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Poultry Farmers' Perception and Coping Strategies to Climate Change: Implications on Poultry Production in Bono East Region, Ghana

[1] Michael Azumah Apuri, [2*]Hamdiyah Alhassan, [1]Esther Cobbinah and [1]Afishata Mohammed Abujaja

[1]*Faculty of Agriculture, Food and Consumer Sciences*
University for Development Studies, Tamale, Ghana

[2]*School of Economics*
University for Development Studies, Tamale, Ghana.

**Corresponding author email address: abena567@yahoo.co.uk*

ABSTRACT

Poultry production has the potential to reduce poverty, food and nutrition insecurity and enhance employment creation. Despite the benefits from poultry farming, climate change is reported to have adverse effects on poultry production. However, literature on the coping strategies adopted by farmers within the Bono East region and their determinants are scarce. Based on this premise, this study used descriptive statistics and chi-square technique to examine poultry farmers' perception and the drivers of the choice of coping strategies adopted to reduce the negative effect of climate change on poultry production in the Bono East region of Ghana. The results revealed that poultry farmers were aware of climate change in their various localities. Majority of the farmers perceived an increase in temperature (63%), a decrease in rainfall (75%) and an increase in drought (60%). The farmers also reported that the changing climate poses severe consequences for poultry production, including, a decrease in the growth rate of poultry birds, increase in the incidence of diseases outbreak, high birds' mortality rate and low feed quality. The main coping strategies used by the poultry farmers are litter spreading and cleaning out and planting of trees. The Chi-square analysis revealed that marital status, ($X^2 = 10.403$, $P < 0.05$), educational level ($X^2 = 15.653$, $P < 0.01$), and main occupation ($X^2 = 21.011$, $P < 0.01$) are the factors that influence the choice of coping strategies used by the poultry farmers. Hence, education interventions on enhancing poultry farmer's awareness and knowledge about different coping strategies to improve their adaptive capacity on climate change should be encouraged.

Keywords: *Bono East region, Chi-square Analysis, Climate Change, Coping Strategies, Perception, Poultry Farmers*

INTRODUCTION

Livestock production plays a vital role in the economy of Ghana. It accounts for 14% of agricultural GDP in Ghana (Ministry of Food and Agriculture, MoFA, 2020). The poultry business is one of the livestock enterprises that has played an essential function as a business activity with great prospects for providing employment to the youth and promoting economic development (Ekunwe *et al.*, 2006). The poultry sector in Ghana, accounts for about 34% of domestic meat production and

employs about 2.5 million people (Adei & Asante, 2012). Rajendran and Mohanty (2003) stated that poultry production is one of the common secondary businesses undertaken by farmers to enhance their income. This is so because it gives fast income, does not require large land and capital and can be undertaken by ordinary farmers. As indicated by Mottet and Tempio (2017), poultry farming is one of the quickest-growing enterprises of world meat production especially in developing and transitional nations. Killebrew *et al.* (2010) reported that the demand for meat including chicken and eggs in West Africa is increasing because of the increase in population and migration of people to urban centers. Similarly, Anang and Agbolosu (2013) found that the poultry sector has a good future for development and it has all that it takes to support in addressing the shortage in the supply of animal protein as well as create employment opportunities.

According to MoFA/DFID (2002), the poultry sector plays an important role as a 'safety net' by serving as a quick money-generation venture. Although the poultry sector contributes a little to the agricultural Gross Domestic Product (GDP), it plays a vital role in the provision of income to reduce rural poverty and the supply of meat and eggs to reduce malnutrition. There are small, medium and large-scale poultry farms in Ghana, producing 50-5,000 birds, 5,000-10,000 birds and above 10,000 birds respectively (Anang & Agbolosu, 2013). Aning (2006) stated that poultry farming in Ghana is made up of a sub-sector of local poultry comprising, local fowls, guinea fowls and ducks, mainly kept in the free-range system. Commercial poultry production is normally undertaken near urban centers because of the high demand for chicken and eggs (Anang & Agbolosu, 2013). Poultry production in Ghana as a business involves the rearing of birds for meat and eggs (that is broilers and layers production).

Ekunwe *et al.* (2006) stated that layer production is popular in Ghana because egg production is more competitive than broiler production. The reason is that the broiler business is faced with competition from imported poultry meat from the United States and Europe which is cheaper than the local chicken. The quantity of eggs produced is the major determinant of profit in commercial layer business as it provides about 90% of the revenue from the business (Ekunwe *et al.*, 2006), this was also emphasized by Anang and Agbolosu (2013).

In Ghana, the poultry sector is seriously being threatened with collapse by some importation policies (Aning, 2006; Killebrew & Plotnick, 2021). This, in addition to a chain of problems posed by climate change, bad husbandry practices, etc. are all possible challenges that compromise the full benefits that can be derived from the poultry enterprise in Ghana (Abioja & Abiona, 2020; Renaudeau *et al.*, 2012). Notwithstanding these challenges, the poultry business is still ongoing and has the potential to employ many people and provide the animal protein needs of people in the country and beyond. According to the United Nations, climate change refers to continuous variation in the various elements of the climate. These elements include temperature, rainfall, humidity and soil moisture. Climate change may be due to human actions or as an outcome of natural changes. Many artificial factors necessitate changes in the climate across the globe. These are bush burning, felling of trees, poor environmental sanitation, burning of fuel, drilling of boreholes as well as manufacturing of cement (IPCC, 2007). Agriculture contributes 14% of greenhouse gases with the animal production sector contributing significantly to the release of these gases (Krishna, 2011). Even though climate change is worldwide, developing countries such as Ghana are the worst affected because of their low level of adaptive

capabilities (Lemi & Hailu, 2019). Furthermore, poor countries can incur huge costs from a small variation in the climate, particularly due to poor adaptive capacity, inadequate technology and funds to solve the problem (Abioja & Abiona, 2020; Lemma, 2016). Therefore, the repercussions of climate change must be determined and appropriate measures used to overcome the effects. This is vital in the development of the poultry industry in Ghana.

Unlike subsistence poultry production which needs low capital investment, commercial poultry production requires substantial capital investment. In Ghana, the two main production lines in commercial poultry production are broilers and layers production (Abioja & Abiona, 2020). Broiler production is usually done on a contract basis and to meet seasonal demand. On the other hand, layer production is an all-time business for the regular provision of table eggs to be used in the preparation of different dishes. The levels of chicken and egg production in Ghana fall short of the local demand causing the importation of large quantities of frozen chicken products into the country year in and year out from other parts of the world (Aning, 2006; MoFA, 2016). This creates opportunities for investment in the poultry industry in Ghana. However, climate change seems to have serious repercussions on poultry production. Climate change brings about negative effects on poultry production by increasing disease and vectors of diseases, decreasing the quality of feed, reducing the availability of water and increasing morbidity and mortality of birds (Spore, 2008). Rajkumar *et al.* (2011), indicated that high rainfall, high temperature as well as high relative humidity had devastating effects on poultry farming, particularly regarding meat and egg production, the spread of diseases, intake of feed as well as the response of the immune system. Islam and Wong (2017) and Shwartz (2016) indicated that the availability of feed for poultry is greatly affected by rising heat all over the globe. Alade and Ademola (2013), Guis *et al.* (2011), Heffeman (2018) and Rojas-Downing *et al.* (2017) found that climate change reduces the consumption of feed by poultry birds, encourages diseases and pests' outbreak, which subsequently increases the cost of production and reduce output from poultry production. A study conducted by Adesiji *et al.* (2013) also revealed that variations in temperature, as well as high sunshine, have adverse effects on poultry production. These effects consequently reduce poultry yield and hence the profit of poultry farmers. Even though climate change affects both crops and animal sectors, much attention is shifted to crop production neglecting the animal production sector, especially the poultry sub-sector. Poultry farmers require good knowledge about the negative effects of climate change to be in a good position to minimize the negative effects of it on their poultry businesses. Research conducted elsewhere by Alade and Ademola (2013), Adesiji *et al.* (2013) among others revealed that climate change contributes greatly to lowering profit in poultry production. Therefore, research work on the perception of poultry farmers and coping strategies to climate change will contribute immensely to the knowledge of climate change awareness. It is against this background that the paper sought to address the following objectives: (1) To identify the perception of poultry farmers on climate change; (2) to analyze the effects of climate change on poultry farmers' welfare and (3) to examine the coping strategies used by poultry farmers to mitigate the effects of climate change on poultry production and their determinants. It is hoped that the results of the analysis will be inculcated into national and international poultry production and climate change policies to ensure the attainment of the Sustainable Development Goals (SDGs).

The rest of the paper is organized as follows. Section two states the method employed and data collected for the study. The results and discussions are presented in section three. Finally, the conclusion and policy implications of the study are presented in section four.

METHODOLOGY

Study area

The study was carried out in three districts in the Bono East region of Ghana. Figure 2.1 presents the map of the study area. These are the Kintampo North municipal, Kintampo South and Techiman North districts. Ghana Statistical Service (GSS) (2014) indicated that Kintampo North Municipal is located between latitudes 8°45'N and 7°45'N and longitude 1°20'W and 2°1'E. It is surrounded by three municipalities and two districts. These are the Central Gonja Municipal in the North; East Gonja Municipal in the North-East; Pru District in the South-East; Kintampo South District in the South and Bole Municipal in the West. The Municipal is strategically located in the center of Ghana. It is the transit point between the northern part and the southern part of the country. It falls within the transitional zone of Ghana and covers an area of 5,108 km^2 GSS (2014). The mean rainfall is between 1,400mm to 1,800mm per annum, with a mean temperature of 23.9°C. The population of the area is 95,480 with 56.8% of the population living in urban localities. In the municipality, 60.2% of households are engaged in agriculture and 91.4% in crops (GSS, 2014). Chicken dominates the animals reared.

Figure 2.1: Map of Bono East region of Ghana
Source: https://lgs.gov.gh/bono-east-2/

The Kintampo South district, according to GSS (2014), is located between longitude 1°20'W and 2°10'W and latitudes 8°15'N and 7°45'N. It is surrounded by two municipalities and four districts. These are the Kintampo North Municipality at the North, the Nkoranza North and Techiman North Districts at the South, the Atebubu and Pru Districts at the East and the Wenchi Municipality at the West. It also experiences the major and minor rainy seasons with a mean rainfall of 1400 mm-1800 mm per annum. The average monthly temperature is between 24°C in August and 30°C in March (GSS, 2014). The vegetation of the district is the Woodland Savannah. The population of the district is 81,344 people as captured in the 2010 Population and Housing Census, with more males (52%) than females (48%). A little over eighty percent (88.3%) of households are engaged in agriculture (GSS, 2014). With regards to commercial activities in the district, 42.5% of households are into

livestock rearing which is dominated by poultry production.

Techiman North District was part of the Techiman municipality of the then Brong Ahafo region of Ghana. It came into being on June 28, 2012, after it was separated from the Techiman Municipality (GSS, 2014). The district is made up of 64 towns and villages. The major towns in the district are Tuobodom, Offuman, Aworowa, Krobo and Buoyem with Tuobodom as the District Capital (GSS, 2014). Most of the people in the district settled along the Techiman-Wenchi and Techiman-Kintampo routes, which are the two principal roads in the district. The total land area of the district is 389.4 square kilometers. It is found between longitude 1^{o}49'E and 2^{o}30'W and latitude 8^{o}00'N and 7^{o}35'S. It is surrounded by two districts and two municipalities, thus Techiman Municipality at the South, Kintampo South District at the North, Wenchi Municipality at the North-West and Nkoranza North District at the North East. The major rains begin in April and end in July and the minor ones are from September to October with average yearly rainfall in the range of 1660mm and 1260mm (GSS, 2014). The Techiman North District in general is considered as the food basket of Ghana. More than half of the economically active people in the area are engaged in farming and related businesses. The main crops grown in the district are yam, maize, cassava, cocoyam and plantain. The district is among the main producers of tomatoes and cassava in Ghana (GSS, 2014).

Sampling and sampling technique

The multi-stage sampling technique was used to select the respondents for the study. In the first stage, three districts in the Bono East region of Ghana were selected purposively. These three districts are Kintampo North, Kintampo South and Techiman North and were selected because of the availability of large numbers of commercial poultry farmers. In the second stage, a list of commercial poultry farmers with at least two years of experience was obtained from the associations of poultry farmers in the three districts. The list comprises forty (40), fifty (50) and sixty (60) farmers from Kintampo North, Kintampo South and Techiman North districts respectively. A sample size of 120 commercial poultry farmers was considered for the study. The respondents were selected using a systematic random sampling technique to give fair representation and an equal chance of selecting commercial poultry farmers in each of the three districts. A similar study conducted by Gbedemah *et al.* (2018) found this technique useful. Only commercial poultry farmers who have completed at least one production cycle were included in the sample frame. This was to enable the researcher to obtain secondary data on expenditure and income in a production cycle for their farms.

Structured questionnaires were utilized to collect data on the socio-economic characteristics of the respondents, the nature of poultry production and how poultry farmers perceive climate change. The questionnaire was also employed to find out about what poultry farmers are doing in their own way to arrest the adverse effects of climate change on their farms. This method of data collection is in consonance with the strategy used by Liverpool-Tasie *et al.* (2019). The study also interviewed informants and used personal observations to confirm some information gathered from poultry farmers.

Estimation techniques

Descriptive statistics

The data collected was analyzed with the use of Microsoft Excel and Statistical Package for Social Sciences (SPSS). Descriptive statistics such as percentages and frequency distributions were used to summarize and categorize the research findings. Descriptive statistics was

specifically used to identify the perception of poultry farmers on climate change.

Chi-square technique

To examine the factors that influence the decision of poultry farmers on which coping strategies they would use to mitigate the impact of climate change, this study made use of the chi-square technique. The test statistic is given by:

$$X^2 = \sum(O - E)^2/E$$

where X^2 = chi-square statistics,
$\sum$ = summation sign
O = Observed frequency
E = Expected value

Statement of hypothesis

H_0: The choice of coping strategy depends on the socio-economic characteristics of the farmers.

H_1: The choice of coping strategy does not depend on the socio-economic characteristics of the farmers.

Decision rule

The chi-square (X^2) test shows the magnitude of the differences between the observed frequencies and the expected frequencies. When the discrepancies are large, the chi-square (X^2) value becomes large. A large chi-square (X^2) value implies the rejection of the null hypothesis. On the other hand, if the observed frequencies and expected frequencies are very similar, the chi-square (X^2) value becomes small (but not negative). A small value of chi-square (X^2) implies the rejection of the alternate hypothesis. In this research therefore, a 5% significance level is employed.

Table 2.1: Definition of variables

Variable	Dummy
Sex	1=male, 0=otherwise
Age	1=20-29 years, 0=otherwise
Marital status	1=married, 0=otherwise
Religion	1=Christianity, 0=otherwise
Educational level	1= at least JHS, 0=otherwise
Respondent's main occupation	1=poultry farming, 0=otherwise
Number of years in the village	1=10 years or less, 0=otherwise
Years of experience in poultry farming	1=Less than 10 years, 0=otherwise

RESULTS AND DISCUSSION

Descriptive statistics of Variables

Table 3.1 presents the demographic characteristics of respondents from the study area. Most of the selected poultry farmers were within the age group of 40-49 years (55%), followed by 30-39 years which represents (25%). Only 2.5% of the poultry farmers were within the age group of 60 years and above. The age of farmers is one of the paramount factors when considering their socio-economic background. The age of a worker indicates his or her capability and efficiency at work (Adesiji *et al.*, 2013). A greater number (80%) of commercial poultry farmers selected for the study were within the age brackets of 30-39 years and 40- 49 years. Thus, the farmers are productive economically and have a high level of energy to provide the needed human resource for the activities involved in poultry production. The relatively young farmers seen in the poultry production sector may be attributed to the fact that poultry production requires a lot of energy hence, not a good venture for the aged.

Most of the respondents were males (90.0%) and just 10.0% were females. This is in consonance with the findings of FAO (2006) and Tuffour and Sedegah (2013), who revealed that, even though females occupy a pivotal position in farming, they

are very few when it comes to farmers in commercial poultry production. Similar research done in the Greater Accra region of Ghana confirmed these findings by indicating a very high percentage (84%) of the poultry farmers that were interviewed during the research were males (Gbedemah *et al.*, 2018). This revelation is not surprising because females are less likely to endure laborious activities in commercial poultry production than males (Deressa *et al*., 2010). However, females usually dominate when it comes to backyard poultry farming (Liverpool-Tasie *et al.*, 2019) and in the marketing of eggs which is less tedious. Regarding the marital status of the respondents, most of them were married (93.3%) and 5.8% were never married. This implies that the farmers may get labor from their families to assist them in the poultry farming process.

With occupation, most of the respondents (74.2%) were into poultry farming as their main occupation, followed by formal work (23.3%) and housekeeping (2.5%). The implication is that since the farmers are engaged in other occupations in addition to poultry production, they will have other sources of income to rely on in the event of a failure in poultry production. This could therefore be a strategy used by the farmers to minimize the impact of climate change on their livelihood. Those who have formal work stand the chance of securing loans to facilitate their poultry business since they can use their salaries as surety. The level of education of the farmers directly influences the ability of the farmers to keep adequate farm records and read widely for useful knowledge. A well-educated farmer can also easily make observations and draw conclusions on the influence of climate on their production. In this research, a greater number (48.3%) of the farmers had secondary education with a good number (42.5%) also attaining tertiary education. About (0.8%) of the farmer had primary education. The findings of Adesiji *et al.* (2013) support this revelation. This high level of education means that commercial poultry farmers stand the chance of keeping proper records. Again, the finding indicates that commercial poultry farmers in the three districts can at least read and better comprehend information on modern and better methods of production and simple instructions on how to administer drugs to their birds. Therefore, most of the poultry farmers stand the chance to benefit from education programs on climate change.

Table 3.1: Demographic Characteristics of poultry farmers

Characteristic		**Frequency (N=120;)**	**Percentage (%)**
Age	20-29	9	7.5
	30-39	30	25
	40-49	66	55
	50-59	12	10
	60 and above	3	2.5
Sex	Male	108	90
	Female	12	10
Marital Status	Never married	7	5.8
	Married	112	93.3
	Separated	1	0.8
Religion	No religion	1	0.8
	Islamic	15	12.5
	Christianity	103	85.8
	Other	1	0.8
Occupation	Poultry farming	89	74.2
	Housekeeping	3	2.5

	Formal work	28	23.3
Educational level	Primary	1	0.8
	JHS	10	8.3
	SHS	58	48.3
	Tertiary	51	42.5

Source: Field Work, 2021

Poultry Farmers' Perception of Climate Change

Table 3.2 shows the responses of farmers about climate over the past ten years. In their view, a lot of the respondents (60.0%) perceived that the incidence of drought has increased, temperature has increased (63.3%), rainfall has decreased (75.1%), and rainstorms have increased (89.1%). Further, most reported that there has been a decrease in humidity (66.7%), an increase in wind (85.8%) and flash floods (54.2%). As indicated previous literature by Azumah *et al.* (2016) and Lacombe *et al.* (2012), the perception of farmers showed that the amount of rainfall has reduced. Again, studies by Abatan *et al.* (2018); Adejuwon and Odekunle (2006); Ayanlade *et al.* (2017); Juana *et al.* (2013); Kalungu *et al.* (2013); Kemousuar *et al.* (2011); Nyanga *et al.* (2011); Ogalleh *et al.* (2012); and Woldeamlak (2012) showed that the rainfall pattern is unpredictable, drought, flood and temperature has increased. These changes in the various elements of the climate have detrimental effects on poultry production.

Table 3.2: Poultry farmers perceptions of Climate Change Over the Past Ten Years (2011 – 2021)

Item		**Response**		
	Remained unchanged	Increased	Decrease	Don't know
Drought	40 (33.3%)	72 (60.0%)	3 (2.5%)	5 (4.2%)
Temperature	3 (2.5%)	76 (63.3%)	1 (0.8%)	40 (33.3%)
Rainfall	10 (8.3%)	10 (8.3%)	90 (75.1%)	10 (8.3%)
Rainstorms	3 (2.5%)	107 (89.1%)	5 (4.2%)	5 (4.2%)
Humidity	0 (0.0%)	40 (33.3%)	80 (66.7)	0 (0.0%)
Wind	5 (4.2%)	103 (85.8%)	12 (10.0%)	0 (0.0%)
Flash flood	0 (0.0%)	65 (54.2%)	45 (37.5%)	10 (8.3%)

Source: Field work, 2021

Severity of changes in climate variables

Table 3.3 gives the findings of respondents about the severity of changes in climate variables. According to the results, an overwhelming percentage (80.0%) of the respondents said that temperature change was most frequent. About 41.7% of the respondents also said the decrease in rainfall occurs most frequently. Most of the respondents have the perception that there was a frequent occurrence of drought (75.0%). Further, the results revealed that most of the respondents have the perception that a decrease in humidity was less frequent (80.8%), wind was less frequent (47.5%), and flash floods occurred occasionally (50.0%). These findings agree with the perceptions of farmers in a study conducted by Ndoh *et al.* (2015) in which they argued that a reduction in rainfall is occurring more frequently and that there is an increase in flood and drought. Ndoh *et al.* (2015) further indicate that most of the farmers interviewed stated that, recently the rainy season normally starts late and stopped late as compared to many years ago, and that the period for the rains is now more unpredictable. To confirm the farmers' perception, meteorological records in that study area indicated that total rainfall appears to decrease, but at non-

significant rate (Ndoh *et al.,* 2015). The implication of the above findings is that the poultry farmers in the study area have some knowledge about the variations in the various elements of the climate, but do they know what brings about these changes in the climate? The next section will reveal answers to this question.

Table 3.3: Poultry farmers Perception of the severity of changes of climate variables

Item		**Response**		
	Most frequent	Frequent	Less frequent	Occasionally
Drought	10 (8.30%)	90 (75.0%)	12 (10.0%)	8 (6.7%)
Temperature	96 (80.0%)	9 (7.5%)	9 (7.5%)	6 (5.0%)
Rainfall	50 (41.7%)	46 (38.3%)	24 (20.0%)	0 (0.0%)
Rainstorms	0 (0.0%)	16 (13.3%)	97 (80.8%)	7 (5.8%)
Humidity	0 (0.0%)	16 (13.3%)	97(80.8)	7 (5.8%)
Wind	7 (5.8%)	38 (31.6%)	57 (47.5%)	18 (15.1%)
Flash flood	40 (33.3%)	11 (9.2%)	9 (7.5%)	60 (50.0%)

Source: Field work, 2021

Causes of Climate Change

Table 3.4 presents the perception of poultry farmers about the factors that trigger climate change over the years. From the results, most of the respondents reported that bush burning (47.5%) was the factor that mostly causes climate change, followed by deforestation (45.8%), then burning of fossil (5.8%) and (0.8%) are those who had no idea about the causes of climate change. This finding supports the findings of Codjoe *et al.* (2013) and Ndoh *et al.* (2015), who pointed out that climate change is caused by deforestation, indiscriminate bush burning, illegal mining and farming along river bodies, pollution from industries and modernization. Each of these factors contributes to the depletion of the vegetative cover or release of greenhouse gases (GHG) which brings about global warming and changes in other elements of the climate (IPCC, 2013). Even though there are many other factors that bring about climate change, a greater number of the poultry farmers mentioned deforestation probably because it is common in the study area to see people felling trees for charcoal burning and lumber. It is also common to find people burn the bush to search for game and to clear the land for farming activities. Nonetheless, the results of this research are not fully in agreement with the opinion that climate change is caused by disobedience of man to God and disrespect to some customs.

Again, the finding of this study does not support the view that climate change is caused by God to indicate that the world is coming to an end and man cannot do anything about it (Codjoe *et al.,* 2013). There is no scientific basis in this claim, however, it has an aorta of truth in that, the activities of man like felling of trees, indiscriminate bush burning and illegal mining among others, for whatever reasons, are cruel to the environment and deserve punishment to the perpetrators. These activities for example, destroy the vegetation which plays an indispensable role in the absorption of carbon dioxide (CO_2) in the earth crust. The result of these cruel activities is the accumulation of carbon dioxide in the earth crust and consequently increased temperature all over the world. The root causes of the negative activities to environment in the study area could be attributed to the growing population especially in urban areas. This increases the activities of land clearing for agricultural purposes and buildings to provide accommodation for the increasing population. Thus, the destruction of the vegetation and disturbance of the ecosystem. Again, unemployment could

compel people to engage in charcoal burning business and burning of the bush to search for game which promote the destruction of the vegetative cover. It is made clear by the Institute for Security Studies (ISS) (2010) that the menace of deforestation and land degradation should be tackled to depress the emission of GHG, considering the vital role performed by vegetation in the control of global climate system. Since the farmers have at least some knowledge about the activities that lead to climate change, probably, they can take stringent steps to mitigate its adverse effects.

Table 3.4: Perception of Poultry Farmers about the Causes of Climate Change

Causes of Whether Change	Frequency	Percentage (%)
Don't know	1	0.8
Deforestation	55	45.8
Bush burning	57	47.5
Burning of fossil fuel	7	5.8
Total	120	100

Source: Field work, 2021

Table 3.5 presents perception on the causes of erratic and late rains by farmers. According to their views, a higher percentage (63.3%) cited deforestation, followed by bush burning (36.7%). The perception of the commercial poultry producers in the study area is not different from the observation of the GSS (2014), which indicated that the vegetation in the study area has greatly been destroyed by human activities like logging and burning of charcoal. These activities have been fueled by population growth and urbanization especially in urban and pre-urban areas where commercial poultry farms are normally sited. As the population increases, the demand for infrastructure also increases which results in the felling of trees. When the vegetation is disturbed, the pattern and amount of rainfall is also affected through transpiration. Bush burning can have a similar effect since it also disturbs the vegetative cover.

Table 3.5: Poultry Farmers' Perceptions of Causes of Erratic and Late Rains

Cause of Erratic and Late Rains	Frequency	Percent (%)
Deforestation	76	63.3
Bush burning	44	36.7
Total	120	100.0

Source: Field work, 2021

Table 3.6 presents perception of farmers on causes of temperature increase. The highest number of farmers being (59.2%) were of the view that deforestation causes increase in temperature, followed by bush burning (37.5%), burning of fossil fuel (1.7%) and for other reasons (1.7%). This revelation is in concordance with the finding of Codjoe *et al.* (2013) and IPCC (2013) in that, deforestation and bush burning destroy green plants which perform a very important function in absorbing CO_2 from the atmosphere which is known to keep heat from the surface of the earth crust. This phenomenon increases atmospheric temperature. The burning of fossil fuel also releases CO_2 which traps heat at the surface of the earth thereby raising atmospheric temperature. Research conducted earlier indicated that the release of exhaust fumes from internal combustion of engines and the destruction of tropical forest to pave way for agricultural production, as well as felling of trees for domestic and international industries is responsible for

the release of most of CO_2 in Africa (ISS, 2010).

Table 3.6: Perception of poultry farmers on Causes of increase in environmental Temperature

Cause of Temperature Increase	Frequency	Percent (%)
Deforestation	71	59.2
Bush burning	45	37.5
Burning of fossil fuel	2	1.7
Other	2	1.7
Total	120	100.0

Source: Field work, 2021

Perceived effects of climate change on poultry production

Table 3.7 shows the opinion of poultry farmers about the effects of climate change on poultry production. From the results, 62% of poultry farmers indicated that climate change had affected production making growth rate low, 58.3% of poultry farmers expressed the opinion that climate change causes low egg production, 45.8% of farmers indicated that the effect of climate change on egg quality is moderately low. This could be attributed to the fact that birds under high temperature drink more water and consume less feed to reduce the generation of heat by the process of metabolism (Adesiji *et al.,* 2013). Those who indicated very high effect on diseases represent 58.3%, 54.2% of farmers agreed that the effect of climate change on bird mortality is very high. The result of the analysis is in concordance with Attia et al. (2011) and supports the findings of Califi *et al.* (2017) that, the immune system of poultry birds is compromised by heat stress. It is also in line with Adesiji *et al.* (2013). Majority (66.7%) of the farmers indicated that climate change affects feed quality and that the effect is very high. Half (50%) of the respondents support the fact that climate change influences the scarcity of feed, but the effect is low. These results also verify the findings of Abioja and Abiona (2020), who indicated that high temperature, low rainfall and unpredicted rainfall affect the growth of crops leading to poor yields. Consequently, poor yield is a motivating factor for the high price of poultry feed which surely affects the profit of farmers.

Table 3.7: Perceived effects of Climate Change on Poultry Production in the Bono East Region

Item	Response					
	Very high	High	Moderate	Low	Very low	No effect
Growth rate	0 (0.0%)	0 (0.0%)	15 (12.5%)	75 (62.5%)	15(12.5)	15 (12.5%)
Egg production	1 (0.8%)	5 (4.2)	30 (25%)	70 (58.3%)	10 (8.3%)	4 (3.0%)
Egg Quality	0 (0.0%	5 (4.2%)	55 (45.8%)	40 (33.3%)	20 (16.7%)	0 (0.0%)
Diseases	70 (58.3%)	25 (20.8%)	15 (12.5%)	10 (8.3%)	0 (0.0%)	0 (0.0%)
Avail. Feed	5 (4.2%)	5 (4.2%)	50 (41.6%)	60 (50%)	0 (0.0%)	0 (0.0%)
Feed quality	80 (66.7%)	25 (20.8%)	9 (7.5%)	6 (5.0%)	0 (0.0%)	0 (0.0%)
Bird mortality	65 (54.2%)	40 (33.3%)	7 (5.8%)	6 (5.0%)	2 (1.7%)	0 (0.0%)

Source: Field work, 2021

Coping strategies used to mitigate the effects of climate change on poultry production

As it is seen in literature, it is generally accepted that climate change is a reality and it has detrimental consequences on poultry production. Investigation of farmers'

perception in the study area also confirmed this assertion. It is therefore prudent to put measures in place to alleviate the problems created by climate change on poultry production. This study sought to know whether poultry farmers in the study area know of any coping strategy and whether they use or practice any of them on their farms.

Table 3.8 presents multiple responses on strategies adopted by poultry producers to curb the effects of climate change on poultry farming. Out of 219 responses given by the respondents, about (41%) adopted litter spreading and decaking or cleaning as coping strategy. Again, (27%) of the responses were in favour of planting of trees as coping strategy. These two findings may be because of their low cost as compared to the modern technologies. This outcome agrees with Liverpool-Tasie *et al.* (2019), who indicated that litter spreading and decaking or cleaning is preferred by most farmers because, even though it is tedious, it is less costly since the farmers can do it themselves. The adoption of afforestation by the poultry producers to curb the effects of climate change is expected since they have the general perception that deforestation contributes to climate change. About (14%) of the responses favoured engagement in non-poultry work such as rearing of pigs, cattle, sheep, goats and crops cultivation in addition to poultry production as a coping strategy. About (4%) adopted the use of air ventilation, vitamins and energy efficient bulbs as coping strategy and only (3%) ceiled the poultry house and used resistant breeds as a coping strategy. This finding shows a low level of adoption of modern technology by the farmers in the study area. This finding is in line with Fosu-Mensah *et al.* (2012) but contrary to Fadina and Barjolle (2018). The low adoption of these modern technologies by the farmers may be due to their unaffordability nature. The modern strategies are mostly used by large scale poultry farmers who have the financial strength to adopt them. This is in line with Liverpool-Tasie *et al.* (2019) who indicated that the adoption of the modern technologies is restricted to large scale farmers.

Table 3.8: Distribution of Coping Strategies to Mitigate the Effects of Climate Change on Poultry production

Coping Strategy	**Response**		**Percentage of Cases (%)**
	N	Percentage (%)	
Use of air ventilation	9	4	7
Use of vitamins	9	4	7
Use of energy efficient bulbs	9	4	7
Litter spreading and decaking or cleaning out	90	41	75
Engaging in non-poultry work	30	14	23
Ceiling the poultry house	6	3	5
Planting tress	60	27	50
Use of resistant breeds	6	3	5
Total count	**219**	**100**	**179**

Source: Field work, 2021

Factors influencing the choice of coping strategies used by poultry farmers

Table 3.9 shows the chi-square analysis of the association between poultry farmers' coping strategies and their socio-economic characteristics. From the chi-square analysis the following independent variables were associated with type of coping strategy adopted: marital status, (X^2 = 10.403, P <0.05), educational level of respondents (X^2 = 15.653, P <0.01), respondents' main occupation (X^2 = 21.011, P < 0.01) and Number of years in village (X^2 = 4.693, P> 0.05). This implies that marital status, educational level and the main occupation influence the choice of coping strategy used to mitigate the effects of climate change. This may be because those who are married can easily get family labour to help in carrying out the coping

strategy. Farmers with high level of education and those with more experience are expected to have more knowledge about climate change and the husbandry practices that they can employ to respond appropriately to its effects. High level of education also provides farmers with knowledge about the coping strategies. It could also be that farmers whose main occupation is poultry production are more devoted and experienced to the job. They are likely to be more competent in predicting the weather. This helps to increase the probability of practicing coping strategies to mitigate the effects of climate change. According to Fosu-Mensah *et al.* (2012), resource limitation, unavailability of labour and inadequate information are vital factors influencing the use of different adaptation measures for most farmers. However, the remaining factors did not show difference in choice of coping strategy adopted (Table 3.9), implying that they have no impact on the choice of coping strategy adopted by the poultry farmers. Whereas the analysis of this study disagrees with Fosu-Mensah *et al.* (2012) that the level of education has no influence on the choice of coping strategy to adopt, it supports Fosu-Mensah *et al.* (2012) findings that gender and farmers' experience do not significantly influence adaptation measures in the study area.

Table 3.9: Chi-square Analysis of the Relationship between Coping Strategies Adopted and Independent Variables

		Coping strategies						**Test statistics**
		Litter spreading or decaking or cleaning out		Planting of trees		Others (Use of resistant breeds and ceiling the house)		
Sex of respondent	Female	6	66.7%	1	11.1%	2	22.2%	X^2= 1.929 P= 0.381
	Male	36	61.0%	17	28.8%	6	10.2%	
Age group	20-29 years	1	50.0%	1	50.0%	0	0.0%	X^2= 3.493 P= 0.479
	30-39 Years	9	50.0%	5	27.8%	4	22.2%	
	40 years and above	32	66.7%	12	25.0%	4	8.3%	
Marital status of respondent	Never married	0	0.0%	1	100.0%	0	0.0%	**X^2=10.403 P= 0.03**
	Married	42	63.6%	17	25.8%	7	10.6%	
	Separated	0	0.0%	0	0.0%	1	100.0%	
Religion of respondent	Islamic	2	50.0%	2	50.0%	0	0.0%	X^2=1.484 P= 0.46
	Christianity	40	62.5%	16	25.0%	8	12.5%	
Educational level of respondent	JHS	2	66.7%	1	33.3%	0	0.0%	**X^2=15.653 P= 0.004**
	SHS	27	84.4%	2	6.2%	3	9.4%	
	Tertiary	13	39.4%	15	45.5%	5	15.2%	
Respondent's occupation	Farming (Crop and/or livestock)	35	72.9%	6	12.5%	7	14.6%	**X^2=21.011 P < 0.001**
	Housekeeping	2	100.0%	0	0.0%	0	0.0%	
	Formal work	5	27.8%	12	66.7%	1	5.6%	
Number of years in village	10 years or less	12	75.0%	1	6.2%	3	18.8%	**X^2=4.693 P=0.09**
	More than 10 years	30	57.7%	17	32.7%	5	9.6%	
Number of years in poultry production	Less than 10 years	26	54.2%	16	33.3%	6	12.5%	X^2=4.504 P=0.105
	10 years or more	16	80.0%	2	10.0%	2	10.0%	

Source: Field work, 2021

CONCLUSIONS AND POLICY IMPLICATIONS

The outcome of this research indicated that commercial poultry farmers in the three districts have some knowledge about climate change. The study also brought to light that the main causes of climate change in the study area are illegal felling of trees and indiscriminate burning of the bush which are occurring in the area because of illegal logging activities, charcoal burning and hunting activities. The study also pointed out that the effects of climate change on poultry production include low growth rate of birds, low egg production, poor egg quality, the occurrence of diseases and pests, high mortality, poor quality of feed and scarcity of feed. All these invariably reduce output, increase the cost of production and consequently bring about low, no or even negative profit. Therefore, the welfare of the farmers' households is compromised with the impact of climate change. Most of the respondents adopted litter spreading and decaking or cleaning, and tree planting. Farmers who ceiled their poultry houses and those who engaged in non-poultry work are very few. An insignificant number of farmers also use air ventilation, vitamins, energy-efficient bulbs and resistant breeds to mitigate the negative effects of climate change. This is a clear indication that farmers in the three districts do not have the capacity to adopt coping strategies, or their knowledge about how to curb the impact of climate change is low. The educational level, marital status and the primary occupation of the farmers are the determinants of the choice of coping strategies to climate change in the study area.

The findings of this study are imperative especially to poultry farmers, agriculture extension workers, government as well as other development partners. Since the farmers are doing little when it comes to the use of modern technology to curb the emerging challenges of climate change, there should be intensive education on enhancing the knowledge of farmers about the various modern technologies to improve their adaptive capacities. This could be done by building the capacity of agriculture extension workers through in-service training, who will then organize farmers into groups and provide them with the appropriate programs. Since the major causes of climate change in the study area is identified as deforestation and indiscriminate bush burning, stringent regulations should be enforced to check the activities of logging, charcoal production and hunting. This will go a long way to minimize the fast depletion of the vegetative cover which performs important functions in the climate system.

Again, it will be helpful if efforts are made by poultry breeders to breed fast-growing and more adaptable breeds for poultry farmers to reduce the impact of climate change on poultry production. Financial institutions should be encouraged to work hand in hand with poultry farmers in groups to provide support in the form of credit facilities. This will give the farmers the capacity to adopt adaptation strategies that may involve some cost. This will indirectly insure the farmers against the negative effects of climate change.

REFERENCES

Abatan, A. A., Osayomi, T., Akande, S. O., Abiodun, B. J. & Gutowski, W. J. (2018). Trends in mean and extreme temperatures over Ibadan, South-west Nigeria. *Theoretical and Applied Climatology*, 131, 1261-1272.

Abioja, M. O. & Abiona, J. A. (2020). Impacts of Climate Change to Poultry Production in Africa: Adaptation Options for Broilers Chickens. African Handbook of Climate Adaptation. 275-295 accessed from http://link.springer.com

Adei, D., & Asante, B. K. (2012). The challenges and prospects of the

poultry industry in Dormaa District. *Journal of Science and Technology (Ghana), 32*(1), 104-116.

Adejuwon, J. O. & Odekunle, T. O. (2006). Variability and the severity of the "little dry season" in south-western Nigeria. *Journal of Climate,* 19, 483-493

Adesiji, G.B., Tyabo I. S., Bolarin, O., Ibrahim, M. & Baba, S. T. (2013). Effects of Climate Change on Poultry Production in Ondo State, Nigeria. Ethiopian Journal of Environmental Studies and Management, 6(3), 242-248. www.researchgate.net/publication/314533242

Alade, O. A. & Ademola, A. O. (2013). Perceived Effects of Climate Variation on Poultry Production in Oke Ogun Area of Oyo State, Nigeria. *Journal of Agricultural Science* 5(10), 176-181. http://dx.doi.org/10.5539/jas.v5n9p176

Anang, T. B. & Agbolosu, A. A. (2013). Profitability of Broiler and Layer Production in the Brong Ahafo Region of Ghana. ARPN Journal of Agricultural and Biological Science. 8(5): 423-430.

Aning, K. G. (2006). Poultry Sector Country Review. Available at http://wvw.fao.org/docrep/019/i3663e.pdf

Attia, Y. A., Hassan, R. A., Tag El-Din, A. E. & Abou-Shehema, B. M. (2011). Effect of ascorbic acid on increasing metabolizable energy level with or without supplementation of some essential amino acids on productive and physiological traits of slow-growing chicks exposed to chronic heat stress. Journal of Animal Physiology and Animal Nutrition, 95: 744-755.

Ayanlade, A., Radeny, M. & Morton, J. F. (2017). Comparing smallholder farmers' perception of climate change with meteorological data: a case study from south-western Nigeria. Weather Climate Extremes 15:24-33.

Azumah, S. B., Donkor, S. A. & Ansah, I. G. K. (2016). Contract farming and the adoption of climate change coping and adaptation strategies in northern region of Ghana. Environment, Development and Sustainability. A Multidisciplinary Approach to Theory and Practice of Sustainable Development, 18(4).

Calife, A. S., Quinteiro-Filho, W. M., Ferreira, A. J. P. & Palermo-Neto, J. (2017). Neuroimmunomodulation and heat stress in poultry. Worlds Poultry Science Journal, 73: 493-504.

Codjoe, N. Y. F., Ocansey, K. C., Boateng, O. D. & Ofori, J. (2013). Climate Change Awareness and Coping Strategies of Cocoa Farmers in Rural Ghana. Journal of Biology, Agriculture and Healthcare 3(11): 22

Deressa, T. T., Hassan, R. M. & Ringler, C. (2010). Perception of and Adaptation to Climate by Farmers in the Nile Basin of Ethiopia: The Case of Farmers in the Nile Basin of Ethiopia. Journal of Agricultural Science, 149(1): 23-31.

Ekunwe, P. A., Soniregun, O. O. & Oyedeji, J. O. (2006). Economics of Small-Scale Deep Litter System of Egg Production in Oredo Local Government Area of Edo State, Nigeria. International Journal of Poultry. 5(1): 81-83. http://www.pjbs.org/ijps/fin527.pdf., on August 10, 2019.

FAO (2006). Food and Agriculture Organization of United Nations. Livestock's long shadow: environmental issues and options.

http://www.fao.org/3/a0701e/a0701e.pdf. Accessed on 11-9-2020.

Fadina, A. M. R. & Barjolle, D. (2018). Farmers' Adaptation Strategies to Climate Change and Their Implications in the Zou Department of South Benin. Environments, 5(15): 1-17

Fosu-Mensah, B. Y., Vlek, P. L. G. & MacCarthy, D. S. (2012). Farmers' Perceptions and Adaptation to Climate Change: A Case Study of Sekyedumase district in Ghana. Environmental, Development and Sustainability, 8(3): 5-14. DOI: 101007/s10668-012-9339-7 on 22nd January 2020.

Gbedemah, F. S., Torgbor, O. F. & Kufogbe, K. S. (2018). Adaptation Strategies of Poultry Farmers to Rising Temperature in the Greater Accra Region of Ghana. West African Journal of Applied Ecology, 26 (53): 41-55

GSS (2014). 2010 Population and Housing Census. District Analysis Report. Kintampo North District. www.statsghavna.gov.gh. Accessed on 20th January 2020.

Guis, H., Caminadi, C., Calvete, C., Morse, A. P. & Baylis, M. (2011). Modelling the Effects of Past and Future Climate on the Risk of Bluetone Emergency in Europe. Journal of Rural Sociology Interface. http://www.10.1098/rs.f.2011.0255.

Heffeman, C. (2018). Climate change and multiple emerging infectious diseases. The Veterinary Journal 234: 43-47.

Institute for Security Studies Paper 220 (2010). The Impact of Climate Change in Africa. November 2010. Accessed from www.makepeacehappen.net

IPCC, (2007). Climate Change 2007: the physical science basis. Summary for policy makers. Fourth Assessment Report, Cambridge University Press, Cambridge, UK.

IPCC, (2013). Causes of climate change, Impacts and Vulnerability, Responses Strategies, Mitigation and Adaptation. Working Group, I Contribution to the IPCC Fifth Assessment Report, Climate Change: The Physical Science Basis.

Islam, M. S. & Wong, A. T. (2017). Climate Change and Food Insecurity: A Critical Nexus. Environments 4(38): 1-17.

Juana, J., Kahauka, Z. & Okurut, F. (2013). Farmers' perceptions and adaptations to climate change in sub-Sahara African: a synthesis of empirical studies and implications for public policy in African agriculture. Journal of Agricultural Science, 5 (4).

Kalungu, J., Filho, W. & Harris, D. (2013). Pastoralists and farmers' perception of the impacts of climate change and variability on rain-fed agricultural practices in semi-arid and sub-humid regions of Kenya. Journal of Environment and Earth Science, 3 (7), 129-140.

Kemausuor, F., Dwamena, E., Bart-Plange, A. & Kyei-Baffour, N. (2011). Farmers' perception of climate change in the Sekyedumase district of Ghana. ARPN, Journal of Agricultural and Biological Science, 6 (10), 26-36. https:///www.semanticscholar.org

Killebrew, K., & Plotnick, R. (2021). Poultry Markets in West Africa Ghana: evans School of Policy Analysis and Research (EPAR) Brief.(2010); 83. *Prepared for the Market Access Team of the Bill & Melinda Gates Foundation*.

Killebrew K., Gugerty, K. M., and Plotnick R. (2010). Poultry market in West Africa: Nigeria', EPAR brief no. 87. Available

at: https://epar.evans.uw.edu/research/poultry-markets-west-africa-nigeria. WorldCat.

Krishna, P. P. (2011). Economics of Climate Variation for Smallholder Farmers in Nepal. A reviewed Journal of Agriculture and Environment, 12, 6-13

Lacombe, G., McCartney, M. & Forkuor, G. (2012). Drying climate in Ghana over the period 1960-2005: Evidence from the resampling-based Mann-Kendall test at local and regional levels. Hydrological Sciences Journal, 57, 1594-1609.

Lemi, T., & Hailu, F. (2019). Effects of climate change variability on agricultural productivity. *Int. J. Environ. Sci. Nat. Resour*, *17*, 14-20.

Lemma, A. W. (2016). Analysis of Smallholder Farmers' Perceptions of Climate Change and Adaptation Strategies to Climate Change. The Case of Western Amhara Region, Ethiopia. Thesis for Doctor of Philosophy in Environmental Management, University of South Africa.

Liverpool-Tasie, L. S. O., Sanou, A. & Tambo, J. A. (2019). Climate change adaptation among poultry farmers: evidence from Nigeria, 157: 527-544. http://doi.org/10.1007/510584-01902574-8

MoFA (2016). Ministry of Food and Agriculture; Ghana Livestock Development Policy and Strategy.

MoFA(2020). Ministry of Food and Agriculture. https://mofa.gov.gh/site/component/k2/item/554-revamping-the-poultry-sector-in-ghana#:~:text=Livestock%20production%20is%20an%20important,poverty%20cannot%20be%20over%20emphasized. Accessed 8th December, 2023.

MoFA/DFID (2002): The Role of Livestock in Rural Livelihoods in Ghana: Final Report; presented to Ministry of Food and Agriculture (MoFA) and Department for International Development (DFID), Accra, February, 2002.

Mottet, A and Tempio, G. (2017). Global poultry production: current state and future outlook and challenges. World's Poultry Science Journal 73(2): 1-12. Retrieved: https://doi.org/10.1017/S0043933917000071 Accessed: 19/05/2021.

Ndoh, M. L., Bitondo, D. & Balgah, R. A. (2015). Climate Variability and Change in the Bamenda Highlands of Northwestern Cameroon: Perception Impacts and Coping Mechanisms. British Journal of Applied Science and Technology 12(5): 1-18.

Nyanga, H., Johnsen, F. & Aune, J. (2011). Pastoralists and Farmers' Perceptions of Climate Change and Conservation Agriculture: Evidence from Zambia. Journal of Sustainable Development, 4: 4.

Ogalleh, S., Vogl, C., Eitzinger, J. & Hauser, M. (2012). Local perceptions and responses to climate change and variability. The case of Laikipia district, Kenya. Journal of Sustainability, 4: 3302-3325.

Renaudeau, D., Collins, A., Yahav, S., De Basilio, V, Gourdine, J. L. & Collier, R. J. (2012). Adaptation to hot climate and strategies to alleviate heat stress in livestock production. Animal 6:707-728

Rajendran, K. & Mohanty, S. (2003). Comparative Economic Analysis and Constraints in Egg Production under Cage vs. Deep Litter System of Rearing in India. International Journal of Poultry Science. 2(2): 153-158. Retrieved on December 10, 2019, from

http://docsdrive.com/pdfs/ansinet/ijps/2003/153-158.pdf

Rajkumar, U., Reddy, M. R., Rama Rao, S. V., Radhika, K. & Shanmugam, M. (2011). Evaluation of growth, carcass, immune response and stress parameter in naked neck chicken and their normal siblings under tropical winter and summer temperature. Asian-Australian Journal of Animal Science. 24(4): 509-516.

Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T. & Woznicki, S. A. (2017). Climate change and livestock; Impacts, adaptation and mitigation. Climate Risk Management, 16: 145-163.

Shwartz, M. (2016). Climate change surprise: High carbon dioxide levels can retard plant growth, study reveals. Stanford News Service: https://news.stanford.edu/pr/02/jasperplots124.html accessed on 17th April, 2019).

Spore Magazine. (2008). Climate Variation: Pest and Diseases. Spore Magazine August Special Issue: CTA, pp 5-6.

Tuffour, M. and Sedegah, D. (2013). What holds us back: Constrains among broiler producers in Ghana. Scientific Journal of Animal Science, 2(10): 264-272.

Woldeamlak, B. (2012). Climate change perceptions and adaptive responses of pastoralists and farmers in central highlands of Ethiopia. International Journal of Environmental Studies, 69 (3): 507-523.