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Smallholder farmers' insight on climate change in rural Ghana

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Abstract: The Offinso Municipality in the Ashanti region of Ghana as an agricultural region, is vulnerable to climate variability and climate change. A greater segment of the population is least able to buffer and reverberate from climatic stress. This paper assesses the perceptual insights of rural smallholder farmers on climate change and how it influences their adaptation practices. Using a triangulation of the quantitative with qualitative methodological approach we purposively sampled 102 farmer respondents and 15 key informants from 3 communities in the Municipality. Quantitative and qualitative data collected were analyzed using descriptive statistics technique of cross-tabulation and frequency tools in the statistical package for social sciences Version 17 and thematic content analysis respectively. The results from the respondents indicated that a myriad of factors are responsible for the anthropogenic climate change. These were the deforestation, bad farming practices, bush burning and emissions from light industrial and vehicular emissions. Also considered was the precarious effect of climate change on smallholder farmers' crop yield, due to reduced rainfall and high temperatures, the proxy variables for climate variability and change. These adverse impacts accordingly have repercussions on their livelihood sustenance. Thus, the practicing of agroforestry as both adaptation and mitigation among smallholder farmers is essential to build local resilience, and to promote climate-smart agriculture.

ABOUT THE AUTHORS

My research interests include environmental resources management, with focus in forestry, climate change and land use in Ghana and Africa. I am also interested in applying the techniques of remote sensing and geographic information system (RS/GIS), to analyze peri-urban Land Use and Cover Change dynamics on climate variability and climate change, leading to the introduction of the new concepts of peri-urban heat and rural cool troughs, into the urban heat island literature, under the West African Science Service Centre for Climate Change and Adapted Land Use (WASCAL). I am also experience in environmental resources management engagements with Project with the Forest Research Institute of Ghana (FORIG)/Tropenbos International-Ghana as a Research Scientist (Co-PI) and also on DFID-funded Climate Impact Research for Capacity Building and Leadership Enhancement (CIRCLE) in climate change adaptation among forest fringed communities in Ghana and Africa.

PUBLIC INTEREST STATEMENT

The Offinso Municipality is one of the main food producing regions of the Ashanti region, Ghana. It is also a major forest district in Ghana. However, human pressures on the forest have resulted in deforestation. Activities of trees and forest resources exploitation have affected the quality of the forest. As a way of farmers' adaptation to climate variability and change, additional farms cultivated have led to the clearance of new forest frontiers, ostensibly, for agricultural purposes. Forest cover helps in combating the human-induced greenhouse gas emissions, particularly carbon dioxide, by sequestering these gases from the atmosphere, thereby, reducing local to global warming phenomenon. Stakeholders from the Forest Commission, Farmer Associations and Civil Society Organizations need to promote the global effort of reducing emission from deforestation and forest degradation to conserve forest carbon, while ensuring effective carbon stock management (REDD+), *in tandem* with the sustainable development goals (SDGs) 13 and 15.

Subjects: Environmental Studies; Environment & Society; Ecology -Environment Studies; Physical Geography

Keywords: climate variability; climate change; perception; smallholder; Offinso; Ghana

1. Introduction

In Ghana, like other sub-Saharan countries, smallholder farmers hold enormous potential to be used as agents to manage forest that address adverse impacts of changing climatic disorders. It is assumed to have a greater prospective to impound carbon and is often considered as an alternative land use strategy that offers solutions to land use systems that release carbon into the atmosphere (Syampungani, Chirwa, Akinnefest, & Ajaji, 2010). An example of such land use systems is forest degradation. Agroforestry systems are therefore very important in agriculture where a number of people depend on land for their livelihoods (Murthy et al., 2013).

Offinso municipality is one of the forest fringes in Ghana that relies mostly on agriculture for its development and livelihoods (Offinso Municipal Assembly, 2015). The municipality with 73 communities and 2 urban characteristics has about 50% of its population engaged in agriculture. Agriculture in the municipality is principally subsistent, which is also vulnerable to climate variability. This situation has invariably affected the crop output and in the process, threatened agricultural-based rural livelihoods. The consequences of climate variability and climate change on agriculture have the potential to render most people in the municipality jobless, hence rendering their livelihoods at ransom. Extreme climatic events in the municipality which include increased temperature, erratic rainfall pattern, storms and intermittent flow of streams are associated with crop failures (Appiah & Azeez, 2016). It is in view of this condition that there is the need to assess through research, smallholder farmers' strategies to combat climate variability and climate change.

The Offinso municipality is one of the main food producing regions of the Ashanti region of Ghana. It is also one of the hitherto, major forest districts of the forestry commission of Ghana. In recent times, however, human incessant pressures on the forest cover have resulted in the loss of considerable proportions of the forest. Activities of tree logging and other forest resources exploitation have affected the quality of the forest. Through unsustainable farming activities, substantial areas of the forest have been removed and degraded in the process. Coupled with the vagaries of climate variability and climate change, food crop yields have been dwindling, with time. As a way to adapt, one of the farmers' adaptation strategies to obviate low crop yield, is the expansion of farm numbers, by the cultivation of new plots of land that have led to the clearance of new forest frontiers, ostensibly for agricultural purposes. The fact still remains that forest cover plays critical role in combating the anthropogenic induced greenhouse gas emissions, particularly carbon dioxide, by sequestering these gases from the atmosphere, thereby, reducing local to global warming phenomenon. It is essential and imperative, therefore that stakeholders from the government, represented by the forest Commission and farmers, as well as civil society organization identify the need for the conservation of forest resources through the global effort of reducing emission from deforestation and forest degradation to conserve forest carbon, while ensuring effective carbon stock management (REDD+).

Scientific evidences have been used to underscore the existential reality of climate variability and change on the activities of smallholder farmers in the Offinso municipality (Appiah & Azeez, 2016; Amisah, Gyampoh, Sarfo-Mensah, & Quagrainie, 2009; Gyampoh, Idinoba, & Amisah, 2008). Yet, little research attention seemed to have been given to the empirically-grounded perceptual perspectives of smallholder farmers, who are direct receivers of adverse impacts of climate change on their farming activities, in the municipality. Furthermore, the knowledge available among these farmers is not particularly documented as knowledge that holds potential to augment the empirically proven scientific results from data simulation and scenarios building. The main objective of this paper as a way of adding a different argumentative trajectory to the climate change literature is to assess the perception of rural smallholder farmers on climate variability and climate change and how it influences their adaptation strategies, in the Offinso Municipality in the Ashanti Region of Ghana.

2. Literature synthesis

2.1. Climate variability and climate change

Climate revolution in recent times has multiplied much recognition globally. According to National Oceanic and Atmospheric Administration (NOAA, 2007), far-reaching research is being prepared around the world to regulate the extent to which climate variability and climate change are stirring, how much of it is being instigated by anthropogenic (man-made) forces, and its potential waves. The IPCC in its work "Climate Modification 2014: Impacts, Adaptation, and Vulnerability" defined Climate variability and climate change as a condition of the climate that can be recognized (example by using statistical tests) by fluctuations in the mean and/or the variability of its features, and that persists for an extended period, classically years or longer. Climatic adjustment may possibly be due to regular internal processes or external forces such as cadences of the solar cycles, volcanic eruptions, and tenacious man-made changes in the configuration of the atmosphere or in land use (Intergovernmental Panel on Climate Change, 2014). In a paper titled "Climate Literacy" climate variability and climate change are defined as a momentous and insistent change in the callous state of the climate or its capriciousness and occurs in response to changes in some aspect of Earth's milieu. These include steady variations in Earth's path about the sun, prearrangement of continents via plate tectonic cues, or anthropogenic reform of the atmosphere.

In developing countries particularly sub-Saharan Africa of which Ghana is inclusive, the adverse implication of climate modification is already evident where population growth, lack of food security, and other socioeconomic factors exacerbate families' vulnerability to impacts (Bishaw et al., 2013). In these countries, the agricultural sector is among the most vulnerable, putting rural population at large risks and at the same time putting additional threat to critical rustic progress anxieties including food safety, poverty lessening and delivery of tolerable standard of living for mounting populaces (Verchot et al., 2007). Some of the most profound climate variability and climate change over years have been droughts, fluctuations in annual rainfall, extreme temperatures and floods (Syampungani et al., 2010).

2.1.1. Anthropogenic climate change

The European Commission (2015) found that carbon dioxide (CO_2) is the greenhouse gas most usually produced by way of human pursuits and it is in charge for 64% of artificial global warming. Carbon dioxide in step with the World Meteorological Oganisation (2013) is truly most effective a small part of the surroundings, but some of the important GHGs. CO_2 additionally spends a very long time within the surroundings increasing the impact it has on the environment. Also, through the commercial revolution; humans have extended atmospheric CO_2 concentration via 30% (World Meteorological Organisation, 2013). Carbon dioxide has extended from fossil gas use in transportation, building heating and cooling and the manufacture of cement and different goods (Intergovernmental Panel on Climate Change, 2007). The attention of CO_2 within the surroundings is currently 40% larger than it was when industrialization commenced (European Commission, 2015).

In addition, the World Meteorological Organisation (2013) has indicated that methane is the second important GHG, produced through human pursuits and is accountable for 17% of man-made international warming, nitrous oxide for 6% European Commission (2015). The most massive sources of Methane come from the decomposition of natural matter from landfills and in agriculture (World Meteorological Organisation, 2013). The IPCC (2014) also noted that methane has recently increased through human activities like agriculture and landfills.

One most important cause of climate variability and climate change according to the World Meteorological Organisation (2013) is nitrous oxide. Nitrous oxide may be a very strong greenhouse gas which is mass-produced within the agriculture sector, exceptionally in the construction and use of healthy fertilizers (World Meteorological Organisation, 2013). European Commission (2015) also notes that fertilizers containing nitrogen produce nitrous oxide emissions. Nitrous oxide is also emitted via human hobbies similar to fertilizer use and fossil gas burning and ordinary tactics in soils and the oceans (IPCC, 2007).

Additionally, Chlorofluorocarbons (CFCs) compounds produced for industrial use, regularly in refrigerants and air conditioners have the ability to cause climate variability and climate change (World Meteorological Organisation, 2013). Halocarbon gas concentrations have extended primarily as a result of human movements. Common techniques are also a small supply (IPCC, 2014). Fluorinated gases produce an awfully robust warming outcome, up to 23,000 occasions greater than CO_2 (European Commission, 2015). They're now regulated under the Montreal Protocol as a result of their adversarial influence on the Ozone Layer (World Meteorological Organisation, 2013). In keeping up with the IPCC (2007), most important halocarbons including chlorofluorocarbons which were used greatly as refrigeration sellers and in different industrial strategies before their presence in the surroundings have been located to reason stratospheric ozone depletion.

However, the abundance of chlorofluorocarbon gases is decreasing for that reason of global regulations designed to guard the ozone layer (IPCC, 2007). Deforestation, forestland degradation, agricultural hobbies and the combustion of fossil gases and different industrial pursuits have however continued to increase atmospheric carbon dioxide and other greenhouse gases (Marland et al., 2003, mentioned in Syampungani et al., 2010).

2.2. Impacts of climate variability and climate change on crop production

The most profound and direct impact of climate variability and climate change are on agriculture and food systems; Increasing temperatures and unpredictable rainfall in both amount and timing, frequent extreme weather and higher severity of pests and diseases are among the more drastic changes that would impact agriculture and food systems negatively (Lobell et al., 2008 cited in Syampungani et al., 2010). Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation (Nelson et al., 2009). Agricultural production is severely compromised due to loss of land, shorter growing seasons, and more uncertainty about what and when to plant (UNFCCC, 2007).

Nelson et al. (2009) found that changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world such as the mid latitude, the overall impacts of climate variability and climate change on agriculture are expected to be negative, threatening global food security (Nelson et al., 2009).

According to Adams and Sibanda (1998), carbon dioxide is fundamental for plant production; rising concentrations have the potential to enhance the productivity of agro ecosystem. They also indicated that although temperature increases can have both positive and negative effects on crop yields, in general, temperature increases have been found to reduce yields and quality of many crops, most importantly cereal and feed grains.

The optimistic effects of climate variability and climate change on agriculture are concerned with the CO_2 attention increase, crop development interval raises in greater latitudes; the uncomfortable side effects incorporate the growing incidence of pests and illnesses, and soil degradation because of temperature change (Kang, Khan, & Ma, 2009).

2.3. Climate variability and climate change adaptation

From adaptation viewpoint, Perry and Sumaila (2007), defines adaptation as the action that people take in response to, or in anticipation of, projected or actual changes in climate to reduce adverse impacts or take advantage of the opportunities posed by climate variability and climate change. Nonetheless, Stern (2007) also defines adaptation as the process of adjusting to new conditions, stresses and natural hazards that result from climate variability and climate change. Stern further explains that adaptation to climate variability and climate change take place in response to impacts experienced already, as well as in anticipation of expected impacts.

The Intergovernmental Panel on Climate Change (2007), on the other hand, defines adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (IPCC, 2007). According to the IPCC (2007), anticipatory adaptation is an adaptation that takes place before impacts of climate variability and climate change are observed; also referred to as proactive adaptation. Autonomous adaptation is adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems; also referred to as spontaneous adaptation. Planned adaptation is adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

2.4. Agroforestry practices and climate change in the context of Ghana

The practice of introducing trees into agricultural crops has been the practice of humans throughout the world's history; with the ultimate aim of supplementing food and income on tree production (Bishaw, 2013). For instance, in Ghana, trees have been used in farming system unconsciously for maintaining soil productivity and for favourable effects on crops (Amanor, 1996). Amanor further explains that farming in Ghana under conditions of low soil fertility and constraints of fertilizer access make farmers develop techniques to promote soil and crop nutrition and to maintain shade for healthy plants, farmers use trees on their farms as adaptation to climate variability and change.

Agroforestry has been defined variously by different researchers and agencies. For instance, the United States Department of Agriculture (U.S. Department of Agriculture, 2013) defines agroforestry as the intentional integration of trees and shrubs into crops and animal farming system to create environmental, economic and social benefits. Schoeneberger (2009) also defines agroforestry as intentionally combining agriculture and forestry to create integrated and sustainable land-use systems. It involves the use of working tree practices that are intentionally planted and managed in rural landscapes and communities (Schoeneberger, 2009).

Leakey (1996) introduced a complex definition for the term in 1996 as a dynamic ecologically based natural resource management system that through the integration of trees on farm land and range lands diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (Climate Interventions, 2015). Sathaye (2004) cited in Murthy et al. (2013) said agroforestry is simply, the practice of introducing trees in farming. The above definitions suggest that agroforestry comprises integrating trees into farms and this is not different from what is being practiced in Ghana and hence, Offinso Municipality, for the purposes of income diversification among farmers and more importantly enhance carbon stock management.

Syampungani et al. (2010) notes that agroforestry serves as an alternative land use technique that presents a substitute to land and forest degradation and to loss of biodiversity via supplying trees and fuel trees from the farm that may or else be obtained from adjoining or a distant wooded area (Minang, van Noordwijk, & Swallow, 2012). Murthy et al. (2013) highlight the major role of agroforestry in enhancing land productiveness and improving livelihoods in both developed and developing nations. Farmers plant trees to pursue their livelihood ambitions by way of sales from woodfuels to safeguard their threatened household food security and to ensure efficient use of available land, labour and capital (Syampungani et al., 2010).

Schoeneberger (2009) notes that agroforestry practices per se, do not result in the conversion of agricultural land to woodland. Instead, it is identified as a suitable practice complementary to agricultural forests lands integration. It is further noted that agroforestry should not be a suggestion of an "afforestation" programme, as it provides new trees where there have not been trees before.

However, by way of definition, the scales of agroforestry plantations do not qualify as "woodland area" but rather an integral aspect of modern agricultural systems.

Verchot et al. (2007) argue that of all the land uses analyzed in the Land Use, Land Use Change and Forestry (LULUCF) report of the IPCC, agroforestry offers the highest potential for carbon sequestration in developing countries. They note that agroforestry has such a high potential, not because it is the land use practice with the highest carbon density, but because there is such a large area that is susceptible for land use change (Mbow et al., 2014). Syampungani et al. (2010) also argues that agroforestry holds great potential for mitigating climate change by addressing food security and livelihood needs of smallholder farmers in southern Africa. Although the carbon mitigated within a single agroforestry planting is small taken within a whole-farm context, the amount can become significant to mitigate large amount of GHGs (Schoeneberger, 2009). Agroforestry systems therefore have the capacity to reduce the carbon emissions into the atmosphere through carbon storage in trees biomass and through protection of existing forests (Syampungani et al., 2010).

As observed by Kaushik and Sharma (2015), there exists a complex dimension to rural livelihoods, poverty incidence and climate change under developing economies. The intricacies of the nexus have also not been adequately ascertained through research. In view of this situation, adaptation options that are potentially embedded within the rural households and community lifestyles in general are not fully exploited to an appreciable extent. In a related study of farmers' adaptation response to climate variability in the Offinso Municipality, Appiah and Azeez (2016), indicate that agroforestry is one of the farmers' on-farm crop management activities undertaken to conserve soil moisture as well as nutrients. The municipality, through the forestry services division of the Forestry Commission, is implementing reducing emissions from deforestation and forest degradation, as well as the conservation of and sustainable management of forest biodiversity and enhancement of forest carbon stock (REDD+) programme (Offinso Municipal Assembly, 2015).

2.5. Theoretical grounding of the paper

Studies have indicated that areas with significant tree cover are relatively cooler as compared to areas without sufficient trees cover. This is because according to Brown, Pijanowski, and Duh (2000), carbon dioxide accounts for over 75% of all greenhouse gases emitted into the atmosphere. This occurs through burning of fossil fuels and the clearing of lands for agriculture, residential and industrial purposes. These observations were developed from different scenarios of current and future land-use changes, which satisfy the demand for food, biofuels and afforestation (or reforestation) complexes, to mitigate CO_2-induced climate change (Brovkin et al., 2013). To abate the carbon emission is where agroforestry holds great potential to mitigate climate change. This paper derives its theoretical strength from the human ecological (HE) thinking, which aptly places the role of human beings and their interactions with the natural and social environments. This is identified, as a more appropriate sub-theme/theory under the Political Ecology theory (Stokols, Lejano, & Hipp, 2013).

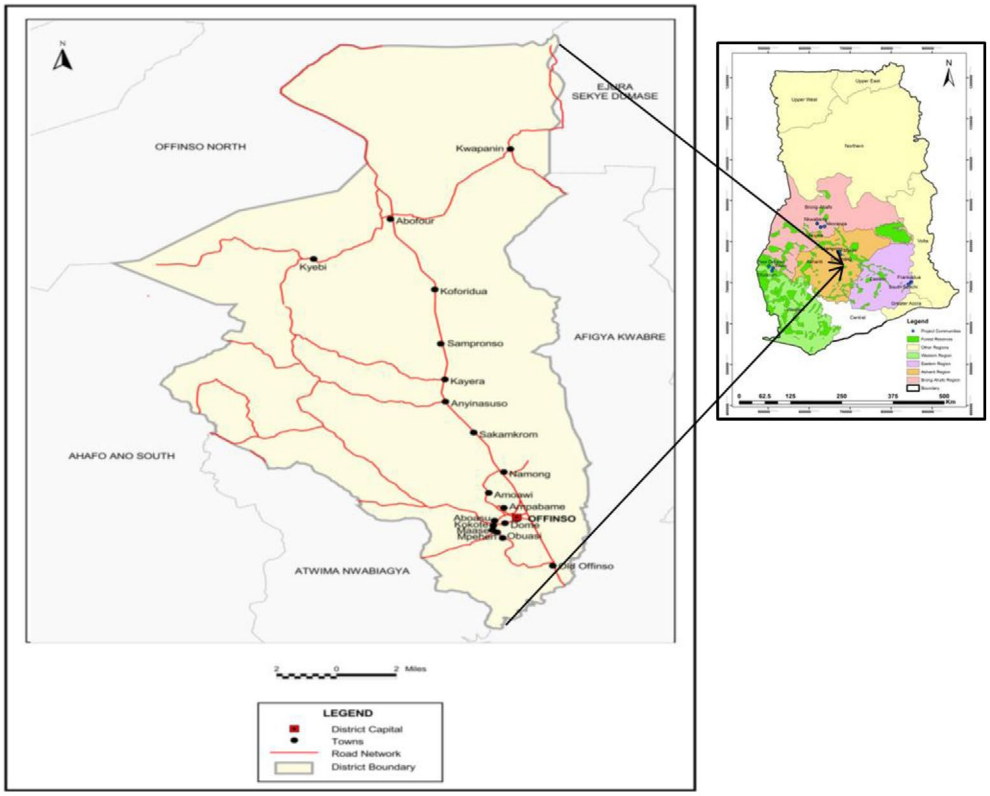
Human ecology is a term originating from a sociological approach which borrows concepts and ideas from the field of ecology and apply them to the analysis of human interactions with their biophysical and social environments (Zimmerer, 2004). Smallholder farmers in the Offinso Municipality are the agents of ecological change. Through their farming practices and the potential engagement in agroforestry, the interactions between these farmers and the forest services division (FSD) as stakeholders in the *Taungya* systems provide the necessary co-benefits of land tenure and tree tenure respectively.

3. Materials and methods

3.1. Profile of the study area

Offinso Municipal Assembly has a total population of 76,895, 48% of which are males (GSS, 2012). The municipality is located in the North-western part of Ashanti Region and thus lies between Latitudes 6°95′N and 7°15′N, and Longitudes 1°35′W and 1°50′W. About 68% of the people engaged

Figure 1. District map of Offinso Municipality showing some selected communities.



in agricultural activities possibly because a large percentage (72%) of the Municipal is rural (GSS, 2012). It is bounded to the north by Offinso North District, Ejura-Sekyedumase Municipal to the East, Sekyere South in the South-East and Atwima Nwabiagya and Ahafo-Ano South Districts to the West (Figure 1). With a total land area of 585.7 km^2, the temperature is fairly uniform ranging from 21 to 32°C. The district has an average annual rainfall of 103.8 cm, with a double maxima rainfall from April to June and September to October as the rainfall season whiles August to September, and December through February is the dry season. Agriculture in the Municipal is mostly rain-fed.

3.2. Research design and sampling techniques

The approach of this paper is an enquiry that involves the use of both qualitative and quantitative approaches so that the overall strengths of each of the approaches would be complemented (Creswell, 2009; Onwuegbuzie, 2003). Mixed method research, thus, allowed the researchers to draw a more holistic picture of the potentials of agroforestry as climate variability and climate change adaptation strategy and the challenges that hinder its practice (Johnson, Onwuegbuzie, & Turner, 2007, cited in Zurc, 2014). The quantitative variables surveyed are the age, number of occupations engaged in by respondents, and the quantification of their perceptions of climate variability and change and their modes of adaptation strategies. Additional quantitative variable was the crop yields obtained to the department of food and agriculture to aid in the analysis.

Non-Probability sampling technique was used to purposively sample 102 participants for the household questionnaire administration during the survey. Key-informant interviews were conducted with five respondents being selected from the Ministry of Food and Agriculture (MOFA), Planning department and Forestry Services Division. These persons were selected based on their stake in the subject matter of agroforestry and farming. The sample size "*n*" for the study was derived from the Gomez and Jones (2010) formulae below;

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

Table 1. Sample size of communities

Communities	Sampling frame	Sample proportion	Sample size
Abofuor	1,200	0.97	44
Kwapanin	600	0.98	35
Asuboi	450	0.98	23
Total	2,250		102

Source: Ministry of Food and Agriculture, Offinso Municipality (2012).

where n is the sample size of the study, "N" is the total population and "e" is the margin of error. Further, the respective community proportions by quota "p" was derived from the sample size "n" according to this formula in Equation (2). The result is displayed in Table 1.

$$p = \left(\frac{\text{Population of community}}{\text{Total number of all 3 communities}} \right) \times n \quad (2)$$

3.3. Collection and analysis of data

The main methods of data collection for the study were survey, observation and in-depth interviews. During the survey, 102 partially pre-coded questionnaires were administered to the smallholder farmers from the three selected communities, namely *Abofuor*, *Kwapanin* and *Asuboi*. This was done in tandem with observation and 15 in-depth interviews, which brought the total sample size to 117 for the collection of the quantitative and qualitative data respectively, on agroforestry as a climate change mitigation strategy from the research participants in Offinso Municipality.

Quantitative data were analysed using descriptive statistical tools such as cross tabulation and frequencies embedded in the Statistical Package for Social Sciences (SPSS) v.17 for windows application. This method was useful in describing single variables specifically the distribution of attributes it comprises (Babbie, 2007). The qualitative data obtained from the in-depth and key informant interviews, were classified into themes and the relevant responses that have bearing on the objectives of the study teased out, with some of them presented in direct quotations.

4. Results and discussions

This section presents and discusses the results in tandem, the respondents' insights in climate variability and climate change in the municipality. From an individual local perspectives of the phenomenon, climate variability and change will be referring to climate-changes specific to the region, or in terms of the dynamics resulting from anthropogenic activities, particularly forest cover degradation and deforestation as well as poor farming practices, that have tendencies to increase the concentrations of heat-trapping gases (especially CO_2), in the local atmosphere, with anticipated long-term global warming effects.

4.1. Demographic characteristics of respondents

4.1.1. Age of respondents

From the field survey, the ages of participants ranged between 20 and 60 years (Table 2). Over all, a total of 117 respondents took part in the research. Of this number, 59% fell between the age class 20 to 49 years and this formed the majority of our respondents (Table 2). According to Ghana Statistical Service (2012) the active working population range is 15 to 59 years. It can therefore be argued that majority of our study participants are within the working population age range in *Asuboi, Kwapanin* and *Abofuor*.

The findings suggest that majority of our respondents are youthful and therefore forms the backbone of the municipality. This is because agriculture according to the Offinso Municipal Assembly (2015), is the main economic activity in the municipality. The findings therefore imply that a

Table 2. Demographic characteristics of respondents

Demographic characteristics	Frequency	Percent
Age		
20–29	18	15.4
30–39	21	17.9
40–49	30	25.6
50–59	31	26.5
60-above	17	14.5
Total	117	100
Sex		
Male	73	62.4
Female	44	37.6
Total	117	100
Marital status		
Single	20	17.1
Married/Cohabiting	74	63.2
Separated	15	12.8
Widow/Widower	8	6.9
Total	117	100
Educational background		
None	26	22.2
Primary	17	14.5
JHS/Middle School	55	47.2
SHS/Vocational/Tech.	12	10.6
Tertiary	7	6.0
Total	117	100

Source: Field survey (2015).

decrease in agriculture production has the potential to present agriculture as non-lucrative economic activity, which could prevent many of the youth from engaging in the venture in the municipality. A decrease in agricultural activities may also render the agriculture-based livelihoods of many of the participants vulnerable to poverty in various forms. It is therefore imperative to make agricultural activities lucrative and sustainable to protect the livelihoods of farmers and protect the youth from migrating out from the municipality.

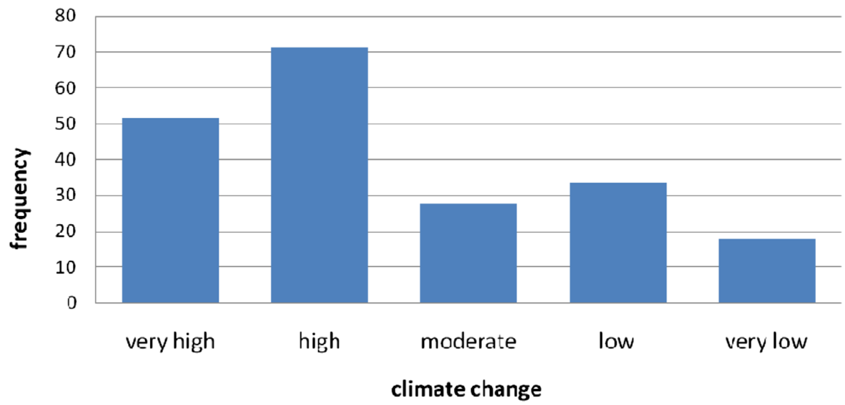
4.1.2. Sex of respondents

With regard to the sex of our study respondents, Table 2 show that more males (62%) are into farming than females (38%). Majority of our female participants claimed that they are into other non-agricultural activities aside small scale farming. Many of them reported that agricultural activities require brute force which they do not have. The findings therefore imply that women are not likely to stay into the agricultural sector for a long time. There is therefore the need to introduce other non-farm activities that would absorb such farmers who do not have such brute force to engage in productive farming. Table 2 also shows that most of the respondents were married.

4.1.3. Educational background of respondents

With regard to the educational background of our study respondents, majority of our respondents (80%) have had some formal education ranging from primary to tertiary education. Few of the respondents (20%) had no formal education and therefore could not read and write (Table 2) Parry et al. (2009) stated that there is a positive relationship between formal education and productivity of

Figure 2. Farmers' perceptions on the effect of climate variability and climate change on crop production.



labour. The findings therefore imply that with 79.5% respondent having basic formal education, productivity of a farmer is likely to increase since they are able to acquire and possibly apply scientific knowledge in their farming activities, to increase their output. However, for the few who have not been to school, it is important that the introduction of new and technical methods of farming be translated in the municipal's local dialects (*Twi*) and well explained to such farmers to also benefit.

4.1.4. Other occupations aside farming

Many of the study respondents in the Offinso municipality are engaged in other occupations aside farming. This number constitutes 60% of the respondents (Figure 2). Majority of respondents reported that they engaged in trading, masonry, commercial driving and *kente (a traditional royal cloth)* weaving to supplement farming. These activities according to the respondents were done on small-scale bases. One woman from *Abofuor* also reported why she was into trading alongside farming by stating that;

> I solely depend on this land to feed myself and family. Now the land has been taken away from me and there is the need to relocate to a new land which would be given to us by the forest commission. But as of now no land has been shown to us. I cannot sit at home folding my hands. I therefore engaged in this trading to feed my family till the new land is released to us. But I am a potential farmer too.

There is however a substantial number (40%) who are solely dependent on agriculture in the municipality. The findings here show that there are other lucrative economic activities that attract people and such activities must be integrated into the local development plan. These findings also indicate that the municipality has a diverse economy and not solely dependent on agriculture.

The findings suggest two arguments in this section. First, it can be argued that respondents are into other economic activities aside farming because the earnings from farming are usually not enough to fully support the farmers' household income. Such farmers would therefore engage in other economic activities, *in tandem* with farming, to supplement their agricultural-based incomes. Second, it can also be argued that agricultural activity in the municipality is seasonal and therefore makes farmers redundant at some point in time. In order not to remain redundant, these farmers then engage in some other activities to earn off-farm income to support their families during the off-season when agriculture activities are not brisk. It was identified from the study that 40% of the respondents were engaged in only farming. The remaining proportion, were engaged in both farming and other income-supplementing economic activities, even during the farming season. The findings therefore imply that farmers who find themselves in more lucrative jobs are likely to leave the agricultural sector. This renders the sector insecure and threatens food security in the municipality (Table 3).

Table 3. Farmers' perception of climate variability and change

Understanding of climate variability and climate change	Frequency	Percent
Change in seasonal rainfall	39	38.2
Flooding	7	6.9
Change in temperature characteristics	37	36.3
Change in solar radiation	9	8.8
Change in seasonal rainfall, excessive storm, temperature rise	7	6.9
Change in seasonal rainfall, change in temperature, change in solar radiation	3	2.9
Total	102	100

Source: Field Survey (2015).

4.2. Perceived climate variability and climate change in the Offinso Municipality

In the study communities, respondents claimed that evidence of climate variability and climate change and its adverse effects on crop production is increasingly being felt. They reported that erratic rainfall pattern, windstorms, increase in temperature and floods were signs of climate variability and climate change in the communities. These reports largely support Osafo's (2010) claim that temperature in all ecological zones of Ghana are rising, whereas rainfall levels have been generally reducing and patterns have increasingly becoming erratic. These perceptions of respondents on climate variability and climate change are elaborated in Table 3.

Erratic rainfall pattern according to respondents is one clear sign of climate variability and climate change in the municipality. Respondents perceived that climate variability and climate change have become unpredictable and it is associated with erratic rainfall. They claimed that rainy seasons could either delay when farmers predict a fall of rains or receive rains when they least expected them. As a result, respondents claimed they end up not planting their crops since they are not able to predict rainfall as before and that hinders agriculture production, putting their livelihoods at risk (Akinbami, Ifeanyi-Obi, Appiah, & Kabo-Bah, 2016).

Respondents also indicated, there was observed increase in temperature, as evidence of climate variability and climate change in the municipality. They mentioned that temperatures in recent years have consistently been rising, coupled with prolonged dry weather conditions. Respondents attributed this to the cutting down of trees by chainsaw operators and the forest service division (FSD). The FSD personnel were blamed for granting concessionaires the permit to harvest large volumes of trees, with the consequences of exposing the land to direct sunlight. An interview with some FSD officials revealed that, trees were deliberately cut to replace non-economic trees with economically viable trees. This result suggests that local people are not aware of operations of the FSD and that implies that local traditions and norms are likely to contradict that of the FSD good practices and vice versa, in the event of non-stakeholder engagement for clarity of benefit sharing of ecosystem services, during environmental resources management (Norbu, 2012).

Frequent windstorm is another observed evidence of climate variability and climate change in the communities. Windstorm according to respondents causes severe destruction to crops. They also reported that windstorm has become severe in recent years and usually destroy plantations. According to respondents, windstorm not only destroys plantation but it also destroys houses and other properties. In an interview with some agroforestry farmers, they claimed that severe windstorms that are associated with rainfall cause flood that destroys most of their crops; these have tendencies to deleterious effect rural livelihoods (Wang et al., 2017).

The results here suggest that climate variability and climate change in the Offinso municipality is increasingly being felt and the net effects are destruction of crops and livelihood sources. One male farmer from *Kwapanyin* who reported on the severity of the climate variability and climate change said;

Table 4. Farmers' perception on the causes of climate variability and change

Causes of climate variability and climate change	Frequency	Percent
Emission of vehicular and industrial fumes	8	7.8
Removal of vegetation	68	66.7
Bush burning	18	7.6
Bush burning, removal of vegetation	7	6.9
Emission of vehicular and industrial fumes, removal of vegetation, bush burning	1	1.0
Total	102	100

Source: Field survey (2015).

> Climate variability and climate change have reduced my crop produce to about half my previous gains. I used to harvest about five bags of cocoyam per acre but now it is even difficult to harvest two bags of cocoyam. It makes it difficult for me to cater for my family and pay my children's school fees. The climate variability and climate change is really disturbing us. We need to come together and do something about it.

This conforms with Blaser's (2012) assertion that climate variability and climate change have devastating effects on lives and properties.

4.3. Farmers' perception of causes of climate variability and climate change in Offinso municipality

In terms of causes of climate variability and climate change in the study area, majority of the respondents (67%) reported that the removal of vegetation has increased the changes in climatic conditions in the area (Table 4). This is in consonance with Syampungani et al. (2010) findings that deforestation, forest land degradation and agricultural activities increase the amount of carbon dioxide and other greenhouse gases which lead to climate variability and climate change. A related work by the European Commission (2015) on the causes of climate variability and climate change have also suggested that cutting down of trees leads to the release of carbon dioxide stored in trees into the atmosphere which adds to the greenhouse effects.

Another important cause of climate variability and climate change reported by the respondents is bush burning in the municipality. About 18% of the respondents indicated that unguided burning of bush for activities especially agriculture and hunting purposes cause climate variability and climate change. Some of the respondents claimed that frequent bush fires in the area have been a challenge. In *Kwapanin* for instance, farmers lamented that frequent bush burning has contributed to climate variability and climate change. A woman engaged in agroforestry reported;

> Bush fires are rampant in this area. This is caused by careless farmers and bush meat hunters. They set fires and leave it in the bush destroying our farms. The fires also destroy our Cedrela and Teaks and prevent them from growing. I think this is a cause of climate variability and climate change here.

According to the farmers, bushfires in the municipality have resulted in deforestation in the area. The farmers also indicated that bushfires in the area have contributed to food insecurity. The findings here again support the view of the IPCC (2007) that climate variability and climate change are also caused by unguided agricultural activities.

Furthermore, about 8% of the respondents said that climate variability and climate change in the municipality is also caused by the emission of vehicular and industrial fumes. For instance, respondents from *Abofuor* claimed that the emission of fumes by a wood factory in the community contributed to the cause of climate variability and climate change in the area. The results of the study are in consonance with the findings of the World Meteorological Organisation (2013) the climate could be caused by the burning of fossil fuel. The findings of our study also agree with the IPCC (2014) that chloroflourocabons (CFCs) from industrial activities contribute to climate variability and climate change.

4.4. Perceived impacts of climate variability and climate change on food crop production in Offinso municipality

Results from our study indicated that climate variability and climate change in Offinso Municipality has adversely affected crop production in the area. About 26% of the respondents indicated that the adverse impact of climate variability and climate change on crop production is very high whiles 36% of the respondents said that the negative effect of climate variability and climate change on crop production is high (Figure 2).

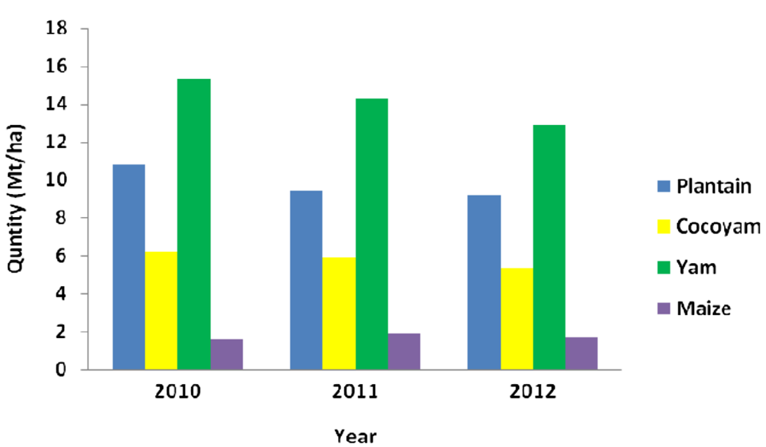
This clearly attests to the fact that the alteration in climate has severely contributed to reduction in crop production in the study communities. Interviews with a group of farmers at *Kwapanin*, particularly revealed that the impact of changes in climatic conditions in the Offinso Municipality on crop production has been very devastating. “The quantity we have been producing have drastically reduced; most especially maize” (Agroforestry Farmer, 2015). The results agree with what Nelson et al. (2009) found in their study that the overall effect of climate variability and climate change on crop production is failure and decline in crop yield. Data from the Ministry of Food and Agriculture (MoFA) in the Municipality largely supports our findings for example that maize production decreased from 1.90 metric ton per hectare in 2011 to 1.70 in the year 2012 (Figure 3).

Vegetable production in the area has been affected adversely by climate variability and climate change. According to these farmers vegetables such as egg plants and cabbage production have been affected. They indicated that frequent outbreak of pests and diseases have been some of the effects of climate variability and climate change in the area. The findings agree with what Lobell et al. (2008) found: that higher severity of pests and diseases are among the more drastic changes that would impact agriculture and food systems negatively. The results of our study also support the information given by MoFA in the municipality that the production of plantain reduced from 10.80 metric ton per hectare in 2010 to 9.40 metric ton per hectare in 2011 and 9.20 in 2012 (Figure 3). In general, the findings have shown that the impact of climate variability and climate change in Offinso Municipality on food crop production has been very dreadful.

Generally, farmers in the municipality were familiar with the term “climate variability and climate change”. However, the understanding of “climate variability and climate change” and its causes varied widely among respondents and across communities. This finding resonates with a similar study by Rankoana (2016) in the Limpopo Province in South Africa, where research participants on the perception of climate change varied widely. While many respondents thought that climate variability and climate change is synonymous with flood, many took it as heavy or irregular rainfall, storm, drought, or some other type of natural disaster (Ogalleh, Christian, Vogl, Eitzinger, & Hauser, 2012).

Figure 3. Yield of agricultural products in Offinso municipality (2010–2012).

Source: MOFA (2012).



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Irrespective of the level of understanding of climate variability and climate change, the study found a high level of awareness about the effects of climate variability and climate change. Erratic rainfall and increased temperature were the most commonly perceived and therefore, mentioned results of climate variability and climate change among respondents. As impact of climate variability and climate change, loss of agricultural crop, food, health hazards and housing hazards were reported widely. Many of the respondents indicated, their households have already been adversely affected by climate variability and climate change. This observation is supported by the findings of Ogalleh et al. (2012), on the perception and responses to climate change in elsewhere Kenya.

5. Conclusion

In rural Ghana, particularly the selected study communities in the Offinso Municipal Assembly, the impacts of climate variability and climate change are evident among the rural smallholder farmer households; as expressed variously in terms of how the phenomenon occurs and its adversities on their economic livelihoods. However, the extents of these impacts, the study identifies were mostly pervasive among subsistent farmer households. In their bid to fashion out adaptation strategies, to contain the scourge of climate change, certain actions have turned out to have been rather maladaptation. For instance, the clearing of new forest frontiers as means of expanding their number of cultivated farms as well as the application of more agro-chemicals have tuned out to adversely affect local climates, as scientific evidence has proven.

Further, studies on the vulnerability intensities among the smallholder farmers have not been exhaustive as far as the occupational disaggregation and geographical locations are concerned; this, the paper has also sought to also espouse. Generally, the impacts of climate variability and climate change on rural livelihoods and related dimensions remain shallowly studied. Specifically, the same relationship among smallholder farmers remains inadequately examined.

This paper has further revealed the adaptation options that are potentially embedded within the rural households and communities in general. There exists a complex dimension of rural livelihoods, poverty incidence and climate change in developing economies which continue to dominate development research, at least in sub-Saharan Africa. This means, adaptation policy considerations should necessarily include the perceived outlook of rural smallholder farmers, for holistic positive outcomes.

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