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Full Length Research

Farmer's observation on climate change impacts on maize (*Zea mays)* production in a selected agro-ecological zone in Ghana

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Although maize farmers may not have a clear understanding of climate change, they live close to natural resources and are among the first in perceiving and reacting to environmental changes. They have observed and felt the effects of decreasing rainfall, emphasizing changes in the regularity, length, intensity and timing of rainfall; increasing air temperature, increasing sunshine intensity and seasonal changes in rainfall pattern which is affecting their farming practices. Moreover, farmers are also aware of the interacting effect between bad management practices and changes in climate. For instance, deforestation and clearing of riparian vegetation is considered a major factor increasing soil erosion; the use of agricultural chemicals close to the rivers and streams create hazards for the environment. The study indicates that changes in the onset and cessation of rain have negative impact on maize production and this pose a serious threat to household food security since maize is the staple food of most Ghanaians. Consequently, effective and efficient adaptation and mitigation measures should be promoted to prepare stakeholders in maize production systems to enhance their resilience and flexibility.

Key words: Climate, Maize farmers, maize, Ghana, rainfall.

INTRODUCTION

Climate variability and change have been and continue to be, the principal source of fluctuations in global food production in countries of the developing world where production is highly rain dependent (Oseni and Masarirambi, 2011). In Ghana, agricultural production is mainly rainfed with the arable lands under irrigation being less than 2% (MoFA, 2003; GIDA, 2010). Rainfall however has seen a decline over Ghana since the 1970s and has only begun to increase slightly since 2006 (Owusu and Waylen, 2012; Lacombe *et al*., 2012).

Maize is produced on nearly 100 million hectares in developing countries, with almost 70% of the total maize production in the developing world coming from low and lower middle income countries (FAOSTAT, 2010). In large parts of Africa maize is the principal staple crop accounting for up to 51% of consumed calories. The crop has seen increasing production since 1965 (FAO, 2008; Morris *et al*., 1999). It is the number one crop in terms of area planted and accounts for 50-60% of total cereal production. Additionally, maize represents the second largest commodity crop in the country after cocoa (Millennium Development Authority, 2010). Maize production plays a vital role in food security for many poor households in Ghana (MoFA, 2011) with a per capita consumption of

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over 100 kg while also serving as a cash crop (FAO, 2008). A national survey carried out in 1990 revealed that over 94% of all households consume maize (Alderman and Higgins, 1992). Boateng *et al*. (1990) had earlier found that maize and maize-based food accounted for 10.8% of the total food expenditure of all households in Ghana. Maize production forms 45% of agricultural production which remains the main source of livelihood for most Ghanaian, providing employment to more than 60 percent of the population and contributing about 30% of gross domestic product (ISSER, 2011). Maize production contributes over 20% of incomes earned by smallholder farmers in Ghana (Acquah *et al*., 2012). Maize is thus one of the most important crops for Ghana's food security.

In Ghana, maize is produced predominantly by smallholder resource poor farmers under rainfed conditions (MoFA, 2011), resulting in high yield fluctuation mainly determined by rainfall changes and to lesser extent market forces. Consequently, the overall maize production in the country has remained relatively unstable both in terms of area harvested and volume because of reliance on traditional farming methods. Under traditional production methods and rainfed conditions, yields are well below their attainable levels – maize yields in Ghana average approximately 1.5 metric tons per hectare (FAO, 2008). However, yields as high as 5.0-5.5 metric tons per hectare have been realized by some farmers using improved seeds, fertilizer, mechanization and irrigation in years with favourable rainfall. Maize farming practices have improved with the adoption of improved technologies by farmers. These technologies include improved seeds like hybrid and open pollinated varieties, timely planting, proper spacing, timely weeding and harvesting. Minimum or zero-tillage has also been encouraged in recent years with the use of herbicides.

Agriculture is inherently sensitive to climate conditions and is one of the most vulnerable sectors to the risks and impact of global climate change (Parry *et al*., 1999). Considerable research has occurred on the effects of weather/climate on agricultural production, but few have focused on the effects of climate change on maize production in Ghana. Anderson and Hazell (1987) argued that adoption of common high-yielding varieties, uniform planting practices and common timing of field operations have caused yields of many crops to become more strongly influenced by weather patterns, especially in developing countries.

This study therefore examines the challenges faced by smallholder maize producers in the transition agro-ecological zone of Ghana.The study assesses farmers' perceived climate changes in recent decades, and uses those perceptions to give a context for further analysis of their responses to changing climate.The study then assesses the local strategies maize farmers use to cope with climate change and variability. The study concludes with lessons drawn from this work that can inform policy and decision making to improve maize production and food security of households in Ghana.

METHODOLOGY

The study areas

The study was conducted in the Ejura-Sekyedumase district of the Ashanti Region and the Wenchi Municipality in the Brong-Ahafo Region of Ghana. The two areas are located in the transition agro-ecological zone of Ghana. The study used randomly selected communities in two districts. In the Ejura-Sekyedumase district, the study focused on Ejura, Sekyeredumase, Duaponko-Nwoase, Subingya, Nkoranza, Nkwanta and Teacherkroum while in Wenchi district, the study focused on Twumkrom, Wenchi, Akrobi, Subenso, Mpeasem and Tromoso. The transition zone is a forest-savanna ecotone between the Guinea Savanna of the north and the Semi-deciduous forest of the south. It coincides with the Ghana Meteorological Agency (GMet) Zone C agro-ecological zone (Figure 1). It runs from west to east between approximately 5°N to 8°N roughly in accordance with the regional rainfall pattern. Considering human impact on the vegetation of the zone, its current state might be described as a savanna-forest mosaic, with mean annual rainfall between 1,200 mm and 1,500 mm, declining towards the north. The migrating Inter-Tropical Convergence Zone (ITCZ) and monsoons produce peaks of rainfall in May/June and September/October. The major rainy season begins in late March/early April and runs until mid July. This is followed by a short dry spell in July–August and the minor rainy season of September–October, which precedes the November–March long dry season. Figure 2 shows monthly rainfall for the Wenchi station in agro-ecological zone C. The rainfall regime is associated with a high degree of year to year variability of the onset of each rainy season and particularly so at the beginning of the minor rainy season (Owusu and Waylen, 2012).

Data and methods

The study utilized focus group discussion (FGD) and key informant interviews for primary data collection. The FGD was conducted in each of the selected study communities with an average size of8 farmersper group. The small number allowed every farmer to have the opportunity to share in the discussion. In Teacherkrom and Subensoa FGD was conducted with settler farmers who have the additional burden of land ownership to deal with in the face of climate change. A total number of 268 maize farmers were interviewedof which 70 were women. In each community, two opinion leaders/large scale farmers identified by the district agricultural officer were also

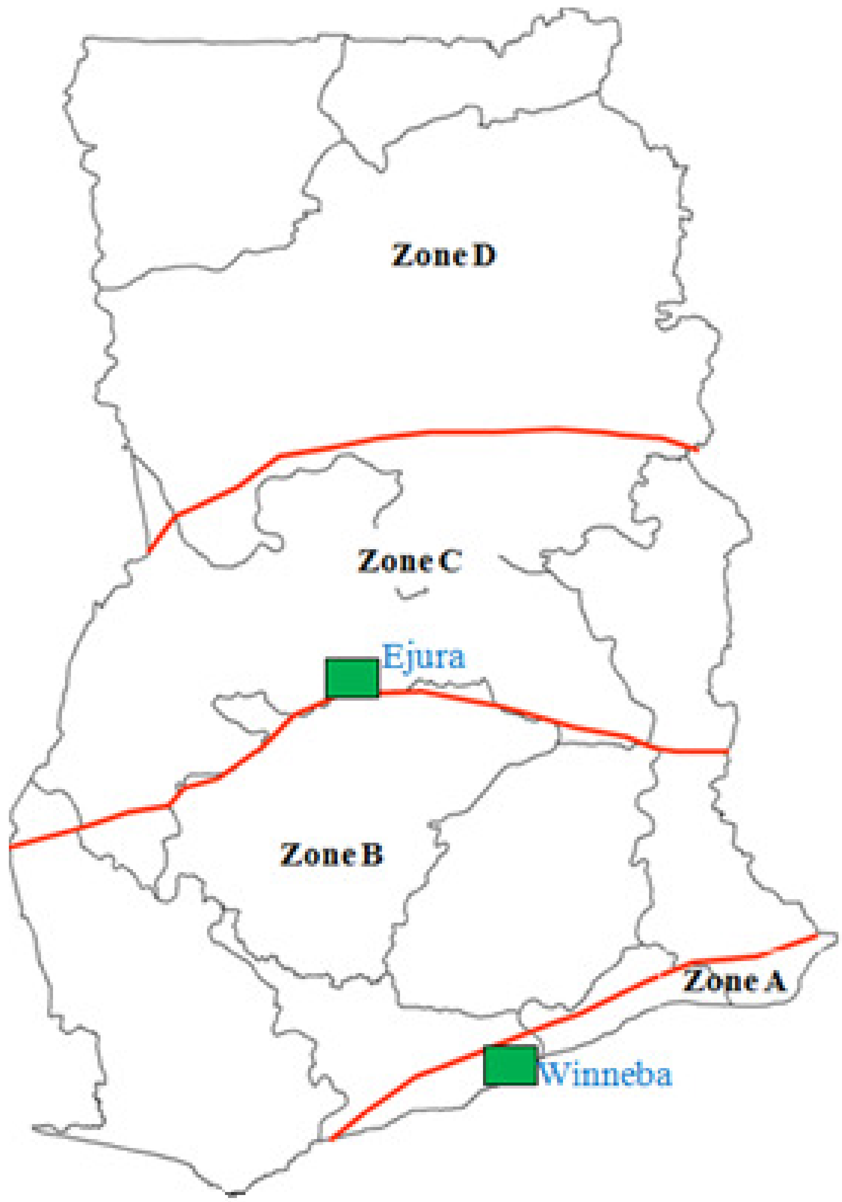

Figure 1. The Ghana Meteorological Agency Agro-ecological zones of Ghana

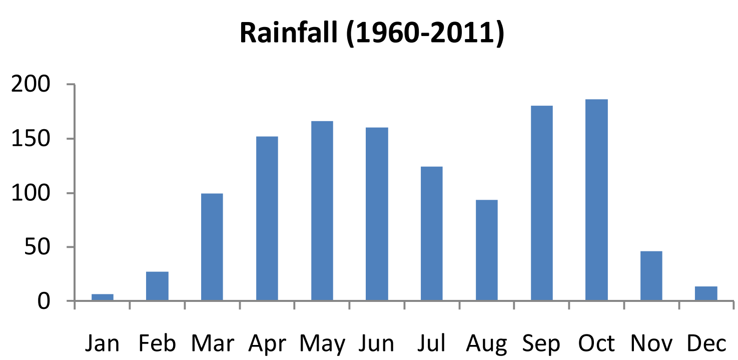

Figure 2. Mean monthly rainfall pattern for the Wenchi station in agro-ecological zone C from 1960 to 2011.

Table 1. Demographic characteristics of maize farmers interviewed.

Community	Total No. of farmers	No. of Male famers	No. of Female farmers	Average age (years)	Farm size (hectares)	Average family size	Average years of farming experience	Average level of education
Twumkrom	29	20	09	35	3-5	4	12	6
Ejura	39	24	15	30	20-40	5	17	6
Sekyeredumase	15	10	5	40	6-10	4	10	8
Wenchi	37	29	8	40	10-40	5	21	8
Akrobi	17	12	5	25	1-2	4	13	7
Subenso	16	13	3	30	11-15	5	12	6
Tromoso	14	12	2	45	3-5	4	13	9
Teacherkrom	02	1	1	30	40-50	4	15	9
Nkwanta	27	23	4	35	11-15	5	20	9
Mpeasen	22	17	5	30	3-5	5	18	6
Nkoranza	18	12	6	40	11-15	5	21	5
Subingya	14	11	3	35	3-5	4	17	6
Duaponko-Nwoase	18	14	4	30	3-5	5	18	6

interviewed.

The following information wassought during the interviews.

i. Biodata of farmers
ii. Educational level
iii. Gender
iv. Information on farm activities – farm size, crop types, degree of mechanization, sources of seed and types of hybrids chosen
v. General impacts of changes in rainfall on their maize activities
vi. Estimation of yield comparing 30 years ago and present
vii. Coping/adaptation strategies
viii. Challenges to farmers from climate change
ix. Other factors like the use of fertilizer, loss of soil fertility
x. Information on Second/Minor Season farming yield
xi. Where and how farmers get information to guide their decisions and how they use the information

To corroborate the information provided by the farmers, district agricultural officers or their representative were also interviewed for their expert opinion on rainfall changes and its challenges for maize production over the last two decades. Other information sought from the district officials were the role of government in maize production in the transition zone and the general institutional support for adaptation.

RESULTS AND DISCUSSION

The average years of farming, experience ranged 10 and 21 years and level of educational attainment was 5-9 years (Table 1). The implications of these results are that the farmers have acquired many years of farming experience, however, majority of the farmers were not literate enough to understand and/or implement a modern system of farming and adopt new technological innovation in agriculture to enhance productivity. Although the farmers get some interventions from the advice of extension officers, the high level of illiteracy among the farmers (Table 1) in the study area may be detrimental to agricultural productivity. Table 1 shows that the average level of formal education of farmers ranges from 5 to 9.

Farmer's perspective on climate change

From the FGD, it emerged that farmers have experienced reduction in rainfall amounts and changes in the rainfall regime. It was reported that there have been changes in the onset and as well as the cessation of rainfall for the rainy seasons in recent decades. They believe that the situation is mainly due to changes in rainfall patterns, which they cannot predict for their planting dates. Farmers reported the changes in the rainfall pattern to have occurred over the past 15 - 20 years but the effect has been especially severe the past 3 years. This observation is consistent with typical behavior in which recent harsh condition are remembered more clearly than older events.

At Twumkrom, a general question about observations on climate variability raised interesting points for discussion. The farmers stated that in the past, the major raining season started around the end of February but presently it starts around April, i.e. it starts late. They also reported that the rains stop early. The rainfall pattern in this community has generally worsened, and it is affecting crop production in both the major and the minor seasons according to the farmers.

When asked what they think is the cause of the changing pattern of rainfall, some claimed it is God's way of doing things. Others said the cause resulted from using agro-chemicals and deforestation. In fact, all the focus groups agreed that deforestation is a major cause of the recent declines and changes in the rainfall pattern in the transition zone. Farmers here believe that the cause of the changes in the rainfall pattern is the cutting of big trees in the surrounding forests and also the destruction of forest cover by some community members through bush fires. The farmers believe that by enforcing community laws on bushfires, the climate will change to favor them.

Impacts of climate change on maize yields

A question about the yield of maize now compared to some years back brought complicated and emotional answers. For an acre of land, 8-10 bags of maize are harvested. "In the past, we used to harvest fewer bags of maize. This was due to the way we planted the seeds. But with the knowledge we have acquired from the agricultural officers, we now harvest a minimum of 10 bags of maize with the help of agro-chemicals."

Yields in general are high in good years of rainfall as confirmed by the district agricultural officers in all the study communities. This they attributed to improved extension service, utilization of planting in rows, application of fertilizer and agro-chemicals. The farmers pointed out that improvements in field management practices aided by effective and available extension services and improved varieties of maize are the main reasons they obtain high yield in years with good rainfall.

Climate variability and change that have resulted in increased temperatures and variations in rainfall amount and pattern are still the main worry of maize producers in the transition zone. Farmers suffer low yield in "bad years" as they are not able to harvest any grain at all in some seasons due to rainfall failure. Other challenges were identified by the FGD as storage and market access, and emergence of pest and diseases.The migrant farmers in Teacherkrom and Subenso identified lack of land ownership as a worry especially in adaptation to the challenges posed by climate change.

Field management practices

The size of land being cultivated by the farmers in the communities ranges between 2-5 hectares. A significantly higher proportion of farming area is still cultivated with simple hand tools like cutlasses and hoes. Most farmers are not able to employ modern mechanized equipment, such as tractors top low their farm. There is no availability of modern farming tools to the communities and therefore the option left them is sticking to their old system of manual farming.

Farmers pointed out that they get better yield in recent years since they put into practice the advice of extension officers. They agreed that the rains were good in the past and so they did not care to consult the extension officers in their activities. Most of the farmers now adhere to the recommended sowing by the agricultural extension officers.

Fertilizers play a critical role in maize cultivation for obtaining high yields.Also organic manure is in most cases evenly spread and incorporated into the soil during land preparation, while fertilizer mixtures are applied in furrows some 5 cm away from the rows and thoroughly mixed prior to sowing of seeds following which the soil is firmed up. Top-dressing of fertilizer, especially urea is done following the weeding. Top dressing is done when maize is knee-high stage or at flowering.

Improved maize varieties

There are available markets for the improved maize varieties most of which mature earlier and are more drought resistant than the traditional varieties. The varieties that farmers cultivate include Obaatanpa, Aburohemaa, and Okomasa. Aburohemaa and Obaatanpa which are improved varieties, which give better yield according to the farmers but traditional varieties are widely grown in the community because they last longer when stored.

The local and composite varieties which were popular in earlier decades are gradually getting replaced with hybrids. However, the majority of maize farmers are small-scale farmers, farming on less than 3 ha and follow low input cultivation practices using landraces and saved seed for planting. Small-scale farmers plant mostly their own indigenous varieties, which are typically robust and comprise qualities important to them. According to the farmers, they can replant the seed without experiencing yield reduction as with hybrids. Many of the indigenous varieties have been on the verge of extinction and thus need to be conserved for future crop improvement programmes. The farmers' main concern with the improved varieties are that they are less disease resistant and do not store for long periods. However, they prefer the improved varieties during the minor rainy season and in years when the major rainy season delays because the maize takes less time to mature and requires less rainfall. The nutritional value and the taste of the various improved varieties equally influence the choice of maize cultivated. However, there was no agreement among the farmers in the preference of a particular variety.

Marketing

Having an effective marketing organization in addition to a facility for value addition and product diversification can

Table 2. Information on maize farming practices.

Community	Season of farming	Mixed farming	Onset of rainfall in the last 10years	Maize crop variety	Major challenge
Twumkrom	Minor	Yam	Late	Okomasa	Storage, marketing
Ejura	Major	Yam, beans, groundnuts	Late	Obaatanpa, Aburohemaa, and Okomasa	Farm inputs
Sekyeredumase	Both	Tomato, livestock	Late	Obaatanpa, Aburohemaa	Fertilizers, marketing
Wenchi	Both	Yam, beans, groundnuts, water melon	Late	Obaatanpa, Aburohemaa, Okomasa	Rainfall variability
Akrobi	Major	Cassava, yam, livestock	Late	Aburohemaa, Obaatanpa	Rainfall variability, marketing
Subenso	Major	Tomato, yam	Late	Aburohemaa, Obaatanpa	Farm inputs, storage
Tromoso	Both	Yam, groundnuts	Late	Aburohemaa, Obaatanpa	Fertilizers, marketing
Teacherkrom	Both	Yam, beans	Late	Aburohemaa, Obaatanpa, Komesa	Farm inputs, storage
Nkwanta	Both	Yam, cassava	Late	Aburohemaa	Farm inputs, storage
Mpeasen	Major	Yam, groundnuts	Late	Aburohemaa	Storage, marketing
Nkoranza	Both	Yam, beans	Late	Aburohemaa, Obaatanpa	Rainfall variability
Subingya	Major	Yam, beans, honey extraction	Normal	Aburohemaa, Komesa	Farm inputs
Duaponko-Nwoase	Major	Yam, beans, groundnuts	Early	Aburohemaa, Obaatanpa	Farm inputs

serve as an incentive for further addition to the productivity. However, maize farmers lack such organization and so buyers take advantage of the marketing snags and approach farmers with their own prices which vary with time after harvesting. Early harvested maize around April-May may have an appreciable price per 150kg bag because of its scarcity. Maize prices also appreciate between November of the proceeding year and February when maize is scarce and lands are being prepared for cultivation.

Farmers could store their maize in wait for good prices from buyers but apart from lack of storage facilities, many other responsibilities of the farmers prevent them from storing the maize to get higher prices, and they are therefore forced to accept prices given to them by the buyers. Many of the farmers are poor small-scale farmers and need the money made from the maize farms to cater for other duties in the house.

Challenges

Farmers in all the communities discussed their challenges (Table 2). There were some challenges common to all the communities whiles others are peculiar and minor. The minor and uncommon challenges include difficulty in getting labor to prepare the land early before the rainfall onset; high labor cost per acre of land; and access to loans. Due to the difficulty in accessing loans from financial institutions to pay labor and to buy farm inputs to start farm cultivation, the potential yield is not always attained. In a particular community the land is filled with rocks and therefore farming implements cannot function well on the land. Some communities experience delay in ploughing due to unavailability of tractors and which affects the time of planting. Treated maize seeds are sometimes scares during the planting period and farmers resort to local varieties for cultivation. Major and common challenges are outlined in the subsections below.

Storage

Generally, storage facilities are scarce in all the communities visited. While some communities have number of silos, others have none. The maize is mainly sun-dried on the farm and stored in barns and huts.

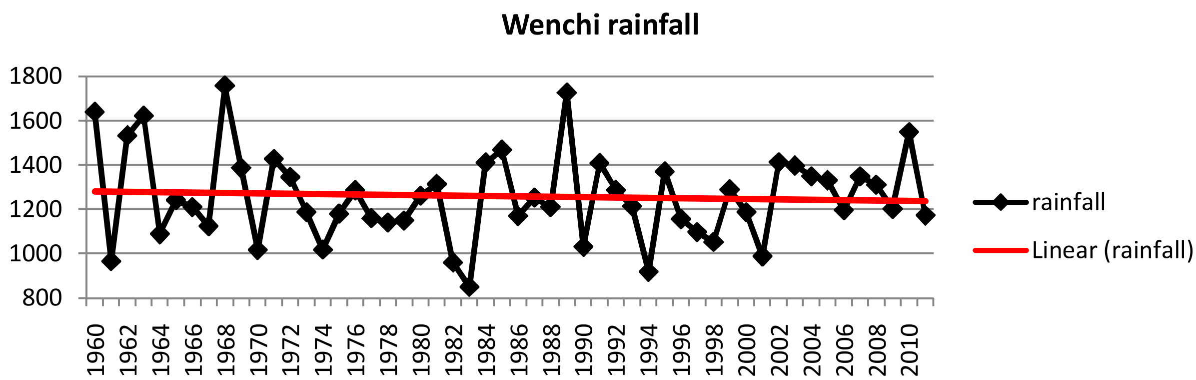

Figure 3. Annual rainfall for the Wenchi station in agro-ecological zone C.

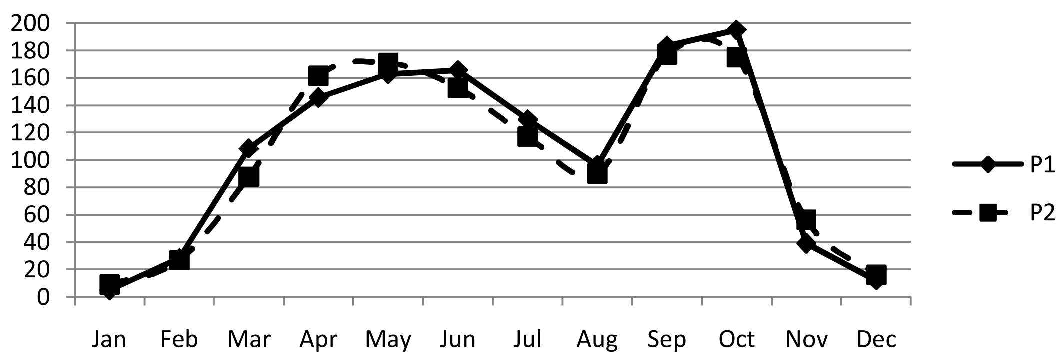

Figure 4. Rainfall for the Wenchi station showing two climatic periods: P1 (1960-1989) and P2 (1990-2011).

Famers depend on government to provide storage facilities.

Emergence of pests and diseases

Although maize is generally seen as a hardy crop, the incidence of insect pests and diseases is of major concern for the farmers. The shortening of the raining season causes pestand diseases to attack the maize crops. Two main types of diseases are the Leaf blight (*Helminthosporium* sp.), and rust (*Puccinia sorghi*).The control of Leaf Blight and Rust on maize is normally achieved by spraying 0.2% Indofil M-45 (2 g L^{-1}) and 0.1 % (1 gL^{-1}) Bavistin (Carbindazim) respectively. The major insect pest that attacks maize, documented by Gupta *et al*. (1996) and confirmed by the farmers, is the maize stem borer (*Chilo* sp.). Stem borer can be controlled with Furadon (Carbofuron) or phorate (Thimet) granules or by spraying Quinolphos (1.5 ml L^{-1}).

Changes in the rainfall pattern

We found that the general rainfall amount has decreased in recent year (Figure 3). Also the number of rainfall events and amount of rain during the first rainy season was perceived to have decreased consistently, while the number of dry spells was perceived to have increased. The onset of the first rainy season was observed by farmers to be later nowadays than before (Table 1). This is confirmed with the recorded rainfall data (Figure 4). Conversely the first season cessation was mentioned to be earlier but there has not been much difference between the major and the minor season. These two perceptions were consistent with the perceived shorter season duration (Figure 3 and 4; Lacombe *et al*., 2012; Owusu and Waylen, 2012).

Coping strategies

Some farmers have resorted to cultivation of maize in one of the two rainfall seasons. Some cultivate in the major rainfall season only while others cultivate in the minor raining season only (Table 2). A few farmers tried to acquire pumps for irrigation but could not realize it benefits because labour and fuel cost was expensive and not much cultivation could be done. Most of the farmers have resorted to other crops that do not need much rain and require shorter time to cultivate like beans, water melon, and yam. These compensate for the losses in maize farming and other farming activities like animal rearing, mushroom growing, and honey extraction (Table 2).

Conclusion

Maize production is the dominant agricultural activities in the two study areas. Two maize crops, a year are mainly cultivated during the major and the minor seasons under rainfed conditions. Sowing time vary in the communities with early sowing in some communities which are low lying and late sowing in other communities which are highlands based on their prediction of the rainfall. The traditional sowing time for main season maize though ideal from rainfall prediction point of view, it may encounter drought of variable durations effecting considerable reduction in its productivity. Sowing of maize may be delayed by a month to ward off the climatic assaults that often result in partial or complete crop damage. Thus, timely sowing is not devoid of the element of risk.

This study investigated farmers' observation of climate change and the impact on rainfed maize production in Ghana. The vulnerability of maize production systems to climate change and variability in Ghana depends on its time of occurrence relative to the growth stage of the crop. Maize production in Ghana depends solely on rainfall and its variability affects its production. The study indicate that changes in the onset and cessation of rain have negative impacts on maize production and this may pose a serious threat to household food security since maize is the staple food of most Ghanaians. Thus, effective and efficient adaptation and mitigation measures should be promoted to prepare stakeholders in maize production systems to enhance their resilience and flexibility when facing inevitable climatic change and variability.

Recommendations

Based on focus-group discussions, the application of agro-chemicals increased grain yield considerably if there is sufficient rain. It is therefore recommended that, to improve the rate of agro-chemical adoption, the government could subsidize the cost of agro-chemicals in order to make it affordable for farmers to purchase. Government policies should ensure that terms for bank credits are flexible to enhance farmers' access to affordable credits, which will increase their ability to boost crop production and productivity, enhance flexibility to change crop and soil management strategies in response to climate change. It is also recommended that the government should consider ways of establishing irrigation systems in the region for supplementary irrigation. There is no knowledge of the economics of agro-chemical use in the region under climate change.

Further study should examine actual records of fertilizer application, rain occurrence and actual yields. Doing so could strengthen the basis for these recommendations.

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