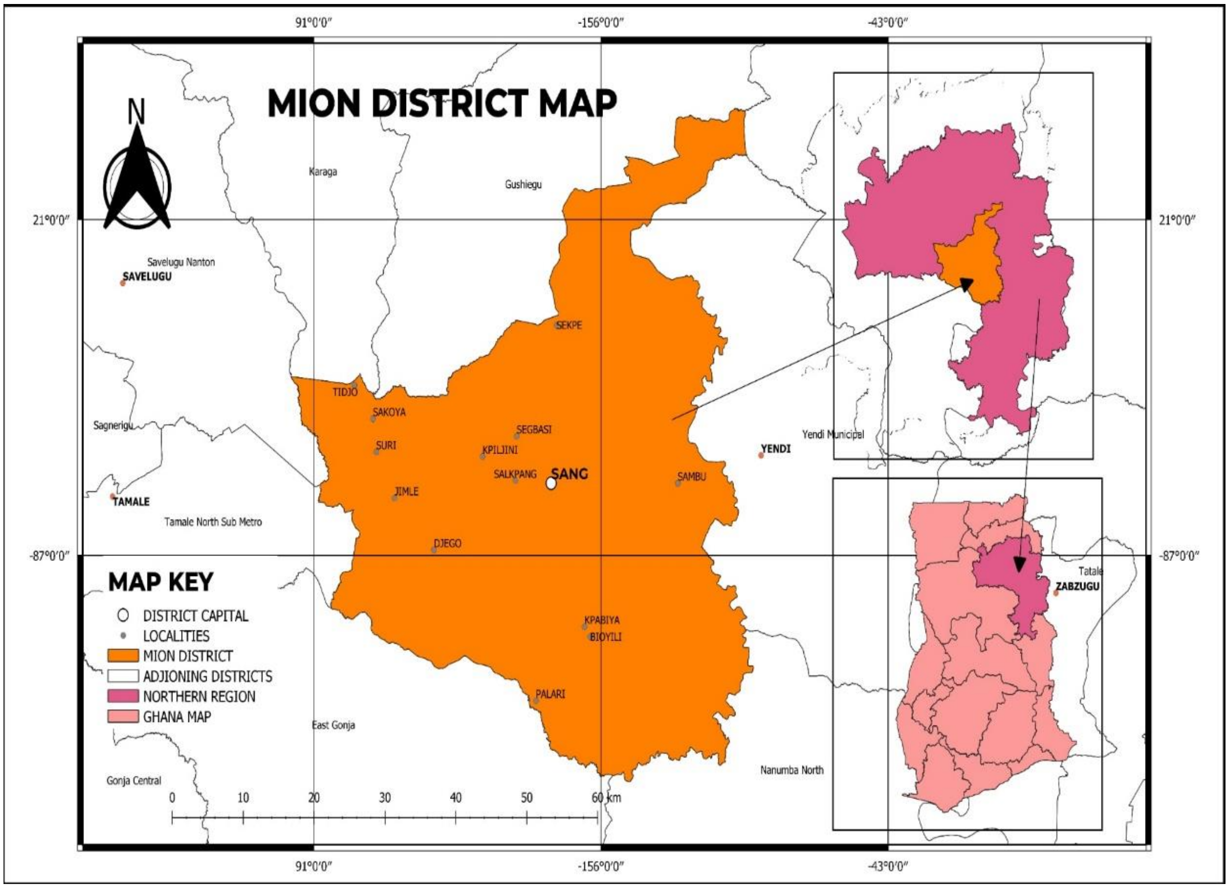

Figure 2: District Map of Mion
Source: Author's own construct, 2020

The Mion District has a landmass of 2,714 km^2. The District has three (3) area councils, which include Jimle, Sang and Kpabya. There are twenty (20) electoral areas and one hundred and seventy-one (171) communities in the District. Chiefs and family heads hold land in trust of the people and individuals can only acquire land for construction and agricultural practices by presenting cola nuts and cash through them. People who acquire land for farming present some quantities of their harvest at the end of the farming season to the landowners in appreciation for the acquired land. The cultural settings of the northern part of Ghana including Mion District do not give women equal access to land as their male counterparts. They can only acquire land through men, usually their husbands.

The mean annual rainfall for the Mion District is 715mm, while the mean wet season rainfall for the District is 750mm, which takes place between April-October. Annually rainfall recorded in the District varies between 750mm and 1050mm. Temperature in the area may also vary between 14^o Celsius at night and 40^o Celsius during the day (GSS, 2014). This implies that there are high temperatures in Mion District. The District is located within the Guinea Savannah where there are high incidences of bush burning that negatively affect the vegetation and consequently the climate of the District. The District was carved out of Yendi Municipality in 2012 to enable development to reach all communities.

The economy of the District is largely dependent on agriculture because it is the main occupation of the people. Over 90 percent of the people depend on agriculture for their survival because it has a vast land for agricultural activities such as the cultivation of cereals, and tubers and the rearing of animals such as cattle, sheep, goats, and pigs. Poultry, including guinea fowls and local fowls are also an essential aspect of the agricultural activities of the people of Mion. The District has a total household of 8,842 and about 93.3 percent of these households do crop farming while 6.7 percent of the urban dwellers are crop farmers (GSS, 2014). Others are engaged in small-scale and medium-term businesses such as wholesale, retail of general goods, transportation, fish mongering, mechanical engineering, blacksmithing, bakery and agro-processing such as rice processing, groundnut oil and Shea butter extraction. The District has nine agricultural extension agents (AEAs) and the AEAs farmer ratio is one to three thousand, five hundred farmers (1: 3,500).

Methodology

To gain a broader and depth understanding or perspective of the topic under study and the conceptual framework, there was the need for the study to employ the mixed methods approach. This was necessary because the two methods within the design could help the researcher to offset possible weaknesses inherent to the predominant method, as indicated by Morse (2016). Although the design allows the use of both qualitative and quantitative methods, the study was largely quantitative, with which qualitative data provided a supportive role to the quantitative data. The mixed methods approach provided a better understanding of the study problem and unveiled the effects of rainfall and temperature as well as socio-economic factors such as irrigation agriculture and the use of an improved variety of seeds, agriculture extension services on the cultivation of cereal crops in Mion District of Northern Ghana as illustrated by the conceptual framework of the study.

The study resorted to primary and secondary sources of data. Primary data were collected from cereal crop farmers, agricultural extension officers and agricultural related non-governmental organizations on the effects of rainfall and temperature on the yields of cereal crops in the Mion District of northern Ghana.

Existing literature on climate variability and crop production was reviewed. This made it possible for us to obtain data from published documents, books, articles, reports, theses and archives of government institutions.

The study used probability and non-probability sampling techniques in the selection of farmers for investigation. With the probability sampling technique, the study employed systematic random sampling technique in selecting respondents from four communities. This technique helps to minimize bias, and it is simple to use (Taherdoost, 2016). With this technique, household heads were randomly selected from every 11th house in each of these four selected communities for questionnaire administration, having known the number of households in each community under study. This gave each household head an equal chance of being selected. A total number of one hundred and thirty farmers were interviewed, comprising of 91 males and 39 females (household heads and representatives of household heads).

With the non-probability sampling technique, the Mion District was purposively selected because about 98 percent of those employed in the agricultural sector do crop farming (GSS, 2014). Sang, Kpabya, Sakpe, and Sambu were also selected based on their location in the District (Sambu to the east, Kpabya located at the South, Sakpe to the north while Sang, the District capital (Mion) is at the centre). A purposive sampling technique was also employed in selecting one respondent each from the Department of agriculture, extension officers from selected communities, and the Director of Bonsu Farms based on their in-depth knowledge of the influence of rainfall and temperature on yields of cereal crops.

Using a simplified formula provided by Yamane in 1967 (Polonia, 2013) a sample size of one hundred and thirty respondents were selected. The formula is presented as follows;

$$n = \frac{N}{1+N\,(e)^2}$$

Where:

n = Sample population N = the population size

We get the sample size as:

n = 130

Note: N = number of households

The formula is reliable at 95 percent Confidence Interval with a margin of error of 5 percent (Kasiulevicious et al., 2006). The sample frame for the study consists of a total household size of one thousand four hundred and forty-eight (1,448) (GSS, 2014). The sample size for each community is presented in Table 1.

Table 1: Population and Sample Characteristics of Selected Communities

Community	Population	Total Number of Household	Sample Size From Selected Household
Sambu	3,263	286	26
Sang	7,278	669	60
Kpabya	3,174	275	25
Sakpe	1,607	218	19
Total	15,322	1448	130

Source: 2010 Population and Housing Census (GSS, 2014)

The study relied on questionnaire administration, key informant interviews, and Focus Group Discussions as data collection methods. The primary data on the effects of rainfall and temperature variability on cereal crop yields were collected from cereal crop farmers, agricultural extension officers and Non-Governmental Organizations in agriculture using the following methods and tools. Primary data were obtained through questionnaire administration using semi-structured questionnaires to collect information from cereal crop farmers. A total number of 130 questionnaires were administered to crop farmers covering areas such as demographic characteristics of respondents, variations in rainfall, temperature, and crop production, as well as extreme climatic events and crop yields**.**

In-depth interviews were conducted using interview guides for various stakeholders, such as leaders of farm associations, the District Director of the Department of Agriculture, and

Agricultural Extension Agents on the effects of climate variability and yields of cereal crops in the study area. These people were purposively selected for the interview based on their in-depth knowledge of the research topic.

Focus group discussions were also held among respondents in the study communities. Dibb et al., (1994) described focus group discussion as an instance where the researcher generates discussion concerning one or more topics in a group of 6 to 12 members. Focus group discussion is a qualitative method in research where questions are asked in an interactive manner which give respondents the freedom to express their opinion about the issues being discussed (Ashirwadam, 2014). Focus group discussions comprising of eight members in all the four communities were organized with the help of focus group discussion guide to collect data on the effects of climate variability on cereal crop yields. Each focus group was made up of 8 participants, the groups in Sang and Kpabya were all females while those of Sambu and Sakpe were only men. This ensured that women were able to express themselves freely concerning how they are affected by climate variability (rainfall and temperature). Participants were randomly selected with the help of various research assistants in these communities.

The discussions were geared towards assessing the effects of climate variability on yields of cereal crops. Focus group is usually made up 6 to 12 participants where the researcher tries to table several topics for discussion (Ferrell et al., 1994).

Existing literature was reviewed on climate variability and crop production by obtaining data from published documents, books, articles, reports, thesis and archives of government institutions.

Quantitative data obtained using questionnaire administrations were analyzed using descriptive statistics as a component of SPSS version 17 and presented using charts. In addition, qualitative data obtained from key informant and focus groups were analyzed using `content analysis and presented in the form of quotations.

Results and Discussions

Perceived Changes in Climatic Conditions

Figure 1 illustrates perceived changes in climatic conditions as indicated by the respondents. From the study, 70% of respondents indicated high temperature as perceived change in climatic conditions in the Mion District of Northern Region, 38% of respondents indicated low rainfall as perceived change in climatic conditions in the Mion District of Northern Region, whereas 8% of respondents could not tell as to whether there has been any change in climatic conditions. Many studies have confirmed significant internal or natural climate variations and changes that can be attributed to the El Nino effect. The types of El Nino that are causing natural variations of the climate system include; El Nino Southern Oscillation (ENSO), Arctic Oscillation/ North Atlantic Oscillation (AO/NAO), Atlantic Multi-decadal Oscillation (AMO), and the Pacific Decadal Oscillation (PDO) (Delworth & Mann, 2000; Mantua & Hare, 2002). It is observed that ENSO is considered as one of the significant contributors of the year-to-year variability of global weather patterns and global temperature (Fan et al., 2011; Christensen et al., 2013; Zhongming, 2013).

A male farmer in Kbabiya had this to say in a Focus Group Discussion ‘‘*For the past 25 years, temperatures have been very high in the Mion District with a corresponding low rainfall. This is an indication that, there is a change in climatic conditions. However, this is not good for* *cultivation of cereals*". Figure 3 illustrates perceived changes in climatic conditions in the Mion District.

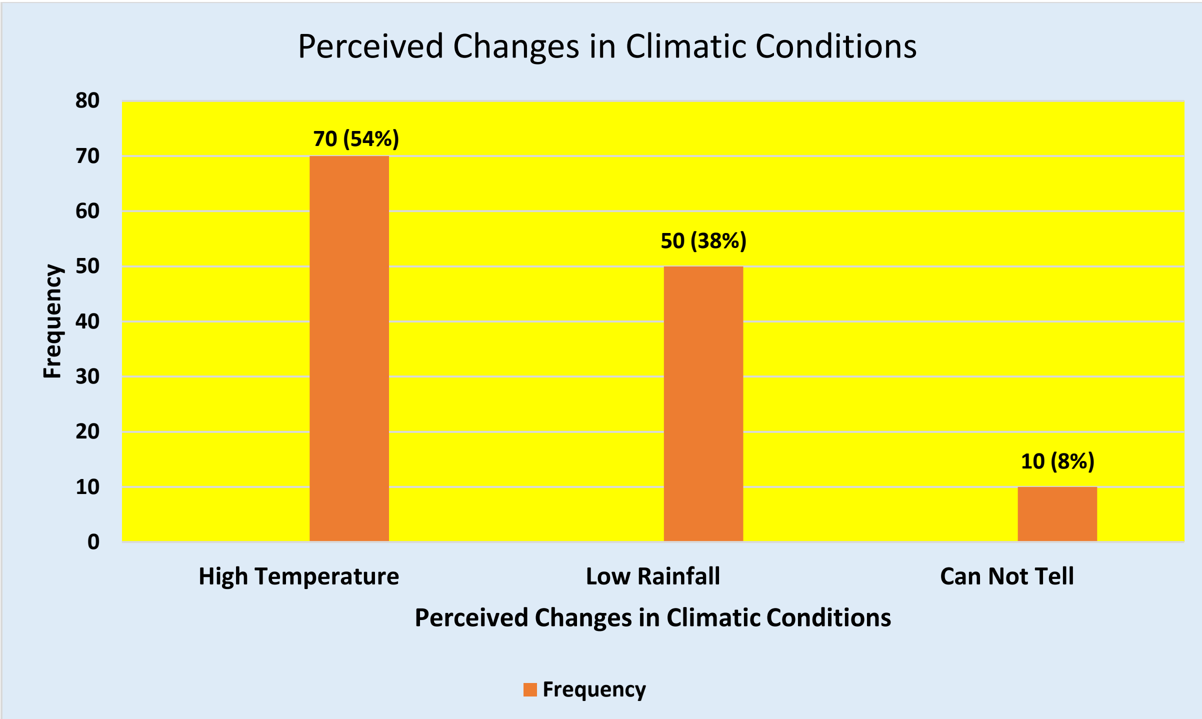

Figure 3: Perceived Changes in Climatic Conditions

Source: Field Survey, 2020

Perceived Effects of Rainfall and Temperature Variability on Yields of Cereal Crops.

Perception of Farmers on the Effects of Rainfall Variability on Cereal Crops Production

From the study, 85 percent of the farmers believed that rainfall variability has led to decreased crop yields of cereals such as maize, rice, and millet. In comparison, 13 percent of the farmers said the variability in rainfall has rather increased crop yields. In furtherance, 2 percent of the farmers said that rainfall variability has led to total crop failure. This is in line with the findings of Mertz et al. (2010), who attributed low crop yields to inadequate rainfall and its erratic distribution.

Rainfall is considered an important climate variable that determines the yield of many crops (Yadav et al., 2014). Interaction with farmers during a focus group discussion revealed that rainfall variability has effects on the yield of cereal crops. All the respondents believed that there were variations in rainfall in the study area. A male farmer at Sakpe community, during focus group discussion, had this to say:

> *"Rainfall does not come as we used to get it. At first, we used to get our first rain four months after we celebrate Christmas and this period in Dagbani is called 'movilasaha', at this period, shea trees bear fruits which is an indication that we would get our first rain and surely it will come for us to start land preparation for the year farming to start but now the rain come and go at any time and this has reduced the duration we use for farming within a season from four months to just one month" (Focus Group Discussion- Sakpe, 2020).*

This has confirmed the findings of MESTI (2013) that there is decrease in yield of many cereal crops because of the shortening growing season in Ghana. Figure 4 is an illustration of the perceived effects of rainfall variability on yields of cereal crops.

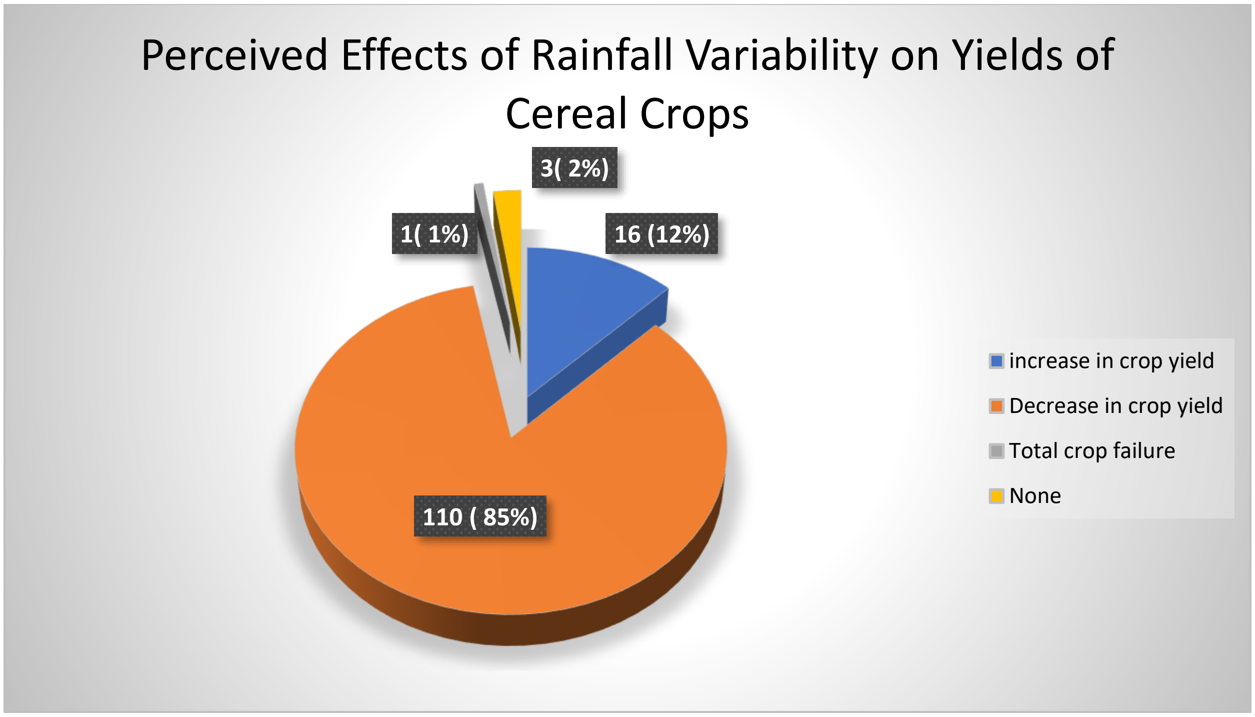

Figure 4: Effects of Rainfall Variability on Crop Yields of Cereals

Source: Field Survey, 2020

Types of Cereal Crops Affected by Variability in Rainfall in the Mion District

Many of the farmers mentioned maize as the most affected crop in terms of decrease in yield, followed by rice and millet, respectively, while a smaller percentage of the respondents mentioned other crops. Figure 5 is an illustration of cereals crops affected.

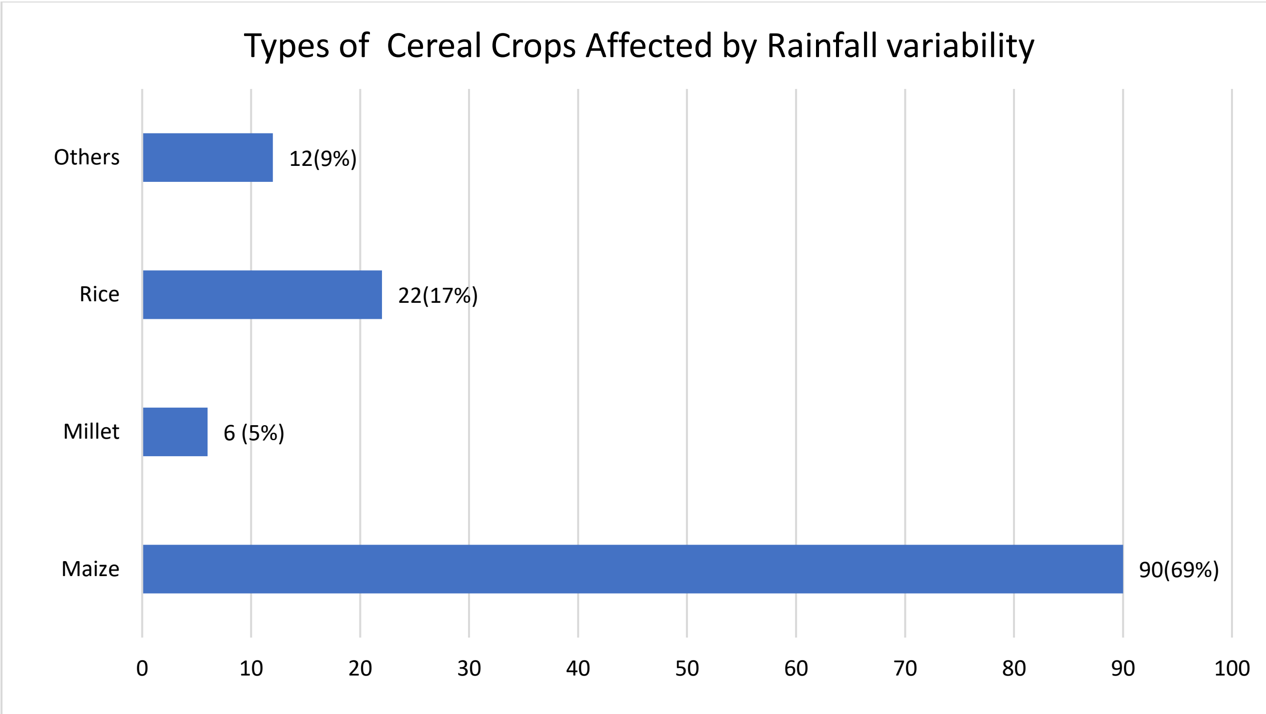

Figure 5: Types of cereal crops affected by variability in rainfall in Mion District from 1991-2015

Source: Field Survey, 2020

Perception of Farmers on the Effects of Temperature Variability on Yields of Cereal Crops

The majority of respondents (85 percent) maintained that the variation in temperature has led to a decrease in crop yields of cereals in recent times whiles a few of them (12%) are of the view that the observed changes in temperature has led to an increase in yields of cereal crops whereas 3 percent of the respondents said that temperature variation has led to total crop failure in the study area. An Agriculture Extension Officer at Kpabya community had this to say in a Key Informant Interview

> *"For me, I will say that there is an increasing temperature for some time now and this increase in temperature negatively affects agricultural crops in terms of yields".*

This is consonance with the findings of Bita and Gerats (2013) where they mentioned that 3^{o}C to 4^{o}C increased in temperature will lead to 15 to 35 percent decrease in crop yields.

Types of Cereal Crops Affected by Temperature Variability in the Mion District

The study shows that majority of the farmers indicated maize as the most affected crop by observed variation in temperature followed by rice while millet was mentioned as the third most affected crop by the crop farmers and yet some of the respondents indicated other crops as the most affected crops by temperature variability as shown in figure 6.

Figure 6: Types of Cereal Crops Affected by Temperature Variability in the Mion District from1991-2015

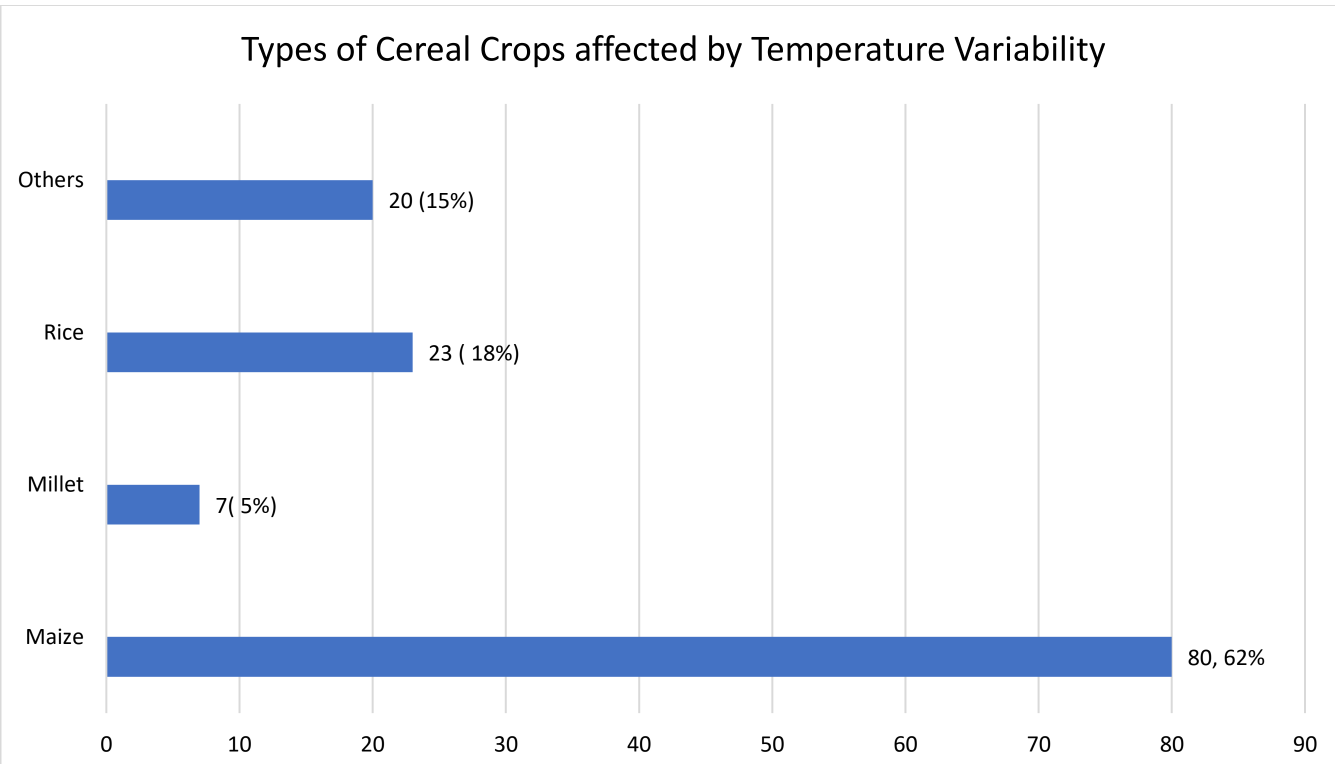

Figure 6: Types of cereal crops affected by temperature variability in the Mion District from1991-2015
Source: Field Survey, 2020

The study indicated that rainfall and temperature do not have the same effects on the cultivation of cereal crops. Most of the farmers maintained that variations in rainfall and temperature (maximum and minimum) have negative effects on the yields of cereal crops. At the same time, some noted that optimum temperature was needed for plant growth and development.

Some farmers during focus group discussions in Sang also attributed the decrease in yields of cereal crops to low soil fertility, poor farm management, and lack of agrochemicals such as fertilizer. A female farmer during a Focus Group Discussion at Sang community had this to say:

> *"These days if you cultivate maize without applying enough fertilizer, you will not get anything but this wasn't the case in the past. Also, if you control the weeds early enough even if you are not able to get fertilizer, you may get something small which will not be as much as if you apply fertilizer" (In-depth interview- Sang, 2020).*

This supports the work of (Tadele, 2017) where it is stated that low soil fertility, scarce moisture, weeds, insects, pests, and diseases are responsible for agricultural output in many African countries. The respondents also mentioned that lack of rain leads to an increase in temperature and that both rainfall and temperature contribute to the growth and development of crops. This also supports the conceptual framework, which explains the important contribution of rainfall and temperature towards enhancing agricultural output.

Factors that Enable Farmers Responses to Impacts of Rainfall and Temperature Variability in the Mion District

It is disclosed from the study that farmers in the Mion District resort to some socio-economic factors in response to impacts of temperature and rainfall variability. This is in line with the conceptual framework of study, which justifies that, yields of cereal crops are not only influenced by biophysical factors such as rainfall and temperature variability. There are also socio-economic factors such as Agric extension services, application of fertilizer, irrigation farming, use of improved variety of seeds, and favourable government policies such as subsidies and credit facilities to farmers, which influence the yields of cereal crops. From the study, 54% of respondents indicated that they resort to agriculture extension services to enhance the yields of cereal crops, 15 % of respondents indicated that they rely on the application of fertilizer to enhance yields of cereal crops, additional 15% of respondents mentioned irrigation farming as a way of enhancing yields of cereal crops. More so, 8% of respondents mentioned the use of an improved variety of seeds as a way of enhancing yields of cereal crops. In contrast, the remaining 8% of respondents indicated favourable government policies such as reliance on subsidies and credit facilities to enhance yields of cereal crops. This supports the findings of FAO (2017). According to the FAO (2017), to cope with the adverse impact of climate variability and extreme events, there is a need for investment, policies, and institutional arrangements to ensure food security. Institutional arrangements and appropriate policies can ensure effective adaptation to climate variability and extreme events. For instance, access to credit, insurance policies, agricultural extension services, irrigation facilities and subsidies on inputs can influence farmer's adaptation strategies (Mccarthy et al., 2010; Asfaw et al., 2015). Figure 7 is an illustration of factors that enable farmers to respond to temperature and rainfall variability.

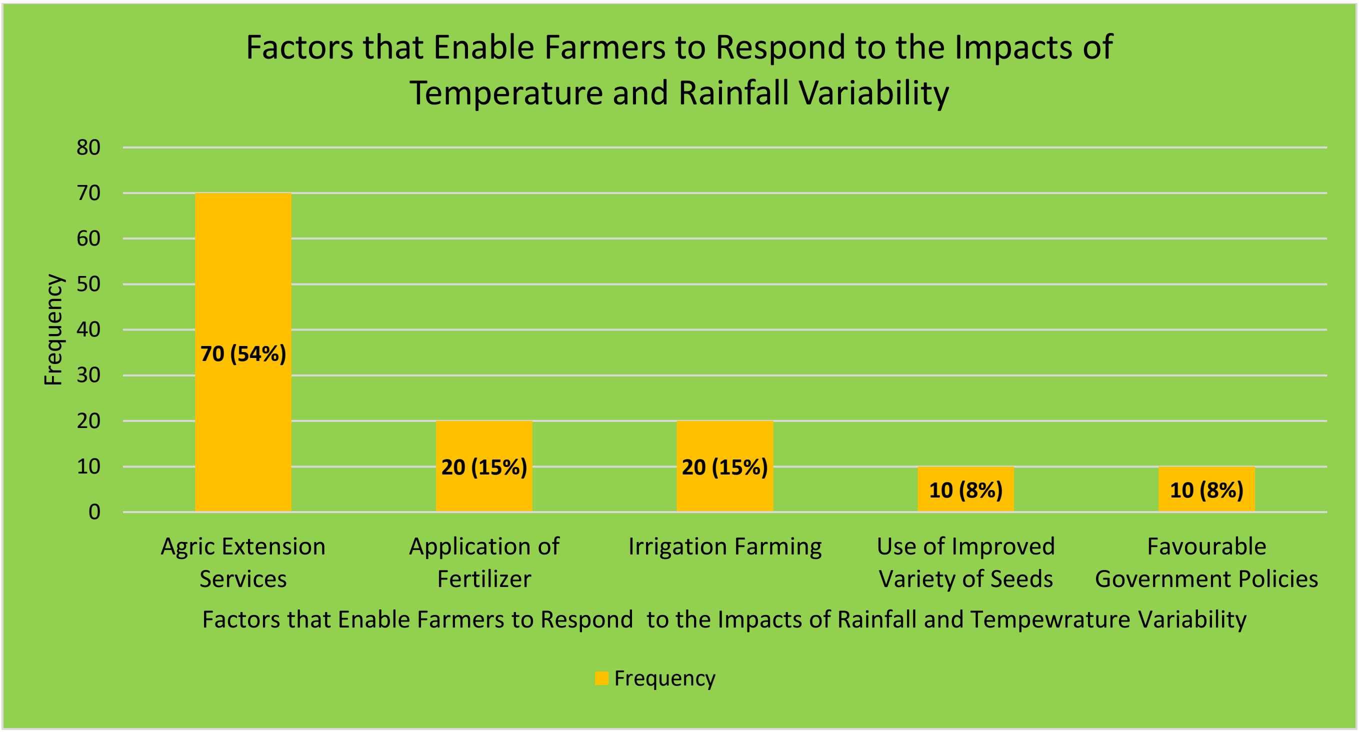

Figure 7: Factors that Enable Farmers to Respond to the Impacts of Temperature and Rainfall Variability
Source: Field Survey, 2020

Conclusions

The study sought to examine perceived effects of rainfall and temperature variability on yields of cereal crops in the Mion District. Logical to the conceptual framework, the study sought to achieve the following objectives: To assess perceived changes in climatic conditions in the Mion District; to assess the perceived effects of rainfall and temperature variability on yields of cereal crops in the Mion District; and to unveil factors that enable farmers to respond to impacts of rainfall and temperature variability in the Mion District. Generally, the study has provided answers to the research questions. This is suggestive of the fact that the study is a contribution to knowledge.

Firstly, farmers are of the view that, there are changes in climatic conditions in the Mion District. Whereas some farmers indicated that, temperatures for the past 25 years have been very high, some other farmers experienced low rainfall in the Mion District. These are indications of changes in climatic conditions.

Secondly, on the issue of perceived effects of rainfall variability on yields of cereal crops, the majority of farmers generally alluded to the fact that changes in rainfall pattern affects the length of growing season. Specifically, a good number of the farmers indicated that, rainfall variability leads to decrease in yields of cereal crops. Also, a smaller proportion of the farmers mentioned that, rainfall variability leads to total crop failure of cereals. These are suggestive of the fact that rainfall variability adversely affects yield of cereal crops.

In addition, the farmers outlined maize, millet, rice, and others as cereal crops affected by rainfall variability. However, the most affected cereal crop is maize as indicated by the majority of farmers.

More so, on the issue of perceived effects of temperature variability on yields of cereal crops, generally, the majority of farmers were of the view that there has been changes in temperature for some time now. They also alluded to the fact that there is a manifestation of effects of temperature variability on yields of cereal crops. Specifically, a good number of the farmers mentioned that variation in temperature leads to decrease in yields of cereal crops. Moreover, a few of farmers indicated that, temperature variability leads to total crop failure of cereals. These means that, temperature variability adversely affects yields of cereal crops.

In furtherance, it is obvious from the results of the study that rice, millet, maize and other cereal crops are affected by temperature variability. It is however noted that, the most affected cereal crop is maize as indicated by the majority of farmers.

Lastly, on the issue of factors that enable farmers to respond to impacts of temperature and rainfall variability, the majority of farmers indicated that they resort to agriculture extension services whereas the remaining farmers rely on application of fertilizer, irrigation farming, use of improved variety of seeds, and favourable government policies.

Recommendations

The following recommendations are forwarded for policy considerations:

The study proposes that government and major stakeholders in agriculture such as NGOs should ensure that additional irrigational facilities are provided to the farmers of Mion District to reduce the adverse impact of rainfall variability in the study area.

Secondly, the study recommended that government should employ more experienced extension agents in the district to educate farmers on climate (rainfall and temperature) variability and agricultural technology transfer to enhance crop productivity in the Mion District of northern Ghana.

It is also recommended that farmers in the Mion District should form cooperative societies, Formation of cooperative societies will brighten their chances of accessing loans from banks in order to expand agricultural output.

The Government of Ghana should also come to the aid of farmers of Mion District through the Ministry of Food and Agriculture by providing them with training on sustainable farming methods, as well as supporting them with agricultural inputs, storage facilities and subsidies.

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