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Climate Change

What we have seen and experienced, from where we stand! Spatio-temporal assessment of climate change manifestations in the Ashanti region of Ghana

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General Note

Article is recommended to print as color version in recycled paper. *Save Trees, Save Climate*.

ABSTRACT

The general consensus on climate change manifestations (CCMs) and its adversarial ramifications demand lucid exposition of the subject in developing economies, especially where rain-fed agriculture is the primary source of development and livelihood sustainability. *'What we have seen and experienced, from where we stand'*, is a paper that assesses CCMs in different agro-geographical zones; OSM and SSD in the Ashanti region of Ghana. This study was conducted using a sample representative (*N*=338) between October, 2015 and May, 2016. Data obtained from designed open and close-ended questionnaires were analysed with Pearson's Chi Square test from the Predictive Analytic Software, PASW (version 17). Overall, 90.2% testified knowledge about climate change. Whilst majority (70%) attributed their knowledge of climate change to changing weather patterns, smallholder farmer's personal experiences in the physical environment constituted the major information source about climate change. Although findings validate spatial variation in terms of smallholder farmers' understanding of climate change, perceived human-induced causes and adaptation strategies utilized, syntheses were reported in relation to perceptual changes in weather patterns and reaction to hotter weather, less and unpredictable rains.

Key words: Climate change manifestations, agro geographic zones, smallholder farmers, Ashanti region

1. INTRODUCTION

Developing countries in Africa are among the most vulnerable to the effects of climate change the world over due to their high reliance on agriculture, predominantly rain-fed agriculture coupled with widespread poverty that render them unable to withstand climate stress. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5), a strong caution has been given to the effect that the changing climate is "unequivocal", and "unprecedented" since the mid- 20th century (IPCC, 2014). Agriculture constitutes the backbone of most African economies. It is the prime contributor to Gross Domestic Product (GDP); the major source of foreign exchange which accounts for about 40% of the continent's foreign currency earnings; and the principal source of savings and tax revenues. Additionally, about two-thirds of manufacturing value-added is based on agricultural raw materials, and 56% of employments for majority of the workforce are obtained by agriculture (FAOSTAT, 2010).

Agriculture is the supreme climate-dependent area of human life. The issue of climate change is not different in sub-Saharan Africa of which Ghana is part Ghana is experiencing increasing temperatures and unpredictable rainfall patterns (EPA, 2000; Nelson and Agbey, 2005). Verchot et al, (2007) argue that evolving nations are going to stomach the effect of climate change and agonize most from its undesirable impacts. This is because the agricultural sector on which large percentage of the population depends for their livelihood is among the most vulnerable to climate change. This is a threat to rural populations who solely depend on agriculture for their livelihoods. In Ghana and most third world countries worldwide, agriculture continues to play very substantial roles in national economies. Climatic factors are rarely stable being characterized by high inter-seasonal to inter-annual variations everywhere in the world. For countries such as Ghana with 70% of its population deriving their livelihood from agricultural activities, changes in climate assume a very critical concern. Agriculture is projected to be considerable y*la-di-da* by climate change in Ghana through increased variability in precipitation, temperature and extreme weather events. Thus, the livelihoods of many of Ghana's rural population are also likely to be at ransom (Schlenker and Lobell, 2010).

The unprecedented manifestations of climate change on a global scale, empirical studies on the impacts of climate change in Africa, specifically Zimbabwe show that the agricultural sector is already suffering from changing rainfall patterns, temperature increases and more extreme weather events, like floods and droughts (Kotir, 2011; Manyeruke *et al.*, 2013). An examination of the situation of Ghana is no isolation, as research continues to establish the impact of climate change on agriculture with temperature and precipitation being the two most central climate parameters that are most studied in climate research due to their instant impact in various socio-economic sectors (e.g. agriculture), including human comfort (Sayemuzzaman *et al.*, 2014). In the case of Ghana, research has revealed that the annual rainfall in the country is highly variable on inter-annual and inter-decadal timescales, making identification of long-term trends difficult (Guodaar, 2015). However, in the 1960s, rainfall in Ghana was particularly high and decreased to particularly low levels in the late 1970s and early 1980s. This caused an overall country-wide decreasing trend in the period 1960 to 2006 of an average 2.3mm/month (2.4 percent)/decade (Mc Sweeney *et al.*, 2008).

2. CLIMATE CHANGE MANIFESTATIONS (CCM) AND SPATIAL VARIATIONS

Review of literature

While there is absolute proof that the climate is changing, there is a lot of uncertainty regarding the pace and extent of the change, and the different impacts on the sub-Saharan regions, sectors, nations, and communities. Earlier studies have presented that the temporal and spatial distributions of precipitation changes were tremendously uneven and variable between regions (Manish, 2014). According to Yaro, (2010) studies have established that the direct and indirect manifestations of climate change are peculiar to different socio-geographical zones, livelihood groups and sectors in Ghana. His study further revealed that vulnerability to climate change is not uniform but differs according to social groups and sectors. Thus, the impacts of climate change are clearly and easily understood by the people most affected by it. In each spatial unit, people and their activities have specific characteristics that influence their ability to swerve the negative consequences of climate change (Yaro, 2010). Also, the 'people in places' paradigm as suggested by

Forsyth and Leach, (1998) permits the experiences of people in differentiated environments to influence the analysis of social phenomena. Therefore, an understanding of the socio-spatial dimensions of vulnerability is crucial to understanding the nature and magnitude of impacts and the associated adaptation strategies enabled by the challenges of the political, social, physical and economic environment (Yaro, 2010).

The vulnerability of a society is influenced by its development path, physical exposures, the distribution of resources, prior stresses and social and government institutions (Adjer et al. 2007). Vulnerability to climate change in Ghana is spatially and socially differentiated. Each ecological zone has peculiar physical and socio-economic characteristics that define their sensitivity and resilience to climate change impacts (National Climate Change Adaptation Strategy, 2008). Based on a study conducted by Getahun, (2012), the contact between climatic elements, vegetation characteristics and sea surface temperature variances are not well-defined, and there are dissimilarities from region to region worldwide. Therefore, the climatic elements amid those components of vegetation dynamics are very irregular and variable spatially and temporally in a very short period of time. Precipitation for instance is much more variable in both time and space than other climatic elements. This spatio-temporal variation of climatic elements has great effect on the vegetation dynamics and seasonal agricultural productivities (Getahun, 2012).

Beneath the context of global warming, the average mean precipitation globally parades an upsurge with a strong spatial variation based on observations and model simulations (Allen and Ingram, 2002; Trenberth et al., 2007 Meehl et al., 2007), in which different areas show different patterns of change in precipitation (Wang et al., 2011; Huang et al., 2013). According to (Yaro, 2010) who found that though climate change is a physical process involving changes in climate variables, it is influenced by social processes that relate to the way society evolves through time. Again, his study establishes the influence of spatial locations on the adaptive capacities of farmers. The capacity to mitigate and adopt to climate change impacts depend on physical, technological characteristics and proactive measures adopted by different socio-economic groups living in differentiated geographical circumstances (Yaro, 2010).

Aside from the relatively significant physiognomies of spatial locations in climate change manifestations on the global scale, existing literature on the subject is unsatisfactorily scanty in the context of sub-Saharan Africa and Ghana in part. Even though there are numerous research regarding the impact of climate variability and change on agriculture (Awotoye and Matthew, 2010; Malla, 2008; Codjoe and Owusu, 2011), very little information exist in the area of climate variability and geographical locations in detail. There is general consensus that climate change or variability is the aftermath of spatial and temporal interaction of climatic parameters with vegetation and other earth-atmosphere component systems (Getahun, 2012). Little remain out of the numerous studies on climate change that primarily examine the influence of geographical locations on climate change manifestations (CCM) in different socio-geographic zones (Barbosa and Kumar, 2011).

For a clearer understanding of the influential variables on CCM in different geographical zones, spatial variations among smallholder farmers and their perceived changes, causes, effects adaptation strategies and general CCM of varied forms cannot be understated. This study examines the spatio-temporal physiognomies of CCM in different socio-geographical zones of Ghana; Offinso South Municipal (OSM) and Sekyere South District (SSD) of the Ashanti region of Ghana.

Data and Methods

The quantitative data for this paper was extracted from a broader, original study that reconnoitered CCM in the Ashanti region of Ghana. The research design of the larger study espoused the mixed methods' approach; encompassing the analysis of solicited quantitative and qualitative data from the study' key informants. The study utilizes the cross sectional analysis of quantitative data from smallholder farmers (farmers operating on small scale or farmlands less than 2 hectares) from OSM and SSD. These two district were among the forest fringes communities in Ghana and have more than two thirds of their population employed in the agricultural sector for development and livelihood sustenance (OSD profile, 2014; SSD, 2016).

The study involved respondents' of 18 years and more who were engrossed in agrarian-based activities in the selected farming communities. This age limit was set a standard for respondents' level of maturity (Republic of Ghana's constitution, 1992) and their ability to observe, analyse and make inferences about CCMs in their farming communities, *ceteris paribus*.

Sampling and study participants

An empirical survey was conducted in the OSM and SSD of the Ashanti region of Ghana, purposively selected between October, 2015 and May, 2016. The Ashanti region was purposively selected based on the dominance of the agricultural sector (65% of total employment) in the region's economic activities, 77% of total farmers' populace's operating farmland sizes less than 1.2 hectares (smallholder farmers) and the abundance of arable lands for cultivation (Ministry of Food and Agriculture (MoFA), 2016). OSM and SSD were selected using the simple random technique from among the total 27 political and administrative district assemblies in the Ashanti region (MoFA, 2016). In sum, a total of ten (5 from each) communities were purposively sampled in OSM; Aboasu, Kokote, Anyinasuso, Asuboi and Mpehin, and SSD; Abrakaso, Domeabra, Afamanso, Bipoa and Bedomase.

A total of three hundred and thirty-eight (*N*=338) respondents were involved in the study. As seen from table 1.0, the respective sample sizes for the communities were based on their respective population sizes to ensure the avoidance of bias and encourage full representation by key informants. The study participants were selected using a three-stage procedure in the simple random sampling technique. The first stage embraced the provision of a list of farming households from the respective communities in both OSM and SSD. Random selection of the required number of the study participants by blindfolded Field Officers from each community constituted the second phase. The final stage involved activities of personal contacts with selected farming households for distribution and discussion of questionnaires. In a situation of absence or a decline in participation, the espoused procedure was diligently followed to get a suitable replacement. Each discussion session spanned a period of 25minutes on average.

Table 1

DISTRICT	SAMPLED SETTLEMENT	SUB-SAMPLE
OFFINSO SOUTH MUNICIPAL	Aboasu	29
	Kokote	32
	Anyinasuso	25
	Asuboi	47
	Mpehin	36
SUB-TOTAL		**169**
SEKYERE SOUTH	Abrakaso	35
	Domeabra	24
	Afamanso	29
	Bipoa	48
	Bedomase	33
SUB-TOTAL		**169**
TOTAL SAMPLE		**338**

The study employed a sample size of three hundred and thirty-eight (N=338); made up of 169 smallholder farmers from OSM and SSD each. This general sample was established on Lwanga and Lemeshow's (1991) method for sample size determination: where n = required minimum sample size; Zα = 5% level of significance which gives the percentile of normal distribution = 1.96; d = level of precision, i.e. 0.05; P = expected incidence of climate change in the study area (70%), (Apt, 2013; GSS, 2012). The study sample was proportionately assigned among the study communities based on their respective population sizes (see Table 1.0).

The Sekyere South district (SSD) is basically an agricultural area with two thirds of its working population being employed in the cultivation of major food crops such as plantain, cassava, maize and yam (Sekyere South district, 2016). Variation in the about 120 days of rainy days per year during the rainy season between March and July, climate change have adverse effect on the social and economic livelihood of the people and this has increased food insecurity in the area due to a fall in food production. SSD and OSM, Ashanti region were selected due to the districts' arid semi-deciduous forest zone (Hall & Swaine, 1981), and the intense farming activities of the district. The farming communities; Bedomase, Boanim, Domeabra, Bepoase and Akrofonso will be randomly selected from the district due to reliance on precipitation and temperature agriculture and forest based products, endemic poverty, land degradation and vulnerability to climate change (Appiah et al. 2009; UNDP, 2007).

'Offinso' comes from the Asante title 'Ofenso' (meaning settled on high of River Offin) which has been Anglicized. As one of the 30 Municipals within the Ashanti neighborhood, OSM was once based via Legislative Instrument (L.I.) 1909

of 2007. OSM which is predominated by the semi-equatorial climate is one of the forest fringes in Ghana that relies mostly on agriculture for its development and livelihoods (Offinso Municipal profile, 2014). The municipality with 73 communities and 2 urban characteristics has more than 50% of its population engaged in agriculture. Agriculture in the municipality is principally rural and sustenance and vulnerable to climate variation which is expected to threaten agricultural output and livelihoods. The consequences of climate change on agriculture may render most people in the municipality jobless, hence rendering their livelihoods at ransom. Extreme weather events in the municipality include increased temperature, erratic rainfall pattern, storms, intermittent flow of streams are associated with crop failures.

Data collection

The study employed both primary and secondary sources of data. Existing reports, records, and publications of various forms of information on CCM in the Ashanti region; OSM and SSD constituted secondary data. This included books, written articles, and reports etc. on CCM in the study areas. Additionally, primary data on CCMs in Ghana, Ashanti region and the study communities were solicited by means of Researchers' administered questionnaires. The severity and varied dimensions of CCM were analysed based on the views of the study participants.

Data Analysis

For the purpose of this paper, quantitative data analysis was central. Responses were properly arranged, coded, cross-checked for inconsistencies and entered into the Predictive Analytic Software, PASW (version 17) database. The results were presented in frequency distribution tables. The descriptions of respondents' socio-demographic physiognomies were carried out. A non-parametric Pearson's Chi-Square tests were carried out to examine the variations between the study participant's district of occupation and the study variables. The level of significance for all tests was determined at $p < 0.05$.

Ethical approval was obtained from the Department of Geography and Rural Development at the Kwame Nkrumah University of Science and Technology, KNUST-Kumasi. The study participants were assured of confidentiality and anonymity concerning responses provided. Participation was purely based on voluntary and convenience of respondents.

3. RESULTS

Sample physiognomies

The standard characteristics of the study participants have been espoused in Table 1.0. The study utilized a sample size of three hundred and thirty-three (N=338). The data revealed that majority of the study respondents were males (56.2%), married/cohabitants (60.4%), 22.5% and 8.9% had achieved secondary and tertiary level of education respectively. Income level revealed was up to GH¢400.00 (104.00USD) per month as at the existing exchange rate of 1USD=GH¢3.85, August-September, 2016. A little below 85% had at least 10 years' experience in agrarian-based activities. A little above 88% of smallholder farming households were ≤ 10 people. Generally, approximately 90% of the study participants had knowledge about climate change. About 70% attributed their knowledge about climate change to the changing weather patterns in their respective localities; Offinso South Municipal (OSM) and Sekyere South District (SSD).

A comparative assessment of association between smallholder farmers' district of occupation and specific socio-demographic physiognomies discovered statistically significant association with educational level ($p \leq .05$), household agrarian-based incomes (64.5% vs. 58.0%, $p \leq .05$), household size (59.2% vs. 64.4%, $p \leq .05$) and respondents overall knowledge about climate change (75.7% vs. 63.3%, $p \leq .05$). On the other hand, there were no significant difference in terms of gender, marital status, years of farming and changing pattern of the weather ($p > .05$).

Table 2

		Total N(%)	Respondents' district of occupation		*p value*
Variables		**338(100.0)**	**Sekyere South District (SSD) n(%) 169(100.0)**	**Offinso South Municipal (OSM) n(%) 169(100.0)**	
Gender of respondents	Female	148(43.8)	98(58.0)	50(29.6)	
	Male	190(56.2)	71(42.0)	119(70.4)	0.347
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Marital Status	Single	90(26.6)	49(29)	41(24.3)	
	Married/Cohabitant	204(60.4)	95(56.2)	109(64.5)	0.114
	Divorced/Bereaved	44(13.0)	25(14.8)	19(11.2)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Educational Level	No school	30(8.9)	24(14.2)	6(3.6)	
	Primary/Basic Education	203(60.1)	90(53.3)	112(66.3)	
	Secondary	76(22.5)	43(25.4)	33(19.5)	0.043
	Tertiary	30(8.9)	12(7.1)	18(10.6)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Household Agriculture-based	≤ GH¢100	38(11.2)	21(12.4)	17(10.1)	
	GH¢101- GH¢250	57(16.9)	15(8.9)	42(24.8)	

Income	GH¢251- GH¢400	207(61.2)	109(64.5)	98(58.0)	0.003
	GH¢ 401- GH¢550	17(5.1)	8(4.7)	9(5.3)	
	GH¢ 551- GH¢1000	19(5.6)	16(9.5)	3(1.8)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Years of farming	≤ 5 years	149(44.1)	85(50.3)	64(37.9)	
	6-10 years	149(44.1)	62(36.7)	87(51.5)	0.631
	11-15 years	13(3.8)	5(3.0)	8(4.7)	
	16-20 years	15(4.4)	8(4.7)	7(4.1)	
	21 or more years	12(3.6)	9(5.3)	3(1.8)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Household size	≤ 5	98(29.0)	41(24.3)	57(33.7)	
	6-10	200(59.2)	109(64.4)	91(53.8)	0.034
	11-15	31(9.2)	14(8.3)	17(10.1)	
	16 or more	9(2.7)	5(3.0)	4(2.4)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Knowledge about climate change	Yes	305(90.2)	147(87.0)	158(93.5)	0.006
	No	33(9.8)	22(13.0)	11(6.5)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Source of knowledge	Newspapers/magazines	18(5.3)	6(3.6)	12(7.1)	0.072
	Radio/television broadcast	129(38.2)	82(48.5)	47(27.8)	0.0042
	Personal experiences in physical changes in the environment	155(45.9)	72(42.6)	83(49.1)	0.0038
	Other farmers	36(10.6)	9(5.3)	27(16.0)	0.173

	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Changing pattern of the weather?	Yes	235(69.5)	127(75.1)	108(63.9)	
	No	49(24.6)	31(18.3)	52(30.7)	0.293
	Not sure/no idea	20(5.9)	11(6.5)	9(5.3)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	

Source; Field survey, 2015 (Chi square value is significant at 0.05) ** Operationalisation and coding of the study variables utilised numbers for representation on the PASW database for analysis. For instance, the dichotomous nature of gender employed '1 and 2' to represent Female and Male respectively. The same operationalization and coding approach was espoused for all variables in the Tables.

A total of 90.2%, *n*=305 of key informants had knowledge of climate change. A comparative analyses between smallholder farmers' district of occupation and knowledge sources on climate change as shown on table 1.0 revealed a statistically significant difference between respondents' experiences in physical changes in the environment as a source of information about climate change and smallholder farmers' district of occupation (x^2 [2, *N*=155]=13.426, $p<.05$). The likelihood dependency on personal experiences by smallholder farmers was slightly higher among farmers from OSM than those from SSD (49.1% vs. 42.6%).

From a divergent viewpoint, smallholder farmers' likelihood dependency on radio/television broadcast as source of knowledge about climate change (x^2 [1, *N*=129] =8.579, $p< .05$) was prevalent among smallholder farmers from SSD than those from OSM (48.5% vs. 27.8%). Other sources of knowledge about climate change such as newspapers/magazines and other farmers when compared with smallholder farmers' district of occupation revealed no significant association between them ($p>.05$). Respondents' from SSD were least likely to resort to newspapers/magazine or other farmers for knowledge-based data on climate change (7.1% vs. 3.6%, and 16.0% vs. 5.3% respectively). Based on smallholder farmers' views on the changing pattern of the weather, approximately, 70% indicated affirmatively. Responses were slightly dominated by participants from SSD (75.1% vs. 63.9%).

A comparative between respondents' district of occupation and understanding of climate change, perceived human-induced causes of climate change and climate adaptation strategies utilised by smallholder farmers on table 3.0 revealed a statistically significant association (x^2[3, *N*=338]=9.872, $p<.05$). Respondents from OSM were more and least likely to associate changes in seasonal rainfall patterns and changes in solar radiation with their understanding of climate change respectively (42.7% vs. 24.9% and 0% vs. 8.8%) as compared to respondents from SSD. On the contrary, smallholder farmers from SSD based their understanding on climate change to changes in temperature characteristics and were least likely to attribute their understanding to windstorms and seasonal changes in rainfall patterns.

Generally, deforestation *N*=135, 40%, indiscriminate bush burning *N*=92, 27.2%, and land degradation *N*=43, 12.7% were common human induced causes of climate change among the study participants. Deforestation was a common human-induced cause of climate change among respondents from OSM whiles bush burning was common among respondents from SSD.

A point Likert scale was used to analyse how the study respondents reacted to the statement that; *'there is hotter weather, less and unpredictable rains'*, about 65%, *N*=220 agreed/strongly agreed to the affirmative. A comparative analyses between respondents' district of occupation and response to the statement revealed no statistically significant association between them ($p<.05$). Respondents from OSM were more likely to administer their strong disagreement to the statement than from SSD.

Commonly, respondents' perceived changes in the weather revealed the issue of decreasing and unpredictable rainfall patterns (32%), increasing daily temperature (29.6%), and prolonged drought (12.4%). The remaining changes were recurrent floods (8.9%), decreasing forest cover (8.6), soil erosion (8.2%), and increasing windstorms (4.7%). The study also revealed no statistically significant association between respondents' district of occupation and perceived changes in the weather.

Based on climate adaptation strategies utilised by respondents from OSM and SSD, a comparison between them showed a statistically significant difference between them (x^2 [3, *N*=338] =15.916, $p < .05$). Premised on the views of the study participants, the top 5 adaptation strategies utilised by respondents were planting of high yielding varieties of crops, consistent tree planting, planting early maturing crops, rain water harvesting and planting of drought tolerant crops. A comparison between smallholder farmer's district of occupation and the type of adaptation strategy commonly used revealed that, respondents from OSM were more likely reliant on tree planting (32.5% vs. 7.1%), crop rotation (16.0% vs. 6.5%), rain water harvesting (13.6% vs. 10.1%) to farmers from SSD. On the other hand, smallholder farmers from SSD were more likely to espouse planting of high yielding crop varieties (30.2% vs. 11.2%), planting drought resistant crops (17.2% vs. 6.5%), agro forestry practices (13.0% vs. 7.7%) and slightly higher to adopt early maturing crops as climate adaptation strategies.

Table 3

Specific research questions on Climate change		Total N(%) 338(100.0)	Respondents' district of occupation: Sekyere South n(%) 169(100.0)	Respondents' district of occupation: Offinso South n(%) 169(100.0)	*p value*
Understanding of climate change	Changes in seasonal rainfall pattern	114(33.7)	42(24.9)	72(42.7)	

	Flooding	57(16.9)	24(14.2)	33(19.5)	
	Changes in temperature characteristics	135(40.0)	83(49.1)	52(30.7)	0.028
	Windstorms	17(5.0)	5(3.0)	12(7.1)	
	Changes in solar radiation	15(4.4)	15(8.8)	0(0.00)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Perceived human-induced causes of climate change	Deforestation	135(40.0)	53(31.4)	82(48.5)	
	Indiscriminate bush burning	92(27.2)	61(36.1)	31(18.3)	0.000
	Farming alongside water bodies	36(10.7)	25(14.8)	11(6.5)	
	Land degradation	43(12.7)	17(10.1)	26(15.4)	
	Excessive tillage	32(9.5)	13(7.7)	19(11.3)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
There is hotter weather, less and unpredictable rain	Strongly agree	140(41.4)	69(40.8)	71(42.0)	
	Agree	80(23.7)	42(24.9)	38(22.5)	1.567
	Not sure	46(13.6)	23(13.6)	13(7.7)	
	Disagree	53(15.7)	26(15.4)	27(16.0)	
	Strongly disagree	39(8.6)	9(5.3)	20(11.8)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	

Perceived changes in the weather leads to;	Decreasing and unpredictable rainfall patterns	108(32.0)	59(34.9)	49(29.0)	
	Prolonged drought	42(12.4)	31(18.4)	11(6.5)	
	Recurrent floods	15(8.9)	7(4.1)	8(4.7)	
	Soil erosion	28(8.2)	12(7.1)	16(9.5)	0.077
	Decrease in forest cover	29(8.6)	16(9.5)	13(7.7)	
	Increasing windstorms	16(4.7)	7(4.1)	9(5.3)	
	Increasing daily temperatures	100(29.6)	37(21.9)	63(37.3)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	
Climate adaptation strategies utilised	Tree planting	67(20.0)	12(7.1)	55(32.5)	
	Rain water harvesting	40(11.8)	17(10.1)	23(13.6)	
	Agroforestry practices	35(10.4)	22(13.0)	13(7.7)	
	Crop rotation	38(11.2)	11(6.5)	27(16.0)	0.003
	Planting high yielding varieties	70(20.7)	51(30.2)	19(11.2)	
	Planting early maturing crops	48(14.2)	27(16.0)	21(12.4)	
	Planting drought tolerant crops	40(11.8)	29(17.2)	11(6.5)	
	Total	**338(100.0)**	**169(100.0)**	**169(100.0)**	

4. DISCUSSION

The study unraveled the nexus between climate change manifestation and place-based variations at OSM and SSD in the Ashanti region of Ghana. A clearer understanding of climate change and its antecedents will help smallholder farmers to be well positioned to adequately diversify farming practices to adapt to climate related ramifications in their communities of occupation (Maddison 2007; Slegers 2008). The study reveals that although physiognomies like educational level, household size, household agrarian-based income and overall knowledge about climate change were substantially varied among smallholder farmers from OSM and SDD, syntheses were observed in relation to their gender, marital status, years of farming and their collective reactions to changing patterns of the weather. Considerable literacy levels according to Leichenko et al.,(2002) lessen vulnerability of smallholder farmers by increasing their abilities and use to information, obtain knowledge and enhanced risk recognition, thus augmenting efforts aimed at dealing with harsh conditions posed by climate change (Leichenko et al., 2002).

The study reveals a substantial fraction (90.2%) of smallholder farmers have significant knowledge about climate manifestations in their communities. This is very paramount in the event where the dearth of satisfactory knowledge about climate change and its impact on agricultural production is a setback to long term sustainable agriculture in most developing countries including Ghana (Kotei et al., 2007). Knowledge about climate change is principal to increasing understanding and chances of smallholder farmers in dealing with climate-related ramifications.

The foremost finding of the study validates spatial dissimilarities in terms of respondents' understanding of climate change, perceived human-induced causes and climate adaptation strategies utilised by smallholder farmers from OSM and SSD of the Ashanti region. Our finding is in congruence with a study conducted by Bindi and Olesen who discovered that climate manifestations vary dramatically from international, national and local scale and such variation in the effects is due to differences in adaptation strategies, which correlate highly with the local cultural, institutional and environmental conditions (Zubair, 2006; Kulawardhana, 2008; Bindi and Olesen, 2011). For instance, variations were observed in terms of respondents' association of their understanding of climate change. Smallholder farmers from OSM were quick to associate their understating (highest to lowest) with changes in seasonal rainfall, changes in temperature characteristics, flooding and increasing windstorms. On the other hand, respondents from SSD associated their understanding (highest to lowest) with changes in temperature characteristics, changes in rainfall patterns, flooding, changes in solar radiation and windstorms. These findings further revealed (table 3.0) that although changes in temperature characteristics and rainfall patterns were cited by both respondents from the OSM-SSD divide, rankings were based on respondents' district of occupation. This is in tandem with studies by (Owusu and Waylen, 2008; Yaro, 2010; Kemausuor *et al*. 2011; Guoodar, 2015). The direct and indirect impacts of climate change are particular to different socio-geographic zones and livelihood groups and sectors (Yaro, 2010). Again, changes in seasonal rainfall patterns; increasing incidence of flooding, and increasing windstorms were more likely for among smallholder farmers from OSM whiles those from SSD were more likely to associate changes in temperature characteristics and solar radiations to their understanding of climate change. The finding establishes that although majority of smallholder farmers of OSM and SSD affirmatively responded to changing patterns of the weather (Kelly et al. 2005; and Deschenes and Kolstad, 2011), responses were slightly dominated by respondents from SSD.

Based on the outcome of the study, variations were observed in term of respondents' knowledge source on climate change. Our findings suggest a considerably greater fraction of smallholder farmers obtaining climate-related knowledge and information from their experiences in the physical changes in the environment. This is in concinnity with a study by Forsyth and Leach, (1998). Comparatively, a moderately higher discrepancy was observed among smallholder farmers from OSM in terms of their dependence on personal experiences in the physical environment. These perceptions are commonly informed by farmers and rural communities' own experiences of how climate change affects their livelihoods (Slegers 2008). On the other hand, respondents from SSD were predominant dependents on radio/television broadcast as climate related source of knowledge. Although our study revealed no substantial discrepancies in terms of respondents' utilisation of newspapers/magazines and other farmers as their knowledge sources on climate change, smallholder farmers from SSD were least likely to resort to them as their source of knowledge about climate change as compared to respondents from OSM.

A 5 point Likert scale was espoused to analyse how smallholder farmers reacted to the statement that *'there is hotter weather, less and unpredictable rain'*. About 65% of respondents affirmatively agreed/ strongly agreed (Deressa *et al*., 2008; Gbetibouo, 2009). Although the study revealed no significant difference between the statement and respondents' district of occupation, smallholder farmers from OSM were more likely to administer their strong disagreement than those from SSD. Generally, there were no significant discrepancies between respondents' district of occupation and perceived changes in the weather. Findings revealed that respondents' perceived changes in the weather were centered on the issues of decreasing and unpredictable rainfall patterns, increasing daily temperatures (Gornall *et al*., 2010; Yaro, 2013) and prolonged drought (Trnka et al. 2010, 2011; Holmgren and Oberg, 2006; Mary and Majule, 2009). Our findings is in tandem with studies by (Minia et al. 2004; Maddison, 2007; Goosse et al, 2010; Datta, 2013; Sayemuzzaman *et al*., 2014) who opined that, temperature and precipitation are two most important climate parameters that are most studied in climate research because of their immediate impact in various socio-economic sectors. Temperature and rainfall have therefore become important variables which can have direct and indirect effects on agricultural crops in general. Other observed changes were recurrent floods, soil erosion, decreasing forest cover and increasing windstorms. Higher temperatures detrimentally affect soil moisture, while prolonged droughts and increasing temperatures create favourable conditions for pests and diseases to multiply thereby reducing crop yield (Garrett *et al.,* 2013). Some of the most profound climate changes over years have been droughts, fluctuations in annual rainfall, extreme temperatures and floods (Syampungani, 2010; Kundu *et al*. 2015; Naveen Kumar *et al*. 2016).

In general terms, human-induced causes were (highest to lowest) centered on deforestation, indiscriminate bush burning, land degradation, farming alongside water bodies, and excessive tillage even though substantial variations existed among respondents from OSM and SSD. Also, deforestation was a common human-induced cause of climate change among smallholder farmers from OSM whiles indiscriminate bush burning was prevalent among respondents from SSD.

Based on climate adaptation strategies employed by respondents, significant variations were associated with choice and utilisation of identified adaptations measures. A study by (Nath and Behera 2011; Luni et al. 2012; Guodaar, 2015) argue that 'local assessment and application of coping strategies allows us to comprehend why and how communities respond to the same type of environmental changes in different ways as variations are experienced differently from farmer to farmer. As vulnerability varies across regions and sectors, the impact from climate change across the globe is also likely to differ (Nath and Behera, 2011). Premised on the views of the study participants, the top 5 climate adaptation strategies used by smallholder farmers were among others planting of high yielding varieties, encouraged tree planting (Gloria et al, 2012), planting early maturing crop, rain water harvesting (Mensah *et al*., 2013), and planting of drought resistant crops. The study showed tree planting, crop rotation, and rain water harvesting as predominant adaptation strategies among OSM's respondents. On the contrary, planting of high yielding crop varieties, planting of drought tolerant crops, agroforestry practices and slightly higher in the use of early maturing crops (Ayanda, et al 2012, Blessing, et al, 2011a) were common among smallholder farmers from SSD. According to (Eakin *et al*. 2012; Bryan et al, 2013; Campos, 2014), the differential capacity of people, as individuals and in communities, to respond and adapt is influenced by a wide set of site-specific environmental, historical, socio-economic, and institutional variables which act conjointly.

The study further revealed that adaptation decisions hinge on numerous factors when farmers are faced with drought related events (Zorom *et al*. 2013). For instance, households with higher income size were more likely to afford adaptation strategies that require extra funding such as the option of expanding the use of old-fashioned raindrops and water preserving methods, purchase rainwater tanks or water impounding basins and purchase improved crop varieties require extra funds households with limited income sizes cannot afford. This finding is buttressed Knowler and Bradshaw, (2007) and Abraham et al, (2011) who discovered the existence of a positive correlation between income status and adoption decisions of farmers. This means that, a higher or an increase in a farmer's household income improves a household's capability to embrace adaptation measures to mitigate climate related challenges. Irrigation and tree planting are long-term measures for adaption to drought. Though the latter is largely agreed by in the science community to not be a major remedy to mitigating drought since doing the opposite (mismanagement of land resource) is not the main cause of climate change in the Sahel regions. And yet, many empirical studies on climate change adaptation including this study, still shows tree planting as a major coping or adaptation measure among households in developing regions. Tschakert et al. (2009) described this as a 'received wisdom which has dominated popular imaginations.'

5. CONCLUSION

This paper analysed the spatial variation between climate change manifestations and OSM and SSD in the Ashanti region of Ghana. The study revealed a higher incidence of climate changes among smallholder farmers in the study districts. Major variations that were revealed spanned from respondents' source of knowledge about climate change, understanding, adaptation strategies utilised, perceived changes and human-induced causes of climate change in the study districts. Among the major human-induced causes of climate change were deforestation, indiscriminate bush burning, and land degradation. The incidence of decreasing and unpredictable rainfall patterns, increasing daily temperature, prolonged drought and recurrent floods were among the factors smallholder farmer's perceived to be their experienced changes in the weather (Nelson and Agbey, 2005; EPA, 2011; Catherine, 2012). The study revealed climate adaptation strategies employed by smallholder farmers to deal with climate manifestations included planting of high yielding varieties, encouraged tree planting, planting early maturing crop, rain water harvesting, and planting of drought resistant crops. As long as limited studies remain in terms of climate manifestation across geographical locations, further inquiry is required to examine the extent and causes of such variations. Also, the role of indigenous knowledge in climate adaptation in Ghana is required to buttress scientific knowledge adoption.

Author contributions

The paper emerged through a collaborative interest of all authors. GOA conceptualized, summarized and designed the study. GE and LPS assisted in the definition of the research theme and designed the research instruments for data collection phase. GOA, FF and RMG analysed the data, interpreted the results and wrote the first draft of the manuscript. All authors approved of the final draft of the manuscript for publication.

Conflict of interest

The authors unequivocally state that they have no conflict of interest to declare.

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