Sustaining Rural Livelihoods: On-Farm Climate-Smart Adaptation Measures among Smallholder Farmers in Rural Ghana

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Abstract

Rural livelihoods, incidence of poverty and climate change are intricately connected in the Offinso Municipality in the Ashanti region of Ghana. Conscious of the vagaries of climate change, smallholder farmers have developed adaptation measures to sustain their subsistent livelihoods. This paper examines the various on-farm adaptation measures among smallholder farmers in the Offinso municipality with the view to drawing lessons for effective policy making and implementation. A triangulation of quantitative and qualitative research design and a non-probability purposive sampling technique were used. On the basis of populations, 300 interviewer-administered questionnaires were used to collect data from smallholder farmers in 6 out of the 24 farming communities in the study area. Data generated were analyzed using thematic analyses of issues as well as through the use of cross and frequency tables, Chi-square test of association and regression at $\alpha_{0.05}$. Farmers undertook some on-farm management practices such as efficient management of irrigation system while substantially, 33.0% of the respondents did not engage in any of the soil water and moisture conservation practices. However, Pearson's chi-square (χ^2) value of 65.6 with a Cramer's V value of 0.288 revealed a significant association between on-farm crop management activities and soil nutrients conservation. This paper recommends vigorous direction of extension work by the Department of Food and Agriculture towards harnessing the identified on-farm climate-smart adaptation measures in the study area for sustainable food production.

Keywords: On-farm activities, livelihoods, climate-smart adaptation, Offinso, Ghana

Introduction

Agriculture is the backbone of most sub-Saharan African economies and thus, contributes substantially to the Gross Domestic Product (GDP) of most sub-Saharan African countries (Chijioke et. al., 2011), including Ghana. The sector employs more than 60% of the population and accounts for about 40% the Africa's foreign exchange earnings (Ludi, 2009; Nhemachena and Hassan, 2007). At the subsistence level in the sub-region, agriculture remains the major source of livelihood and provides the rural dwellers with employment and household income. Estimates indicated that more than 70% of the population of sub-Saharan Africa lives in rural areas, with about 85% depending on rain-fed agriculture and agriculture-based rural activities as their source of livelihoods (Shah et al., 2008).

Throughout the year, agriculture is the major contributor to many household's income with minimal contribution from other alternatively diverse rural livelihood activities in sub-Saharan Africa. Under severe climate change conditions, farmers have had to engage in on-farm adaptation practices that would enable them to improve soil conservation practices to increase their crop yield. This is meant to ensure secured household food security. Bellon and Etten (2014) have explained on-farm conservation as "farmers' continued cultivation and management of a diverse set of crop populations in the agro-ecosystem where the crop evolved or in secondary centres of diversity". This however depends on farmers' active participation, based on their reasons and incentives for maintaining agro-diversity (Bellon et. al., 1997 and cited in Bellon and Etten, 2014).

It is also important to emphasize that the population of sub-Saharan Africa is projected to reach 1.7 billion by 2050 and thus, the development of agriculture in the sub-region is very crucial. This is particularly so, regarding the need to safeguard rural employment and future food security (Shah et. al., 2008), for sustainable livelihoods. Therefore, the importance of agriculture in sub-Saharan Africa cannot be overemphasized as there is a

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direct and strong relationship between the sector and livelihoods (Diao et. al., 2007; Salami et. al., 2010).

The gain from subsistence food production notwithstanding, subsistence food security in recent years is confronted by the scourge of climate variability and change. Climate change, which involves the change in the climate, whether due to its natural variability or as a result of human activities (IPCC, 2007), poses the greatest challenge to the food and agricultural sector in sub-Saharan Africa (Chijioke et. al. 2011). This may be adduced to Africa being the worst affected and the most vulnerable to the impacts of climate change (ADF, 2011). Moreover, Africa, unlike other regions has weak responsive mechanisms and capacity to adequately adapt to the effects of climate change. The irony is that Africa is the least contributor to net global greenhouse gases emissions, which is responsible for climate change (CIGI, 2009).

In the Sudan-savanna to the forest-savanna transitional ecological zone of Ghana, the major food crops produced include cereals (maize, rice, millet and sorghum), roots and tuber (cassava, yam and cocoyam). In the semi-deciduous forest, food crops such as cassava, plantain and vegetables (pepper, tomato, onions, okra, garden eggs), were the most produced crops. In the high forest zone, cash crops such as oil palm, cocoa, coffee, pulses and nuts, as well as fruit crops (oranges, pineapple, pawpaw and banana) areas are prominent (Nyanteng and Asuming-Brempong, 2003).

The productivity of these crops in sufficient quantity was observed by Ngigi (2009) to depend mainly on rainfall availability of irrigation technologies. Thus, crop production is vulnerable to the current scourge of climate variability, which may engender future crop failures. According to IFAD (2011) when food crop production is mainly rain-fed, any seasonal shortfalls in the amount rain received could affect production considerably. On-farm water management (OFWM) as an adaptation measure to combat climate change therefore becomes imperative. The OFWM was defined by Wolff and Stein (2003) as the manipulation of water within the borders of an individual farm, a farming plot or fields for both rain-fed and irrigated agriculture.

According to Skambraks (2014), adaptation is important since it can be used to assess the impact on and the vulnerability of a system, and to develop and evaluate the response options. Various types of adaptations

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have been distinguished with different types of classifications (Eisenack and Stecker, 2012; IPCC, 2001; Smithers and Smit, 1997). Adaptation involves the action that people take in response to, or in anticipation of, projected or actual changes to reduce adverse impacts or take advantage of the opportunities posed by change (Parry *et al.,* 2005). FAO (2006), categorized the adaptation strategies mostly adopted by smallholder farmers in order to manage the effects of climate change and variability into traditional strategies, government-supported strategies, alternative and innovative automatic adaptation strategies, as well as technology driven strategies.

In rural Ghana, particularly within the Offinso Municipality, the impacts of climate variability and climate change are evident among the rural smallholder farmer households. However, the extents of these impacts are invariably limited to the subsistent farming sub-sector. Again, studies on the on-farm adaptation strategies and its effects on rural smallholder farmers have not been exhaustive in Ghana. Kuwornu *et al*. (2013) for instance noted that adaptation strategies in the context of climate change and variability are all those practices that are used by smallholder farmers to either get used to, or minimize the effects of climate change and variability. In their study, Below et al. (2010), could not distinguish between adaptation to climate change and adaptation to climate variability.

Generally, the impacts of climate variability and climate change on rural livelihoods and related dimensions have not been thoroughly studied. Specifically, the same relationship among smallholder farmers remains inadequately examined. As observed by Lisk (2009), there exist 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 communities lifestyles in general are not fully exploited to appreciable extent. Coupled with this, is the policy ambivalence exhibited by weak implementation of rural development efforts, which have not inspired the needed impetus for change in these areas. This various on-farm adaptation measures among smallholder farmers in the Offinso Municipality in the Ashanti region of Ghana were examined with the view to drawing lessons for effective policy formulation and implementation.

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Methodology

The study area

The Offinso South Municipal Assembly is one of the new Municipalities created in Ashanti Region in 2007. The Municipality shares common boundaries with Offinso North District Assembly in the North, Afigya Kwabre in the East and South, Atwima Nwabiagya and Ahafo-Ano South District Assemblies in the West. New Offinso, which comprises 22 suburbs is the Municipal capital. The Municipal lies within latitude 7º15'N and 6º95'N and longitude 1º35'W and 1º50'W; the Municipality has a total land area of about 600km² (Figure 1). Based on the 2000 population census the population of Offinso South Municipal Assembly in 2010 was estimated at 120,585 with a growth rate of 3.5%. The high population growth rate of the Municipality can be attributed to in-migration as a result of favourable climatic conditions and fertile soil, which supports the cultivation of diverse food and cash crops.

The Municipality experiences wet semi-equatorial type of climate, characterised by moderate to heavy rainfall annually with temperature ranging between 21ºC and 32ºC. The rainfall regime is double maxima with annual rainfall between 1250 and 1750 millimetres. The average annual rainfall is 953.40 mm. The major rainy season usually occurs between May and June, followed by a dry spell between August and September. The minor rains occur between September and November followed by dry Harmattan spell till February.

The combined result of the favourable climatic conditions - favourable rainfall, temperature - and fertile soil in the Municipality enhance agricultural production with attendant improved income and living standards of residents. Agriculture is the backbone of the Municipal economy. It employs 62% of the working population and contributes about 55% through food crops and 20% through livestock to households income in the Municipality. The major food crops produced in the Municipality are plantain, maize, yam, cocoyam and vegetables such as pepper, garden eggs and tomatoes. The industrial crops produced are cocoa, oil palm and teak. Teak is not very much cultivated. They are promoted by the Forestry Division for reforestation in the depleted forest reserves. The Municipality's average yield for some selected food crops in 2009 were; maize 1.40mt/ha,

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cassava 10.54mt/ha, yam 13.85mt/ha, plantain 10.71mt/ha, cocoyam 5.97mt/ha and rice (paddy) 1.10mt/ha.

The existence of the forest reserves in the Municipality is a potential for providing timber for the building and the construction industry. The Assembly also earns revenue in royalties (stool lands) and from legal timber firms operating in the forests as concessions and from saw millers.

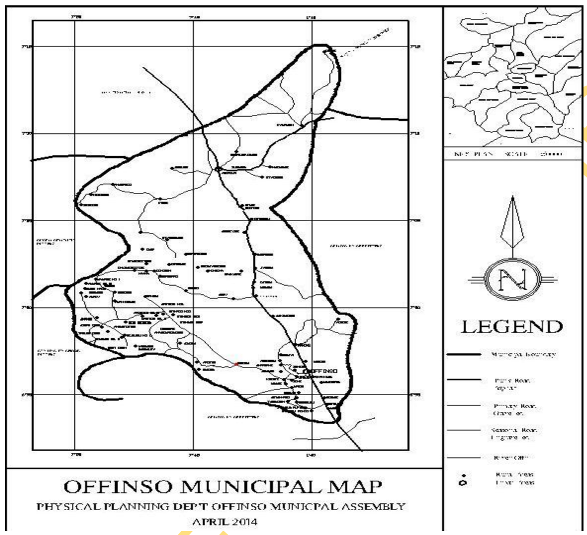

Figure 1: Map of the Offinso municipal assembly

Research design and sampling

The research design was quantitative and qualitative in approach, based on both empirical field work and secondary data sources, in a method of triangulation (Frankfort-Nachmias and Nachmias, 1996). The research was cross-sectional and the respondents' were smallholder farmers' in the study area. Rapid Rural Appraisal (RRA) approach was used to establish rapport with the respondent of both genders in the selected study communities, within the Offinso Municipality of the Ashanti region of Ghana. From the municipality a total of six (6) forest-fringed communities, of purely rural settings were purposively sampled, based on their socio-economic activity as being smallholder farmers and in closer proximities to the forest areas. Out of four thousand (4,000), the total population of smallholder farmers (obtained from the Municipal Agricultural Office), a proportionate 0.8% sample of 300 respondents were selected for the study. However, out of the 4,000 overall farmers' population, only about 3,000 were from the six (6) forest-fringed communities sampled for this study.

Research instrument for data collection and analysis

In all 300 households structured and partially pre-coded questionnaires were administered. Also, three (3) focus group discussions (FGDs) were performed in 3 of the 6 selected communities. This was to get the qualitative aspect of the responses from farmers' subjective views and perceptions. They used these to express themselves, when responding to some of the issues on their smallholder farming, climate variability and change as well as adaptation.

Thus, the selection of respondents and settlements for this project was based on the need to capture the peculiar features of smallholder farming and forest livelihood adaptations to climate change as well as the communities' characteristics in the purely rural context in the municipality. The data obtained were analyzed using cross-tabulations, frequencies, logistic regression and Pearson's chi-square analytic tools at $\alpha_{0.005}$ employing the Predictive Analytic software. The qualitative data was analyzed thematically and integrated in the discussions to buttress the quantitative results.

Results and Discussion

Socio-demographic characteristics of smallholder farmers

The survey took into consideration the socio-demographic characteristics of the smallholder farmers and how these factors influenced their smallholding farming activities as well as their adaptation capabilities in the six communities surveyed. The communities were *Abofour, Adukro, Amoawi, Asuboi, Ayensua* and *Namong*. On the basis of the gender disaggregation of the respondents, it was identified that farming in all the communities constituted a predominant occupation of the males. Out of the total sample of 300 smallholder farmers, 67% and 33% were male and female respectively. The household sizes of the farmers were identified as high on the average. Most of the respondents (51.0%) have household sizes of between 6-10 people, while 34.0% of them had household sizes of 1 to 5

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people. The remaining 15.0% had household sizes of up to a little more than 20 people per household.

Age cohort of respondents

The age cohorts of the farmer respondents indicated that many of the farmers were in their middle to early old age (46-55 and 56-65 years) category. The proportion of farmers identified in these age cohort was 50.0%. The youthful proportion of farmers identified was below 40.0%. This implies that, smallholder farming activities are still not attractive among the youth who are below the ages of 40 years. With farming being engaged by older generation, there are still concerns for food security in sub-Saharan Africa. This is because the active populations are usually found in other economic engagements leaving the farming occupation to their older generations. Apparently however, some of these youths have been educated from the meagre income from agriculture undertakings.

Education level of smallholder farmers

The education levels of the farmers were analysed to compare their level of knowledge about the scourge of climate variability and change with education status. Out of the total respondents surveyed approximately 58.0% had education to the Junior High School and middle school (JHS/Middle) levels. There were quite an appreciable proportion of the farmers, constituting 29% who indicated no form of formal up to primary school education. A little over 12% of the farmers had education up to the tertiary level (Table 1). This factor arguably has implications for the farmers' ability to understand the issues about changing climatic conditions that affect their farming activities. This also affects the adaptation measures initiated by respondents to obviate the adverse effect of climate variability and climate change on their livelihoods.

The marital status of farmers

The marital status of the farmers indicated that a large proportion of them are married. The proportion of married farmers was up to 83%. The remaining 17% were either single, divorced or widow/widower. This social status of the farmers ties in with the size of household that each of the farmers cater for as the heads of these households. Most of the farmers had household sizes range from 6 to 10 people, constituting 51%. Household

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sizes of up to 5 people were next in predominance among the farmers in all the communities surveyed. They were represented by 34%. The remaining 15% was identified among households with sizes in excess of 11 people, as displayed in Table 1.

Table 1: Socio-demographic characteristics

Variables	Frequency	Valid Percent	Mean	Stand. dev.	*p*-value
Sampled Communites					
			3.570	***1.670***	***.015***
Abofour	43	14.3			
Adukro	42	14.0			
Amoawi	72	24.0			
Asuboi	40	13.3			
Ayensua	50	16.7			
Namong	53	17.7			
Gender					
			1.330	***.471***	***.000***
Male	201	67.0			
Female	99	33.0			
Total	***300***	***100.0***			
Age					
			2.927	*1.249*	*.000*
20-35	39	13.0			
36-45	78	26.0			
46-55	90	30.0			
56-65	61	20.3			
66-75	23	7.7			
76+	9	3.0			
Marital status					
			2.090	***.526***	***.000***
Single	17	5.7			
Married	250	83.6			
Widow/widower	20	6.7			
Divorced	12	4.0			
Education Level					
			2.6890	***1.010***	***.000***
No Formal Education	55	18.4			
Primary	34	11.4			
JHS/Middle school	173	57.9			
SHS/Tec/Voc	23	7.7			
Tertiary/Post Sec	14	4.7			
Size of Household					
			1.9267	***.940***	***.000***
1-5 people	101	33.7			
6-10 people	153	51.0			
11-15 people	23	7.7			
16-20 people	13	4.3			
20+ people	10	3.3			

**Missing system =1*

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These characteristics variously influenced the farmers' perception, knowledge and disposition to the vagaries of climate variability and climate change. These were also *in tandem* with the capabilities of the farmers to innovate and implement adaptation strategies against the impact of climate change.

Knowledge of climate change and on-farm adaptation measures

The farmer's level of knowledge of climate variability and change did not significantly influence their on-farm adaptation strategies. This is because, of all the on-farm adaptation strategies identified as being practiced particularly to prevent losses of soil moisture, mulching was the most practiced method. However, only 35.0% of those practicing mulching have 'good knowledge' of climate change. Among respondents practicing irrigation as adaptation measure, only 25.0% had a good knowledge of climate change. It is important to note that, the irrigation being referred to here, does not involve the use of mechanical pumping machines, (although a few use them), the predominant means of 'irrigation' was by the use of watering cans or buckets. Thirty percent of respondents with 'Very good knowledge' of climate change also practiced mulching on their farms, while 15.0% with good knowledge practiced no tillage. Among those with good knowledge of climate change, 35.0% practiced irrigation while 31.0% and 18.0% practice mulching and cultivate drought resistant crops, respectively to mitigate the effect of climate change. The remaining 11.0% with very good knowledge of climate variability and change practiced all other methods on their farms (Table 2).

Table 2: Percieved impacts of on-farm adaptation measures on climate change among respondents

	Very Good	**Good**	**Don't know**	**Poor**	**Very Poor**	Total
Irrigation	19	40	5	11	2	**77**
No tillage	2	25	1	13	2	**43**
Mulching	17	57	6	21	0	**101**
Grow drought resistant crops	10	19	2	5	2	**38**
Other	6	19	4	3	1	**33**
All responses	1	2	0	0	0	**3**
	55	**162**	**18**	**53**	**7**	**295**
Chi-Square test statistic	*χ^2 = 23.422; df= 20; p > .05; Cramer's V= .141*					

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The test of association between the variables, revealed a very weak, inverse relationship between the variables. The p-value was > 0.05, with a Pearson's correlation coefficient (R) of -0.035. This implies that, most of the farmers were applying the various on-farm adaptation practices without necessarily having adequate scientific knowledge of climate change, which informs their action. However, as oblivious as they may be of climate change, their adoption of these various farming improvement practices are climate smart adaptations against climate variability and change. Farmers in the Offinso Municipality however, practiced these methods without recourse to known-scientific based outcomes. They however, affirmed the practices as helpful in adapting to climate variability and change on their farms.

This finding is in agreement with Asefa et. al. (2014) that for generations, farmers in Sub-Saharan Africa have developed knowledge for agricultural adaptations including climate variability adaptation through consistent interactions with their natural environment. These practices, invariably, have not been based per se, on knowledge that are research based. On the contrary, the finding of Buthelezi et. al. (2010) is of the view that farmers land use practices are based on some scientific evaluation of soil suitability based on the scientific knowledge obtained from research.

In synthesis however, there is a correlation between the indigenous knowledge and the scientific knowledge that are applied in farming practices, and these also include the on-farms adaptation strategies used against the impacts of climate variability and change. Meaning that these farmers are actually conscious of what they are doing and the possible outcomes envisaged.

Effects of climate variability and change on the on-farm adaptation measures

In response to the climate variability and change, the farmers undertook a number of measures so at to adapt to the adverse effects. Some of the adaptation measures included the extensification of agricultural activities whereby farmers expanded their farm sizes usually to include other crops or increase the acreage of a particular crop under cultivation. Others also resorted to the increased use of agrochemical and inorganic fertilizer, while others changed the types and variety of crops cultivated. Also, identified was the acquisition of other farm lands for cultivation by some farmers to increase their total output per season.

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Furthermore, other farmers also prepared their land in such a way that the soil moisture will be conserved. Out of the various measures undertaken, extensification of land use and increased use of agrochemical and fertilizers dominated the responses, with a response of 26.0% and 16.0%, respectively. Also, 14.0% of the respondents adopted delaying planting period as an adaptive measure.

Although, one would have expected that the appropriate measure against delayed rainfall for instance, would have been the preparation of land to conserve soil moisture or the improvement in irrigation system, or cultivation of drought-tolerant crops. The contrary was the case. The responses as it were, counters Westengen and Brysting (2014) work that elsewhere in Tanzania, with extension support, farmers responded to delayed rainfall season with the cultivation of drought-resistant crops.

It could therefore be presumed that the adaptation measure being used by the smallholder farmers were not planned; due to the fact that there is no significant association between what the farmers were doing, against the adverse effects of climate variability and change as identified. The chi-square test of association was not significant with the $p > 0.05$. The farmers do agree that there is some form of effects of the changing climatic conditions, on their farming activities. However, their measure in dealing with these effects is not really tailored against the effects so identified. This is because over the years, most farmers have been relaying on their ethno-climatologic knowledge and indigenous farming expertise (Soropa et. al., 2015) to deal with adversities of climate variability and change; this was also evident in the various communities of the municipality.

Location of farm and the crops cultivated

Although very weak, there was a significant association between the location of the farm and the type of crops cultivated. The Chi-square test of association indicated at 16 degrees of freedom a χ^2 value of 47.887 at $p < 0.000$. The Cramer's V strength of association and the correlation between the variables however were 0.187 and 0.008, respectively. This is because of the fact that on the farms, cash crops, food crops and vegetables, were usually located near water sources like rivers and streams. This does not necessarily mean the farmers made use of the water for irrigation. Food and cash crop farms combined was the most consented to being located near some form of water source with a response rate of 54.0%. Location of

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food crops only near water sources was agreed to by 22.0%, while location of vegetable farm near water sources was consented to by 10.0% of the respondents (Table 3).

This implies that the location of the farm to a source of water body per se does not make it amenable for irrigation since according to the farmers one of the challenges they faced was their inability to access proper irrigation equipment in the form of water pumps and other mechanical fittings. However, the farmers do realize the potentials of irrigation to enhance production when confronted with climate change adversities. This agreed with Kurukulasuriya et. al., (2006) who observed from some African countries that irrigation increases agricultural incomes despite moderate temperature increase. They described as irrigation of their farm, (apart from a few who had water pumps), the use of watering cans as means of irrigating their farms. Also, since the location of the farm was not determined in absolute distance terms, what constituted "near" and "far" by the understanding and estimation of the farmers differed.

Table 3: The location of farm and the type of crops cultivation

Crop cultivated	Near lake/pond	Near river/stream	Water wells on farm	Not located near source water	Other	Total
Food crops	8	28	0	31	0	**67**
Vegetables	2	23	2	3	1	**31**
Cash crops	0	4	0	11	0	**15**
Food and Cash crops	17	89	11	44	2	**163**
Agroforestry	0	9	1	14	0	**24**
Total	27	153	14	103	3	300

On-farm adaptation measures employed per community

On-farm adaptation measures (OFAM) by communities indicate that the communities have increased their use of agrochemical and inorganic fertilizers, as a means of boosting production under changing climate condition. As many as 36.0% of the farmers from five out of the six communities namely; Adukro, Amoawi, Namong, Asuboi and Ayensua, respectively in order of magnitude, indicated this. For extensification as a measure of adaptation, 17.0% of the respondents, particularly from Ayensua and Namong indicated this as their predominant practice.

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Some of the farmers also change the type of crops they cultivated from time to time, testing the yield for each over time. Out of all the respondent, 16 percent (mainly from Adukro with 25.0%) of the respondents adopted this measure. Five percent of the farmers either changed the variety of the crop cultivated or prepared the land to conserve soil moisture. A total of eight percent of the farmers indicated, they practiced almost all the up-listed measures as adaptation measures to climate variability on their farms (Figure 2). The Pearson Chi-square test of association between the two variables was significant at $p < 0.000$. A Chi-square ($\chi^2 = 100.004$ at 35 degrees of freedom, with the Crammer's V = 0.262 was reported.

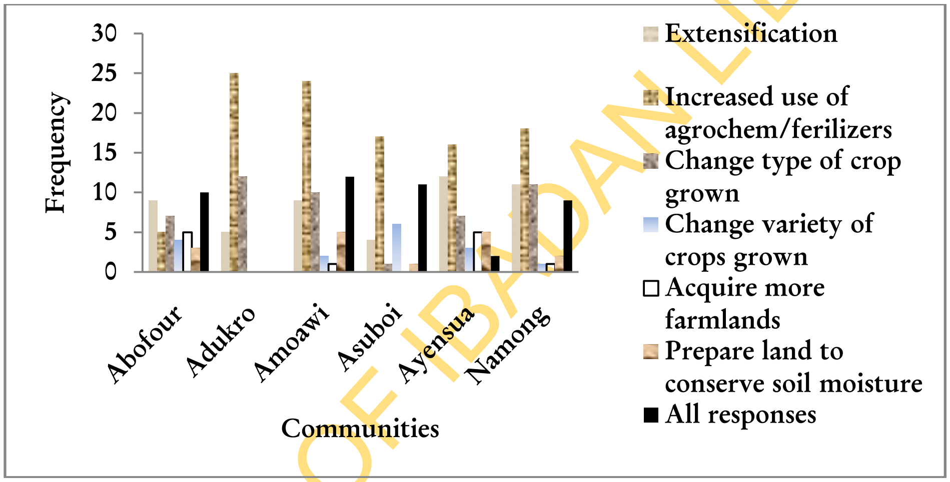

Figure 2: Adaptation measure employed by farmers per community on-farm crop management practices and soil conservation measure

It was therefore pertinent to ascertain some of the farmers' on-farm crop management (OFCM) activities undertaken to conserve soil moisture as well as the soil nutrients conservation techniques engaged in. On crop management practices, the farmers indicated that they either undertook efficient management of irrigation system, cultivate crops that do not require much water, cultivate cover crops such as some leguminous crops or do nothing at all on their farms. These practices were engaged in along with the use of cover crops, green manuring, mulching composting and agroforestry as soil nutrient conservation measures.

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The essence of on-farm soil and crop adaptation to climate change is to engage the farm ecosystem in an integrated manner that ensure crop evolution along a certain pattern of sustainability, which has the propensity to ensure food security for the farmer (Bellon and Etten, 2014). Of all the identified crop management practices for soil nutrient conservation, 31.0% of the farmers indicated that efficient irrigation management helped them to conserve soil nutrients. Also, 27.0 % of them observed that growing of crops that do not require much water helped them to conserve soil moisture as well as soil nutrients. Only nine percent however, were into the cultivation of cover crops as management practice. Quite a substantial proportion (33.0%) though did not undertake any crop management practices to conserve soil moisture (Table 3).

Table 3: On-farm crop management and soil conservation measures

Crop management/ soil conservation practices	Use of cover crops	Green manure /mulching	Composting	Agroforestry	Not applicable	Total
Efficient management of irrigation system	5	9	51	3	14	**82**
Growing crops that require little water	15	14	21	2	18	**70**
Cultivation of cover crops	6	2	6	3	6	**23**
Do none of the above	3	21	22	5	37	**88**
Total	**29**	**46**	**100**	**13**	**72**	**263***
Test statistics	***X^2 = 65.561; df = 18; p< .000 ; CV = .288***					

**Missing system = 37 non-response*

The test of association was however significant and strong with the Pearson's Chi-square (χ^2) value of 65.6 showing a significant probability of error less than $\alpha_{0.05,}$ at p < 0.000, with a Cramer's test of the strength being moderately strong and significant at V = 0.29. This implies that the farmers put in efforts of managing the soil moisture conditions against climate variability especially little rainfall, which they had already identified as being erratic in recent time over the past 15 years. This result resonates well with Wolff and Stein (2003), who reported that in order to maximize soil water in on-farm water management efforts, farmers need to be aware of the relationship that exist between land use and soil water.

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The fact that quite a substantial percentage of the farmers (33.0%) interviewed seem not to know what to do on their farms towards conserving the soil moisture, points to the threatening situation of food insecurity at the households level and by extension, to the community and the municipality at large. The latter category of farmers did manage their farming in a "business as usual" scenario, without recourse to any adaptation measures. For such category, as put by one farmer; "*I leave everything to God; because He gives rain and retains it so at the appropriate time when it rains, I will continue with my cultivation. From now till the next five years remains with God and because no one can predict what God can do, I do not believe in the predictions of science" (Ayensua FGD, April, 2015)* as expressed by female farmer from Ayesua opined in a focus group discussion.

These practices normally do not include the option of out-migration from the farming communities, contrary to some findings that as the livelihoods of the rural population fluctuate with the climatic patterns, some have adopted temporal coping strategies by migrating. In this connection (CIGI, 2009) noted that in western Sudan, sending an older male child to the Capital town, Khartoum to seek paid labour during drought conditions is one of the migration strategies.

Implicitly from the result, despite the observed socio-economic homogeneity among the farmers in the municipality, there exist some differences in adaptation measure intensity and popularity in the selected communities. What is common to all observed adaptations was the traditional coloration to sustaining rural agriculture and livelihoods in the communities sampled. As observed by Mendis et. al. (2003), small communities that rely on limited assets as their livelihood base are more prone to livelihood vulnerabilities; these include that which is imposed by climate variability and change.

In this regard, the differences in the capacities of the individual to adapt to shocks are invariably a function of other positive factors like assets, uncommon to the mal-adapted individual. Factors such as access to education, income sources, family support and remittances, the presence or absence of alternative/second occupation to farming are all complementary towards better adaptation. The intensities of these factors in the communities however, did vary; hence the differences in capacities of the farmers in the municipality to adapt to the vagaries of climate variability and change. However, in the contrary, complementary assets *per se* may not

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be pointers to a successful adaptation. What could be considered also, is the value and lifespan of the asset being considered as the stock backstopping adaptation back; since, as in the axiom of 'big is beautiful', smaller complementary assets may not, in some cases, add up to a bigger asset base with longer time span.

Conclusion and recommendations

Farmers' off-farm adaptation strategies to climate variability and change are function of their tangible and intangible assets. These assets are employed to initiate the various measures that have the potential of ensuring foods security and sustained their household livelihoods. The study has espoused the linkages between adaptation and sustainability of livelihood among the people in the Offinso municipality.

Farmers in the municipality adopted various on-farm adaptation strategies (OFAS) as on-farm measures against the vagaries of climate variability and change. However, the effectiveness and reliability of most of the adapted measures have no concrete scientific basis. This is because, when the effectiveness of adapted strategies was juxtaposed with farmers' educational levels, no significant association was observed between the variables. Thus, where western education is a pre-requisite to establishing scientific effectiveness of adaption strategies, there may not be any scientific basis for farmers' adaptation to climate change and variability in the study area. However, where scientific effectiveness is dependent on years of observations and drawing mental inferences, which seldom fails, as is the case with indigenous knowledge base, it may not be true to completely conclude that observed adaptations in Offinso municipality lack scientific backing.

In some instances, some of the adaptation measure used was; the relocation of farms from lands located in areas without easy access to water. There were other farms that made strenuous effort to manage soil moisture and to enhance the irrigation systems on their farms. The decision was based on their experiences of delayed and limited rainfall during the planting seasons. As an on-farm adaptation measure (OFAM) to bolster crop production, increased use of agrochemicals and inorganic fertilizer among the farmers in almost all the communities was identified.

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There were significant associations between the effectiveness of the adaptation measures and the practices engaged in on farms. The effectiveness of the practices depended on a number of factors, which variously predicted the ODD likelihoods of the farmers' indicating the effectiveness of their on-farm adaptation strategies (OFAS). It was also identified that, most communities practiced common adaptation measures. However there were some of them, which were specifically peculiar to particular community.

The paper recommends that, non-adaptation stances identified among a considerable number of farmers could be addressed through farmer field visits using extension and development, by the Ministry of Food and Agriculture (MoFA). Furthermore, farmers in the various communities could initiate collaborative efforts of developing alternative livelihood to farming as their main occupation. By this, pooling collective resources together and managed by a co-operative model could help build and sustain the farmers' adaptation capacities to obviate the effects of climate change on their household livelihoods. Finally, building farmers' capacities in various aspects of climate variability and change situations by establishing standard practice measures for identified adaptation techniques and learning such with them, in order to prepare them for climate variability and change vulnerabilities.

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