

Full Length Research Paper

Analysis of the effects of climate variability on maize yields in Tano North District, Ahafo Region, Ghana

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This study focuses on the effects of climate variability on maize yields in Tano North District for a 20-year period spanning 1995 to 2015. The Department for International Development model, the “Livelihood Sustainable Framework” was used to drive the tenets of the study which was informed by the Action Theory of Adaptation. Three farming communities namely; Duayaw Nkwanta, Yamfo and Tanoso were purposively selected for the study. A cross sectional study design, mixed method and pragmatic research approaches were used for the study whilst the probability and non-probability sampling methods were applied for the selection of the sample. The quantitative data were analyzed using descriptive statistical tools like frequency using percentages and charts to present the final results. The thematic analyses were used for qualitative data based on common themes in the different responses and direct quotations were used to support the themes to address the research questions. Maize farmers observed that declining rainfall and increasing temperature had a significant negative influence on maize yields which means climate variability has had negative effects on maize yields. Coping and adaptation strategies to address the effects of climate variability on maize yields include on-farm adaptation strategies like application of agro chemicals, crop diversification, change in farm location, irrigation and off-farm adaptation strategies like migration, trading, poultry and livestock rearing. The findings have justified the Action Theory of Adaptation and the conceptual framework of the DFID’s Livelihood Sustainable Framework.

Key words: Climate variability, maize farmers, coping strategies, adaptation strategies, Tano North District (TND), and cross sectional study design.

INTRODUCTION

Climate variability is a relevant issue influencing the livelihood and food security in both developing and developed countries. The Food and Agricultural Organization (FAO, 2011) argues that many countries worldwide are experiencing food crisis because of

droughts and floods linked to climate variability. Although climate variability is one of the largest threats to the world, the poor regions, especially in Africa, have been suffering the most because these areas are least equipped to cope with climate variability effects

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(Mahmood and Jia, 2018). In addition, the situation is expected to become severe in the coming few decades with the changes associated with extreme climatic events. "Climate Variability" refers to a change in the state of climate that can be identified by changes in the mean and/or the variability of its properties which persist for an extended period, typically over decades (IPCC, 2014). It is manifested through: (i) rising temperature (ii) unpredictable rainfall pattern and increased variability (iii) rise in sea level and (iv) high incidence of extreme weather and disasters (IPCC, 2014).

The IPCC (2013) states that Africa is one of the continents mostly influenced by climate variability due to 1°C increase in average annual temperature in the last 30 years (1970 – 2000). Egyir et al. (2015) estimated that temperature will continue to rise, whereas rainfall is also forecasted to decrease in all agro-ecological zones in the country. Studies have revealed that most countries in Sub-Saharan Africa (SSA) are largely dependent on agricultural production (Apata et al., 2011; Alvaro et al., 2009; Burke et al., 2009). These studies revealed that about 17% of Gross Domestic Product (GDP) was derived from agriculture sector in sub-Saharan African countries between the years 2005-2008. It is expected that variability in climate will have serious environmental, economic and social effects on Ghana particularly among rural farmers whose livelihoods depend largely on rainfall.

Agriculture, primarily subsistence is the most important sector of Ghana's economy, with the sub-humid agro-ecological zone being one of the major food producing areas (World Bank, 2018). Agriculture accounts for nearly one quarter of GDP and employs more than half of the workforce, mainly small holders (Ghana Fact Sheet, 2014). There is however, little knowledge on whether farmers perceive climate variability and have observed the effects of climate variability on maize yields as well as adopted coping and adaptation strategies to climate variability in the Tano North District of the Brong-Ahafo Region now split into Bono, Bono East and Ahafo Regions.

Climate stimuli such as erratic and irregular patterns of rainfall and uncertain temperature directly affect agricultural productivity, and influence farmers' response to the effects of climate variability on agriculture. Both male and female maize farmers in developing countries in Africa experience different levels of vulnerability to climate variability on agricultural systems (Macharia and Raude, 2017). The study examined the effects of climate variability on maize yields and maize farmers' adaptation strategies to climate variability in the Tano North District, Ghana.

Farmers have observed changes in rainfall and temperature which they associate with variability in the climate. The farmers' perception is based on the fact that elsewhere, rainfall trend has been increasing over the past three decades (1980 - 2010). Other regions portray decreasing rainfall trend over the same period whilst

temperature trend in all the regions shows increase for the past 30 years (Peprah, 2014). This understanding is supported by the effects of occurrence of extreme weather events, for instance, occurrence of unpredictable rainfall, uncertain temperature and long dry spells over a long period of time on livelihoods of a locality.

The study adopted the DFID's "Livelihood Sustainable Framework" model to drive the tenets of the study which was informed by the Action Theory of Adaptation (Eisenack et al., 2012) to examine farmers' coping and adaptation strategies to climate variability.

The core concepts in the Eisenack et al. (2012) Action Theory of Climate Variability include the stimulus, exposure, and impact concepts etc. A stimulus (rainfall and temperature patterns) is a change of meteorological factors resulting from climate variability. A stimulus (rainfall and temperature patterns) influences an exposure unit (social, technical or non-human systems) actors that depend on climatic conditions such as rainfall and temperature which may result in low crop yield, stunted growth and/or crop failure in the study area. The theory focuses precisely on individuals and collective actors built around established concepts. It posits on the fact that actions require actors and must be supported by intentions. These intentions are geared towards the effects of stimuli-climate variability (Eisenack and Stecker, 2010). Moreover, adaptation requires the use of resources as means to achieve the intended ends. The action theory on adaptation is hereby regarded as an appropriate body of knowledge to put the study into a broad theoretical perspective within research and academic discourse (Figure 1').

The DFID (1999) "Livelihood Sustainable Framework" was adapted and modified to form a new model known as "Climate variability and livelihood adaptation strategies" which was specifically concerned with the shocks of climate variability and use of assets as livelihood strategies to address the menace.

The vulnerability context encompasses the external conditions within the environment which affect the people (maize farmers). Crucial trends coupled with trauma and their reoccurrence, over which people have little or no power, have a high influence on people's livelihoods and on the wider presence of assets. Not all of the trends and their reoccurrence must be considered as negative. Vulnerability is evident in the TND when maize farmers are faced with harsh conditions such as threat or shock of climate variability with insufficient capacity to respond appropriately. It is crucial in assessing the causes of poverty by determining risk and vulnerability of maize farmers as a result of the effects of climate vulnerability in TND. From Figure 2, in this context, risk refers to the possibility of events (external) of trauma, distresses, worries and their likely austerity, whereas vulnerability is the stage of disclosure to risk (hazard, shock) and doubt, and the ability of individuals or households (maize farmers) to prevent, minimize or cope with the risk due to

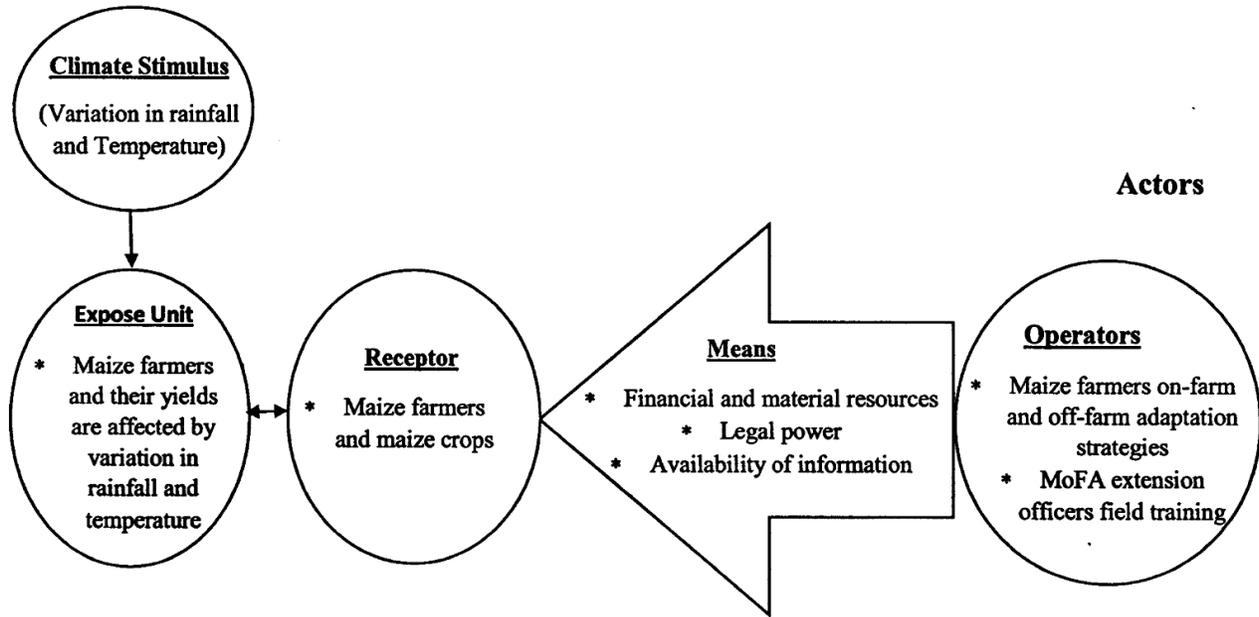


Figure 1. Schematic representation of some core concepts of the Action Theory of Adaptation. Source: Eisenack and Stecker (2010).

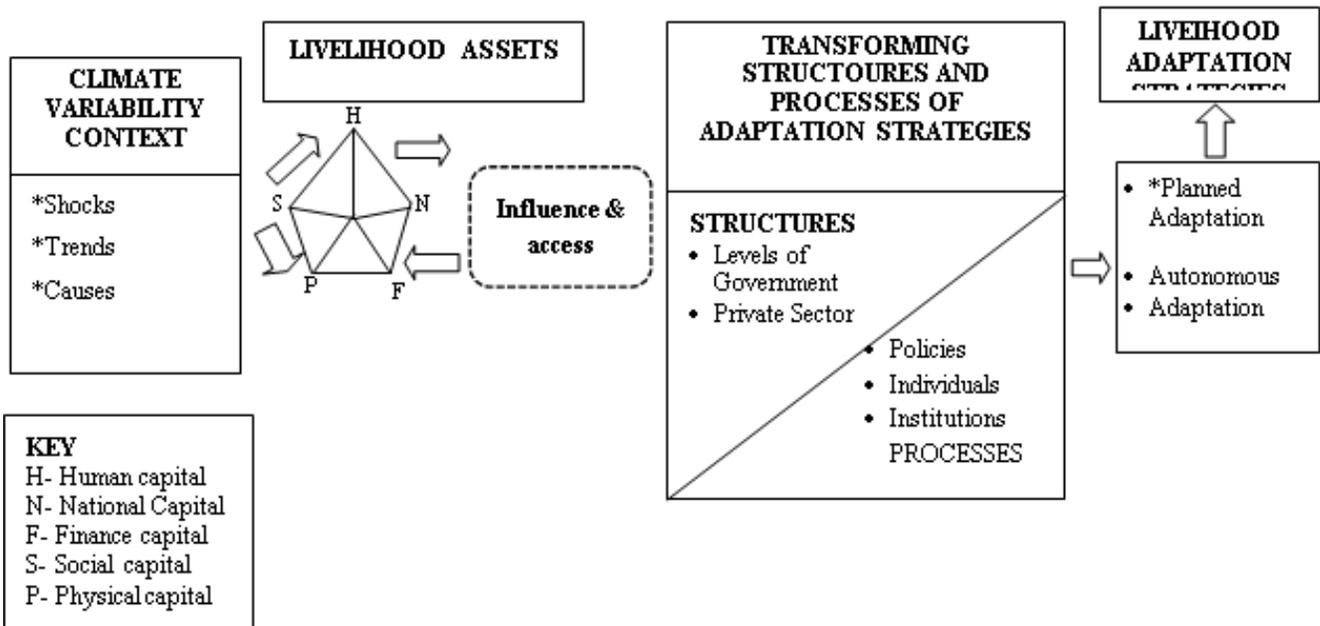


Figure 2. Climate variability and livelihood adaptation strategies. Source: Authors Construct (Adapted and modified from DFID, 1999).

the prevalence of climate vulnerability in TND.

The livelihood approach covers first of all the well-being of the people (maize farmers); it focuses on getting precise and pragmatic understanding of maize farmers' strengths (here called "assets"). It is critical to examine

how maize farmers try to transform these assets into positive livelihood outcomes. The approach is premised on the assumption that most people need several assets to obtain positive livelihood outcomes. Therefore, the SLF recognizes five types of assets or capitals of farmers

upon which livelihoods are assembled, these are; human capital, social capital, natural capital, physical capital and financial capital.

In addition, the availability of motorable roads, access to weather information and reliable energy/power support farmers' ability to produce maize yields in TND. Financial capital is the existence of Farmer Cooperatives Unions, Micro Finance Institutions, Rural Banks (Tano Rural Bank) and remittances from relatives of farmers which enable them to raise enough funds to cultivate maize on large tracts of land. Moreover, most farmers gain capacity from such financial sources to adapt to climate variability in times of low crop yield or crop failure in the District. The justification for the use of DFID's approach to agriculture sought to examine and identify shocks, trends, and causes of climate variability and the need to emphasize the farmers' livelihood assets as prerequisite for making on-farm and off-farm adaptation policies and subsequent implementation of the policies at the farm level to bring about the needed modification in the agriculture sector.

Maize production is isolated for study since it is a key staple food in Ghana and essentially in the study area. Besides, it is a commercial crop which is a source of livelihood for many farmers in Ghana and the study area in particular. Various reports by the Intergovernmental Panel on Climate Change (IPCC) (2013, 2014) have indicated that Africa is one of the most exposed continents to a lot of destruction due to effects of climate variability, because, it often lacks proper adaptation strategies. The threat of climate variability to national development in Ghana is acknowledged with commitments and efforts put in place to address the concerns by agriculturalists and Ghana Trade Unions (Otoo and Asafu-Adjaye, 2014). Matters concerning climate variability and agriculture have attracted the attention of a number of researchers and research institutions globally (IPCC, 2014; Manyeruke et al., 2013). This therefore affirms the existence of climate variability as a serious problem of concern for a developing country like Ghana since agricultural activities are dependent largely on climatic variables like rainfall and temperature, hence more research work must be conducted.

The study area, TND is importantly noted for the production of maize which is basically rain-fed (MoFA, 2013; GSS, 2014). Since agricultural (food crop cultivation) practices in the locality depend largely on rainfall, food security at the district level becomes threatened if the district is adversely affected by uncertainties in rainfall and temperature patterns, and other significant weather events. Also, climate variability poses a great threat to decreasing crop yields and/or crop failure, contributing to increased hunger due lack of food security. Indigenous farmers are not only enthusiastic bystanders of climate variability but are also actively trying to adapt to the changing conditions.

Moreover, literature has focused on either using

qualitative methods alone or purely quantitative methods to look at climate variability and crop production. However, the use of mixed method to study maize farmers' observed effects of variability in climate on crop yield is ill-explored. This study used the mixed method strategy.

Several studies have been conducted in Ghana on effects of climate variability on crop yield by researchers including Codjoe et al. (2013), Barimah et al. (2014), and Fosu-Mensah et al. (2012). These studies gave attention to the broad effects of climate variability on agriculture but not on maize farmers' observed effects of climate variability on maize yields. Also, a study conducted by Acheampong (2015), in Tano North District focused on the assessment of rainfed maize production but did not focus on maize farmers' observed effects of climate variability on maize yields. Therefore, from a reconnaissance survey, it was realised that in the study area, little work has been done on maize farmers' observed effects of climate variability on maize yields and the need for adoption of coping and adaptation strategies to climate variability. The need to beef up literature by gathering information required on maize farmers' observed effects of climate variability on maize yields and the adopted coping and adaptation strategies on and off the farm in Ghana, and the study site in particular, was thus necessary.

The objectives of the study were to

- (1) Analyze the effects of climate variability on maize yields in the Tano North District.
- (2) Examine the coping and adaptation strategies to improve maize production in the Tano North District.

MATERIALS AND METHODS

The district covers a total land area of 837.4 km² and constitutes about 1.8% of the total land area of the Brong-Ahafo Region (Ghana Statistical Service, 2014a). In relative terms, the Tano North District is located south east of the Brong-Ahafo Region of Ghana. The total population in TND is about 79,973 with 50.5% females and 49.5% males (Ghana Statistical Service, 2014b). Although the district has both rural and urban settlements, the rural settlements account for 55.4% whilst urban settlements account for 44.6%. The implication here is that the district has majority of the people in the district in the rural areas (Tano North Profile, 2010). The agricultural sector is the most important sector that provides employment opportunities for half of the district's working force. The dominant economic activities of the people in the district are primary economic activities such as agriculture, forestry, fishing etc. It employs about 62.5% of the labour force in agriculture, forestry and fishing (Tano North Profile, 2010).

Agriculture can be used as a focus for economic growth to result in decline in poverty rate in the district. Maize is seen as a major staple crop in the study area and is therefore cultivated by many farmers. Some maize farmers in the district have formed farmers' association to cater for the welfare of members especially during hard times (Tano North Profile, 2010).

The dominant soil type of the area is forest ochrosols, generally considered to be fertile and appropriate for growing a wide range of

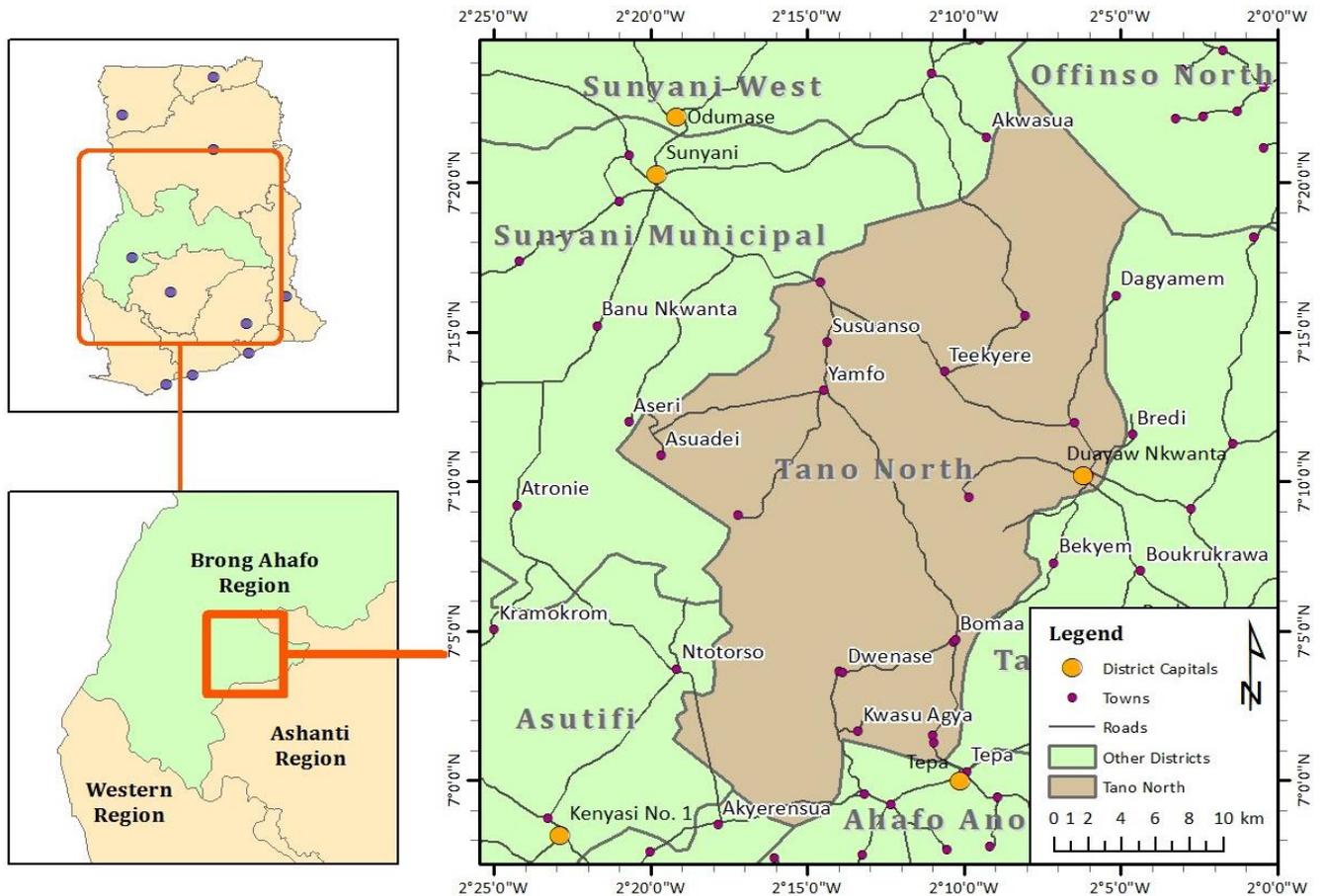


Figure 3. Tano North District map.
Source: Ghana Statistical Service (2014).

arable crops such as maize. The prevalence of climate variability has resulted in loss of some amount of soil moisture affecting crop yield including maize. The prevalence of climate variability in the study area threatens to transform natural ecosystems and disrupt human, social and economic systems that rely on them, perhaps to an unprecedented degree and within a relatively short and long time period respectively.

The area is dissected by Tano River and its tributaries including Subriso, Kwasu and Mankran etc. Rivers in the district are in the closed forest. The water bodies increase in volume in the rainy season due to heavy rainfall and erratic rainfall in the course of the year. The relatively high temperature results in drastic decline in the water volume in rivers and streams during the dry season. Some parts of the district are well drained especially where the place is noted for well-developed loamy soils that support the cultivation of arable crops whereas other parts are poorly drained due to the fact that the bedrock is an impermeable one and clayey soils (Ghana Statistical Service, 2014b). The Tano North District map is shown in Figure 3.

Sampling design and data collection

A pragmatic research philosophy was used for the study, which is a paradigm for social science research that advocates the use of mixed method and serves as a basis for supporting both quantitative

and qualitative approaches. The use of pragmatism in the past decades as a research method has become a novelty (Givón, 2014). This paper adopted the mixed method approach and cross sectional design which enabled the researcher collect quantitative data once from the respondents using the questionnaire instrument and interview whereas the qualitative method such as focus group discussion and observation helped the researcher to get in-depth understanding of the issues.

Multi-stage cluster sampling was used to cluster communities in the TND into urban areas, semi-urban and rural areas. Three communities within the study area were purposively selected. These were; Duayaw Nkwanta (urban area), Yamfo (peri-urban area) and Tanoso (rural area) in the Tano North District based on the intensity of agricultural activities, demographic characteristics, spatial location and climatic features of respective areas relevant to the study. Most of the households in the selected communities were predominantly engaged in maize farming in the TND.

A total of 135 maize farmers (45 from each community) were used for the study. The sample was selected from a total of 204 maize farmers secured from the office of the Ministry of Food and Agriculture (MOFA) at Duayaw Nkwanta. The distribution is indicated in Table 1.

The farmers from each community were screened to purposively select 45 respondents who had lived in the community for a minimum of 20 years. They served as eligible respondents for the survey. The selection of respondents in the study communities was

Table 1. Sample allocation.

Study community	Sample frame	Sample size	Males	Females	%
Duayaw Nkwanta	78	45	37	8	33.33
Yamfo	67	45	30	15	33.33
Tanoso	59	45	20	25	33.33
Total	204	135	87	48	100

Source: Author, 2018

conducted as follows; in the case of Duayaw Nkwanta, 45 eligible respondents were selected from the sample frame of 78 respondents through random sampling with preliminary questions to ascertain their suitability for the survey. To ensure uniformity in the sample size for all study communities, random sampling with preliminary questions were used to select 45 eligible respondents each from the sample frame at Yamfo (67) and Tanoso (59) respectively, thereafter the process was discontinued. Some initially showed little interest but were later convinced to participate in the survey. They were assured of confidentiality of response, avoidance of bias, ethical consideration and respectful treatment. Also, farmers were informed about the social value of the study which sought to bring modification in agriculture in the district to improve crop yield. Therefore, the respondents agreed to participate and gave informed consent.

Thereafter, all respondents agreed to participate in the survey. Two (2) other stakeholders each were purposively selected as key informants from the Ministry of Food and Agriculture (MoFA), and Ghana Meteorological Authority (GMA) to collect primary and secondary data respectively. The basis for the choice of the sample size was due to convenience in using the sampling method to make inference from the target population as well as generalization in relation to the adapted concepts and theories for the study.

The quantitative data was gathered through interview of respondents administered questionnaire in the field of study. The quantitative data collected were carefully examined, summarized, processed, coded using the Statistical Package for Social Sciences (IBM SPSS software version 18) and statistically analyzed using descriptive statistical tools like frequency with percentages and charts to present the final results. The researcher sought respondents' opinions and views using focus group discussions and by observing participants through their responses on effects of climate variability on maize found on maize yield. The qualitative data collected were analyzed thematically based on common themes in the different responses and direct quotations were used to support the themes to address the research questions. The purposive samplings of 15 respondents in a group were employed in selecting participants for a focus group discussion in each of the study communities. Data collection was done in September 2018.

RESULTS AND DISCUSSION

Demographic characteristics of respondents

Data on demographic characteristics of the respondents are indicated in Table 2. The study gathered demographic data from the respondents (maize farmers) who engaged in the cultivation of maize in the district. The results revealed that maize cultivation in the district was practised by both men and women. The majority 87(64.4%) of the respondents involved in this study within

the study communities were male farmers who served as heads due to culturally defined roles while 48 respondents representing (35.56%) were females who were spouses of household heads. This confirms the report by the Ghana Statistical Service (2014a) that more males are engaged in agriculture than females in the Tano North District. Both male and female respondents engaged in maize cultivation in the district. This is in line with observation by Ragasa et al. (2013), that maize is cultivated by men and women. However, the district's maize farming is dominated by males. Domestic obligations limit women and possibly cause gender disparity among maize farmers.

Age distribution in the study area revealed that 90(66.7%) respondents were within age group of 36 and 60 years, followed by 24(17.8%) respondents between 20 and 35 years and the minority of the maize farmers who were above 60 years were 21(15.6%). Since majority of the maize farmers were within the age group of 36 and 60 years, followed by age group of 20-35 years, the implication is that the farming population is economically active and has a relatively greater potential for sustainable maize production because they were strong and energetic. The relatively small number of farmers is above 60 years. This supports the assertion made by Bellon et al. (2011) that the age of the farmer would have a positive effect on technical incompetence in agriculture. The study area had high human capital for agriculture since, majority of the respondents were actively involved in periodic farm training by extension officers of MoFA, NGO's among others.

The results showed that 27(20%) of respondents had no formal education whereas 108(80%) of the respondents completed various levels of education such as Primary School, 19(14.1%); Junior High School/Middle School, 60(44.4%); Senior High School/Secondary School, 24(17.8%); and Tertiary/College/University, 5(3.7%). Education is very important to the success of farm practices such as storing and marketing maize, keeping records, making purchases of relevant farm inputs and helping with long term planning on farm management. However, low level of education is generally observed amongst farmers and this could affect their adaptation to climate variability. This is consistent with the assertion by Wamsler et al. (2012) in El Salvador and Brazil that low level of education was generally observed

Table 2. Demographic characteristics of respondents.

Socio-demographic characteristics	Frequency	Percentage
Sex		
Male	87	64.4
Female	48	35.6
Age (years)		
20 - 35	24	17.8
36 - 60	90	66.7
Above 60	21	15.6
Level of education		
None	27	20
Primary	19	14.1
Middle/JHS	60	44.4
Secondary/SHS	24	17.8
Tertiary	5	3.7
Farm size (acre)		
1 - 3	61	45.2
4 - 6	31	23.0
7 - 9	19	14.1
10 - 15	9	6.7
16 - 20	9	6.7
20 - 25	1	0.7
Over 25	5	3.7

Source: Author (2018).

amongst farmers and this could affect their comprehension of causes of climate variability and adaptation to climate variability. This situation may pose challenges to some farmers' ability to utilize the physical capital (the challenge of using modern farm equipments such as sprinkler machine, irrigation pumps, tractors, and combined harvesters) and ensure that high maize yields are produced by farmers in the District.

Lastly, it was realised that, majority of the respondents, 61(45.2%) had farm sizes between 1-3 acres of land; 31(23.0%) respondents had farm sizes of 4-6 acres of land; 13(28.9%) and 19(14.7%) respondents had farm size of 7–9 acres of land; and 24(17.8%) respondents had farm size above 10 acres of land respectively. There was disparity in the use of land across the study communities due to their demographic characteristics such as urban (Duayaw Nkwanta), peri-urban (Yamfo) and rural (Tanoso). It was realised that, though some farming activities occurred at urban (Duayaw Nkwanta), a larger portion of the land had been used for settlement development and commercial activities.

However, in rural (Tanoso) and peri-urban (Yamfo), most farmers had farmland between 1-7 acres, because the farmlands were located at a far distance coupled with little funds to secure the farmlands for crop cultivation.

This finding shows that greater proportion of the farmers had enough farmland for maize production; hence, access to land is not seen as a major obstacle to their farm work. This is in line with the report of MoFA (2010) that most of the farmers in Tano North district have farm sizes of not more than 10 acres.

The presence of natural capital such as suitable arable land for farming across the study communities enabled the smallholder maize farmers to produce maize yields for use all year round and further processing into its assorted goods through farming activities in the district.

Observation on rainfall and temperature patterns

Out of the total number of respondents (135) that were interviewed, 24 representing (17.7%) were between 20-35 years, 90 respondents (66.7%) were between 36-60 years, whilst 21 respondents representing (15.6%) were above 60 years old. It was realised from the total respondents of the study that, about (53%), (34%), and (14%) respondents noticed a reduced amount of rainfall, a reduction in the length of rainfall and erratic rainfall respectively, whilst 19 respondents cited increased length of rainfall season (Table 3). Specifically, across the age

Table 3. Respondents' observation of the manifestation of rainfall variation.

Age	Increased amount of rainfall	Reduced amount of rainfall	Increased length of rainfall	Reduced length of rainfall	Erratic rainfall	Total
	Frequency (%)					
20-35	2(13.3)	10(28.6)	3(15.9)	6(17.6)	3(21.4)	24(17.7)
36-60	10(66.7)	36(68.0)	12(63.2)	23(67.6)	9(64.3)	90(66.7)
Above 60	3(20.0)	7(13.2)	4(21.1)	5(14.7)	2(14.3)	21(15.6)
Total	15(100)	53(100)	19(100)	34(100)	14(100)	135(100)

Source: Field Survey (2018).

Table 4. Respondents' observation of the manifestation of rainfall variation on maize yields.

Study community	Increased crop yield	Reduced crop yield	Stability in crop yield	Stunted growth	Total
	Frequency (%)				
Tanoso	12(37.5)	18(32.1)	9(31.0)	6(33.3)	45(33.33)
Yamfo	10(31.3)	20(35.7)	10(34.5)	5(27.8)	45(33.33)
Duayaw Nkwanta	10(31.3)	18(32.1)	10(34.5)	7(38.9)	45(33.33)
Total	32(23.7)	56(41.5)	29(21.5)	18(13.3)	135(100)

Source: Field Survey (2018).

groups, majority, 36(68%) of the respondents between the ages of 36-60, 10(28.6%) between the ages of 20-35, and 7(13.2%) above 60 years had observed a reduced amount of rainfall season. This implies that the unstable, unpredictable, limited rainfall and irregular pattern of rainfall resulted in prolonged rainfall season. For instance, as a consequence of more years of experience, it is obvious, as anticipated that respondents within the ages of 31-60 years may have noticed a reduction in the amount of rainfall than respondents between the ages of 25-30 years. This report from the respondents is in line with the district's climatic data on rainfall trends. A key informant from GMA stated:

"Variations in the rainfall pattern have existed over the past years, and the rain does not come on time as expected" (In-depth interview with GMA Officer, 2018).

A female respondent in Duayaw Nkwanta, pointed out in a focus group discussion that:

"The rains are not forthcoming of late; therefore I always get worried on when to start sowing seeds at my farm". (Focus Group Discussion, 2018).

Observation on changes in maize yields due to climate variability

With regard to farmers' observation of manifestation of rainfall variation on maize yield, majority, 56 (41.5%) of the respondents across three communities noticed that

variation in rainfall has resulted in reduced crop yield in the 20-year period whilst 32 (23.7%) respondents noticed increase in crop yield. Out of the 56 (41.5%) respondents, 20(35.7%) were from Yamfo while Tanoso and Duayaw Nkwanta were represented by 18(32.1%) each. About 32 (23.7%) of the respondents reported that variation in rainfall has resulted in increased crop yield from Tanoso, Yamfo and Duayaw Nkwanta. About 29(21.5%) of the respondents reported stability in growth and 18(13.3%) of the respondents reported stunted growth (Table 4). This outcome indicates that, variations in rainfall have resulted in reduced crop yield over the past 20-year period. Also, it was realised that, respondents in Yamfo had perceived a variation in rainfall more than respondents in both Tanoso and Duayaw Nkwanta respectively. The variation in rainfall is observed when the amount of rainfall received varies across the area over time. Rainfall is a major determinant of crop yield within a given growing season.

With regard to this, a key informant from GMA narrated:

"Variations in the rainfall pattern have existed over the past years, and the rain does not come on time as expected" (In-depth interview with GMA Officer, 2018).

This was supported by a male farmer in Yamfo who pointed out in a focus group discussion that:

"So many years ago, boreholes, wells, streams and rivers had enough water during the wet season which helped us to store water for use in the dry season, but nowadays

Table 5. Respondents' observation of the manifestation of temperature variation.

Age	Increased rate of temperature	Decreased rate of temperature	Temperature fluctuations	Stable temperature	Do not know	Total
Frequency (%)						
20-35	10(19.6)	3(15.0)	8(21.6)	1(9.1)	2(12.5)	24(17.7)
36-60	32(62.7)	15(75.0)	24(64.9)	8(72.7)	11(68.7)	90(66.7)
Above 60	9(17.6)	2(10.0)	5(13.5)	2(18.2)	3(18.8)	21(15.6)
Total	51(100)	20(100)	37(100)	11(100)	16(100)	135(100)

Source: Field Survey (2018).

Table 6. Respondents' observations on the temperature variation and maize yields.

Study community	Increased maize yield	Reduced maize yield	Stunted growth	Crop failure	Total
Frequency (%)					
Tanoso	3(37.5)	18(33.3)	13(30.3)	11(36.7)	45(33.33)
Yamfo	2(25.0)	18(33.3)	15(34.9)	10(33.3)	45(33.33)
Duayaw Nkwanta	3(37.5)	18(33.3)	15(34.9)	9(30.3)	45(33.33)
Total	8(5.9)	54(40.0)	43(31.9)	30(22.22)	135(100)

Source: Field Survey (2018).

there isn't much rains. This is because the amount of rain over the years has reduced drastically. The rains are no longer reliable for supply of water to the crops" (Male discussant, Focus Group Discussion, 2018).

Out of the total number of 135 respondents across all ages, it was gathered that, about 51 and 37 respondents observed an increased rate of temperature and temperature fluctuation respectively (Table 5); 32(62.7%) of respondents between 36 and 60 years indicated an increased rate of temperature; whilst 9(17.6%) respondents above 60 years indicated increased rate of temperature. Also, 24(64.9%) respondents between 36-60 years observed temperature fluctuation; and 8(21.6%) respondents between 20-35 years and 5(13.5%) respondents similarly noticed temperature fluctuations respectively (Table 5). The results imply that, climate variability over the past 20 years causes variations with temperature by increasing temperature within the various study communities making these communities hot. This finding is consistent with assertion by IPCC (2013) which states that Africa is one of the continents mostly influenced by climate variability due to 1°C increase in average annual temperature in the last 30 years (1970 – 2000). The causes of the increasing temperature trend in the district were reinforced by the assertion made by one of the meteorological attendants who stated that:

"The result of increased rate of destruction to forest resources in this area is responsible for the high temperature we are experiencing nowadays. If we

continue to fell down trees, the temperature will increase more than what we are experiencing today. My worry is uncertain nature of the temperature" (In-depth interview, 2018).

Again, this was supported by a report by a male farmer who narrated in a focus group discussion that:

"The release of harmful gases into the atmosphere has contributed to intense heat felt during the day. This has negative effect on the farmers' health from day to day" (Focus Group Discussion, 2018).

With regard to farmers' observation of manifestation of temperature variation on maize yield, out of the total number of 135 respondents interviewed, majority, 54 (40.0%) of the respondents were of the view that variation in temperature has resulted in reduced crop yield in the past 20 years; about 43 (31.45%) of the respondents cited stunted growth (Table 6); while 30 (22.2%) respondents cited crop failure. This is in line with the assertion made by Peprah (2014) that temperature trend in all the regions shows increase in the past 30 years. This result implies that variation in temperature has caused a reduction in crop yield. This buttresses the observation in Table 6 that increase in temperature is a function of climate variability which makes it difficult for maize farmers to realize maximum crop yield.

The causes of the increasing temperature trend in the district were reinforced by the assertion made by one of the weather station attendants who retorted:

Table 7. On-farm adaptation strategies to climate variability by gender of maize farmers.

Gender	Application of agro chemical	Crop diversification	Changes in farm location	Irrigation of crop	Mixed cropping	Change in planting date	Changes in crop varieties	Total
Frequency (%)								
Males	39(44.8)	22(70.97)	12(63.16)	6(66.67)	4(44.45)	0(0.0)	4(80.00)	87(64.44)
Females	22(45.8)	9 (29.03)	7(36.84)	3(33.33)	5(55.55)	1(100)	1(20.00)	48(35.56)
Total	61(45.2)	31(23.0)	19(14.1)	9(6.7)	9(6.7)	1(0.7)	5(3.7)	135(100.0)

Source: Field Survey (2018).

“The result of increased rate of destruction to forest resources in this area is responsible for the high temperature we are experiencing nowadays. If we continue to fell down trees, the temperature will increase more than what we are experiencing today. My worry is uncertain nature of the temperature will affect crop yield” (In-depth interview with GMA officer, 2018).

In line with this, a male discussant in a focus group discussion at Tanoso said:

“The amount of maize yields obtained at the end of the farm season has reduced drastically over the past years. This could be as a result of high temperature coupled with unpredictable rainfall pattern for some years. For some years, there is high rainfall, uninterrupted by a long period of drought; we are losing our means of livelihood. We cannot save to build assets for our future” (Male discussant, Focus Group Discussion, 2018).

Based on the local perception of respondents’ observation of climate variability and its effects on maize yields, the study revealed a decreasing trend with significant variation in the rainfall pattern and increased rate of temperature pattern. Therefore, the study area has experienced variability in climate and significant climatic events in the past 20 years (1995 - 2015). This finding confirms the estimation by Egyir et al. (2015) that temperature will continue to rise, whereas rainfall is also forecasted to decrease in all agro-ecological zones in the country. This buttresses the observation that climate variability affects the rate of temperature increase making it difficult for maize farmers to harvest adequate crop. However, the finding of the study shows that majority of the respondents in Yamfo observed the manifestation of climate variability on maize followed by Duayaw Nkwanta and Tanoso respectively.

These fulfil findings of the Action theory of the study which explains that the exposure of farmers to variability in climate is an indication of their vulnerability to variability in climate hence, the need for adaptation strategies to variability in climate. As such, it is important that strategies for adaptation should be encouraged. This seeks to relate the conceptual framework of the study “Livelihood Adaptation Strategies to variability in

Climate”. The responses from the respondents revealed that rainfall and temperature had a significant influence on maize production which is a means of livelihood. Thus, maize production in the district is mainly dependent on rainfall and temperature.

On-farm and off-farm adaptation strategies to climate variability by gender of maize farmers

The distribution of respondents using on-farm adaptation strategies to reduce the shocks of climate variability by gender and distribution by sex of respondents is indicated in Table 7.

With regards to the application of agro chemicals on farm adaptation strategy (Table 7), the results indicate that, 61 respondents (45.1%) employed application of agro chemicals as a strategy in TND to minimize shock of climate variability. The results further revealed that 39(44.8%) male respondents had cited application of agro chemicals as a strategy, whilst 22(45.8%) female respondents cited application of agro chemicals as a strategy including the use of chemical products such as fertilizers, pesticides, fungicides and herbicides on the farm so as to ensure improved yield. It was revealed that male respondents served as the head of the family, who had the financial strength to purchase agro chemicals as well as possess the muscular energy required to apply agro chemicals throughout the farm with ease, whereas few female respondents employed application of agro chemicals as a strategy due to overburdening with domestic roles at home. These include child bearing and house chores like caring for kids, cooking, washing, sweeping, among others. The inability of most female farmers to secure agro chemicals for crops due to financial constraints was confirmed by Egyir et al. (2014) who asserted that adoption of modern on-farm adaptation strategies such as the use of agro-chemicals by farmers who had access to capital was higher than those who lack access.

This was evident during the Focus Group Discussion in Tanoso when a female respondent narrated that:

“The application of pesticides is expensive everywhere in the town; however, without applying it, the maize yields

will be small at the end of the farm season” (Female discussant, Focus Group Discussion, 2018).

With emphasis on use of crop diversification as the on-farm adaptation strategy (Table 7), the results show that, 31(44.8%) respondents affirmed it as a measure employed to reduce the shocks of climate variability. The results indicate that, 22(25.3%) male farmers selected crop diversification as strategy whilst 9(18.8%) female farmers selected crop diversification as a strategy to climate variability. This indicates that, gender influences the choice of adaptation strategy selected by maize farmers. Majority 22(25.3%) of the respondents were male farmers because of their roles performed on the farm during pre-harvest farm operations such as land acquisition, land clearing, ridging, planting, operation of farm inputs, high labour contribution among others which have equipped them to diversify cultivation of crops. This finding is consistent with the view of Uddin et al. (2014) who observed that male farmers adopt crop diversification to reduce the overall farm risk and expand opportunities for farm profit, which generally boosts their average incomes. The statement below was cited in support of the assertion above during the focus group discussion at Tanoso:

“Menial job I did during the off-farm season has enabled me to get substantial amount of money to cultivate food crops such as yam, potatoes, cocoyam, and vegetables such as okro, tomatoes, pepper etc” (Female discussant, Focus Group Discussion, 2018).

For the use of change in farm location as an on-farm adaptation strategy (Table 7), the results show that 19(14.1%) female respondents affirmed change in farm location. The results by gender indicate that 12(13.8%) male farmers selected change in farm location as a strategy whilst 7(14.6%) female farmers selected change in farm location activities as adaptation strategy. It was realised that female respondents owned a lot of farmlands than male respondents who acquired most of their farm lands on lease. This could be attributed to the reason why female respondents change farm location than male respondents.

This finding supports the view of the studies of Onoh et al. (2014), Obayelu et al. (2014) and Uddin et al. (2014) that change in farm location was among the least preferred on-farm adaptation strategies.

A male discussant at Duayaw Nkwanta during a focus group discussion stated:

“Change in farm location is a very important strategy when faced with the effects of climate variability but the cost involved in securing another plot of land for farm activities is very huge” (Male discussant, Focus Group Discussion, 2018).

With respect to the use of irrigation as on-farm adaptation

strategy (Table 7), the results show that 9(6.7%) respondents affirmed the use of irrigation. The results by gender show that 6 (6.9%) male farmers cited irrigation of crop as a strategy whilst 3(6.3%) female farmers cited irrigation of crop activities as a strategy in response to climate variability especially during long periods of drought. Those who had easy access to water sources used irrigation equipment such as knapsack sprayer, sprinklers etc. which result confirms various reports by the IPCC (2013, 2014) that Africa is one of the most exposed continents to a lot of destruction due to effects of the climate variability, because, it often lacks proper adaptation strategies. This was evident during the Focus Group Discussion at Tanoso when a male respondent narrated:

“Supply of water to maize plant is very important for their survival, but most of the water sources are not available; therefore, I rely on carrying water from streams far away to my farm for the crops” (Male discussant, Group Discussion, 2018).

With emphasis on the use of mixed cropping as on-farm adaptation strategy, the results show that 9 (6.7%) respondents affirmed the use of mixed cropping (Table 7). About 4(4.6%) male farmers cited mixed cropping as a strategy whilst 5(10.4%) female farmers cited mixed cropping as a strategy. Thus, female farmers employed mixed cropping strategy more than male farmers in response to climatic variability in TND. The maize farmers that cited mixed cropping as an adaptation strategy confirmed that the measure was effective. This observation is consistent with the studies of Obayelu et al. (2014), Onoh et al. (2014), Ndamani and Watanabe (2015), Ifeanyi-Obi and Nnadi (2014), and Uddin et al. (2014) that mixed cropping was an effective adaptation strategy employed by farmers.

In a focus group discussion, a male respondent at Duayaw Nkwanta said:

“Mixed cropping such as growing vegetables like okro, garden eggs, tomatoes, pepper, at Duayaw Nkwanta relieve farmers from the effects of climate stimulus. However, I am in need of a hybrid variety of these vegetables which can withstand variability of the climate” (Male Respondent, Focus Group Discussion, 2018).

On the issue of change in planting date as on-farm adaptation strategy, the results show that 1 (2.1%) female farmer cited change in planting date across the study communities (Table 7). It was realised that change in planting date as adaptation strategy was least preferred by farmers because of their inability to access adequate information on weather from the district's weather station. Due to this situation, the respondents were not certain of the onset of rains at the beginning of the main season as well as the minor season for planting of maize. This supports the view of Cook et al., (2013)

Table 8. Off-farm adaptation strategies to climate variability by gender of maize farmers.

Gender	Migration	Trading	Poultry and livestock rearing	Transport business (Tricycle)	Total
	Frequency (%)				
Males	23(26.4)	22(25.3%)	25(86.20)	17(94.45)	87(64.44)
Females	9(18.8)	34(60.71)	4(13.80)	1(5.55)	48(35.56)
Total	32(32.7)	56(41.5)	29(21.5)	18(13.3)	135(100)

Source: Field Survey (2018).

who observed that variation in the onset of rains and seasonal rainfall and temperature variations can exacerbate water available for crop production.

This affirms what the officer at the weather station said as follows:

“The weather station is not solely meant for delivery of weather information to the maize farmers in the District but for all other stakeholders. The officers at the weather station are not always compelled to provide maize farmers with weather information. But I am of the view that, provision of weather information enables them to adapt well to climate variability by either planting maize early or at a late date among others” (Officer, GMA).

With regard to change in crop variety as an on-farm adaptation strategy (Table 7), the results indicate that 5(3.7%) farmers cited change in crop variety as a strategy to minimize the prevalence of climate variability. Thus, it was among the least preferred adaptation strategies by respondents in the district. The results show that, 4(4.6%) male respondents and a single female respondent 1(20.0%) cited change in crop variety as adaptation strategy. This could be attributed to the low level of knowledge among most of the respondents about the benefits of hybrid varieties of maize such as ‘Dorke SR’ and ‘Dodzie’ in the study area. Also, it was realised that, most buyers in the market request for the traditional variety such as ‘Aburotia’ than the hybrid variety. This finding is contrary to studies by AGRA (2014), who observed that improved crop varieties lessen farmers’ vulnerability in that they mature much faster and are hence less likely to be adversely affected by climate change compared with the traditional varieties.

In a focus group discussion at Tanoso, a male discussant said:

“I usually plant early local varieties of maize like ‘Aburotia’, which most often provide high yield. Therefore, I am not ready to try any hybrid variety of maize on my farm any time soon” (Male Respondent, Focus Group Discussion, 2018).

The distribution of respondents using off-farm adaptation strategies to minimize the menace of climate variability by gender and distribution by sex of respondents is indicated in Table 8.

According to the use of migration as an off-farm adaptation strategy (Table 8), the results show that, 32(23.7%) respondents employed the use of migration as a strategy to reduce the menace of climate variability. The results further indicate that 23(26.4%) male farmers and 9(18.8%) respondents were female farmers. This is evident that the male farmers employed migration as an off-farm adaptation strategy more than female farmer in response to climate variability in the TND. The finding supports the view of Gbegeh and Akubuilu (2013 cited in Oremo, 2013) that the socio-demographic characteristics of a respondent may influence the decision to adopt a particular adaptation strategy.

A male respondent at Tanoso during FGD sessions had this to say:

“I travelled to the city of Kumasi for casual work such as waiter, head porter, house help etc. during the dry season. This casual works were very beneficial because it enabled me to raise funds to cater for farm activities in the next farm season” (Male discussant, Focus Group Discussion, 2018).

With regard to trading as an off-farm adaptation strategy (Table 8), the results indicate that 56(41.5%) respondents engaged in trading as an adaptation strategy, and that trading was the most preferred off-farm adaptation strategy by respondents in the district. Table 8 shows that, the female respondents employed trading as their off-farm adaptation strategy more than the male respondents in response to variability in climate.

This narrative by female discussants in Duayaw Nkwanta supported the assertion above during FGD session that:

“The sale of provisions is good for me due to increase in prices of goods on the market at the lean season. The income from trade is used for securing farm needs including fertilizer, and pesticides” (Female discussant, Focus Group Discussion, 2018).

With emphasis on the use of poultry and livestock rearing as an off-farm adaptation strategy to reduce the menace of climate variability (Table 8), the results show that 29 (21.5%) respondents employed poultry and livestock rearing as adaptation strategy; 25(28.7%) male

respondents and 4(8.3%) female respondents cited the use of poultry and livestock as adaptation strategy in the district. Similarly, livelihood activities, for instance, rearing of poultry birds like chicken, ducks, guinea fowls and livestock like goats, sheep, pigs, and cattle are mostly reared on free range in the study area. Therefore, such labour intensive jobs such as rearing of livestock are presumed to be done by more males than females. This attests to the fact that, male respondents gained much income to better adapt to climate variability than female respondents.

A male farmer at Yamfo during a focus group discussion narrated that:

“Rearing farm animals provides me with many economic benefits. Also, livestock like goats and sheep reared at home, help to provide meat needs of the family. In addition, I use the faeces of the farm animals as organic manure on the farm” (Male discussant, Focus Group Discussion, 2018).

According to the use of transport business as an off-farm adaptation strategy (Table 8), the results show that, 18(13.3%) respondents employed the use of transport business as an off-farm adaptation strategy in the district. The result shows that 17(19.5%) male respondents and 1(2.1%) female respondent in the district employed the transport business as a strategy. This implies that, transport was among the least preferred adaptation strategy, as male respondents employed transport business as adaptation strategy more than female respondents. This suggests that male respondents are more likely to engage in transport business as an alternative livelihood activity than female respondents.

A male discussant at Duayaw Nkwanta reiterated the importance of transport business during a Focus Group Discussion that:

“I am a farmer and driver at the same time; so during off farming season, I join the booming transport business to transport people and goods from one area to another across the town” (Male discussant, Focus Group Discussion, 2018).

Conclusion

The study sought to determine respondents' observation of the effects of climate variability on maize yields and analyze the coping and adaptation strategies to improve maize production. This outcome establishes that, variations in rainfall have resulted in reduced crop yield in the 20-year period (1995 - 2015). Besides, the variation in temperature has caused a reduction in crop yield. This buttresses the observation that climate variability makes it difficult for maize farmers to harvest abundant crops. The finding of the study shows that majority of the respondents in the study area have observed the

manifestation of climate variability on maize. Also, the findings of the study revealed that both male and female respondents employed coping and adaptation strategies. It was realised that male respondents employed majority of the most preferred on-farm adaptation strategies such as application of agro chemicals, crop diversification, change in farm location, irrigation and off-farm adaptation strategies like migration, trading, poultry and livestock rearing than the female respondents interviewed in the study area.

The findings of the study revealed that, male respondents employed majority of the preferred on-farm adaptation strategies and off-farm adaptation strategies compared to female respondents interviewed in the study area. This implies that, the male respondents were more successful in employing most of the on-farm and off-farm adaptation strategies than the female respondents in the study area. Thus, the proposition that gender is a determinant of maize farmers' success of adaptation strategies to climate variability is vindicated. This implies that, the male respondents were successful in employing most of the on-farm and on-farm adaptation strategies than the female respondents in the study area. The mixed method design has also been amply justified and used to bring clarity to the issue investigated.

To address climate related challenges with national food production, there is a need for stakeholders such as GMA and MoFA through their field officers and extension services to translate the available knowledge and experiences to farmers on adaptation to climate variability through the design and implementation of evidence-based interventions. These include assisting the maize farmers with vital weather information, requisite skills and training to adapt well to the shocks of climate variability. Also, the extension officers of MoFA, must monitor the maize farmers with low literacy skills in the study area to provide them with training on farm management skills for effective adaptation to climate variability. The study further recommends that there must be improvement of existing farm facilities and provision of agricultural infrastructure such as irrigation facilities in the Tano North District. The Government and Non-Governmental Organizations must set up a support scheme for maize farmers to secure their farms and crop yields in times of crop failure. Also, the funds given to them could be used to secure hybrid and drought resistant varieties, fertilizer, and farm inputs to enable maize farmers equip them with the needed materials for producing high crop yield.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

Author Contribution

Both authors contributed substantially to the completion and success of the study.

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