Adaptive Capacity of Farmers to Climate Change in the Kassena Nankana Municipality of Ghana: Implications for climate adaptation strategies

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Abstract

This study analyzed factors that contribute to the adaptive capacity of farmers based on their settlement types and use/access to five forms of capital assets (natural, social, financial, physical and human). The use/access to assets were estimated and categorized into high, moderate and low adaptive capacities. The data was based on a survey of 155 farmers from three communities in the Kassena Nankana Municipality of the Upper East Region of Ghana. From the findings, Manyoro, the urban community, recorded the highest adaptive score although their illiteracy level was highest. Low adaptive farmers had low access to credits and alternative livelihoods compared to farmers with high adaptive capacity. Access to irrigation had a positive significant influence on adaptive capacity. In general, the more accessible a resource was to a farmer, the more adaptable that farmer was to climate change. Following the findings of this study, it is important that policy interventions in the area prioritize creation and encouragement in alternative livelihoods sources as a means of increasing the adaptive capacity of famers in the rural and semi-urban areas. Also, private and government institutions should invest in irrigation and credits facilities as measures for economic growth and adaptation to the effects of climate change on agriculture. Farmers should be empowered through better extension and agro-climatic information and other affordable modern technologies.

Introduction

Climate change effects have moved from just being an environmental problem to a major setback in developments (Reid, 2011). The Sub-Saharan region of Africa is particularly identified to be vulnerable to climate change because 97% of the agricultural lands are rain-fed coupled with a low adoption of modern technology by the populace (Parry et al., 1999; Makondo et al., 2014). In Ghana, the Northern regions are highlighted as being more vulnerable to climate change than the Southern regions because the area falls within the ecological zone of high temperatures and low rainfall. Based on climate predictions, temperatures in the three northern regions of Ghana are projected to increase by 1.7ºC - 2.04 ºC by 2030, with average temperatures rising as high as 41ºC (Stanturf et al., 2011). Aside climate change, poverty and low access to farming information and credits limit farmers' productivity (FAO et al., 2012). The observed impacts of climate change in the Upper East Region only could decrease the amount of physical resources available for agriculture and increase the cost of maintaining destroyed infrastructure.

Studies have shown that the majority of households in rural areas are more likely to be affected by climate change compared to urban dwellings. This is because rural dwellers depend directly or indirectly on climate-sensitive sectors, such as agriculture as their main source of livelihoods and hence most often than not, have little and sometimes no means to cope with climate change. The vulnerability of these people is aggravated by inadequate technical know-how, high illiteracy, lack of property insurance and poor access to public services (UNISDR, 2008).

Identifying factors that contribute to adaptive capacities is particularly significant as it enables the comparison of relative adaptive capacities of settlement types to the impacts of climate change/climate variability (Antwi-Agyei et al., 2012) so that policy makers can

understand the capacity needs and prioritize actions during policy interventions. The main objective of this research is to assess the adaptive capacities of three different settlement types – urban, semi-urban and rural - in the Kassena Nankana Municipality in the Upper East Region of Ghana as basis to inform policy interventions.

Adaptive capacity is related to the vulnerability of a system, i.e., if it is highly exposed and sensitive to the effects of climate and at the same time has low capacity to adapt. Conversely, a system is less vulnerable if it is less exposed and sensitive or has high adaptive capacity. Hence, vulnerability is a function of exposure, sensitivity, and adaptive capacity (IPCC, 2001). Adger et al. (2013) assert that adaptive capacity is influenced by five different capital assets: natural, human, financial, social and physical (Figure 1). Asante et al. (2012), however, argue that there is no one single approach to assessing adaptive capacity of a system as its components are highly dependent on the type of system. This notwithstanding, the adaptive capacity of individuals, households and communities are predominantly determined by their access to and control over the five capital assets (Dazé et al., 2009). This approach is used in this study. Again, a number of empirical studies across Africa have shown that adaptive capacity is indeed related to the five capitals indicated above (CARE, 2011). Access to natural capital allows farmers to engage in bush farming and collection of non-timber forest products (Egyir et al., 2015). Adequate human capital improves access to information on the potential benefits and drawbacks of available technologies (Elias et al., 2013). Access to financial capital enables farmers easily and timely access credit and diversify income (Ahmad and Garcia, 2015). Access to physical capital enhances socio-economic status by making people mobile and process agricultural products (Egyir et al., 2015). Social capital enables farmers to rely on "social collateral" for accessing credits and other productive resources (Bekele et al., 2013). Fostering the adaptive capacity means farmers may have to gain access to technical skills, alternative livelihoods sources, infrastructure and access to markets (Mengistu, 2011).

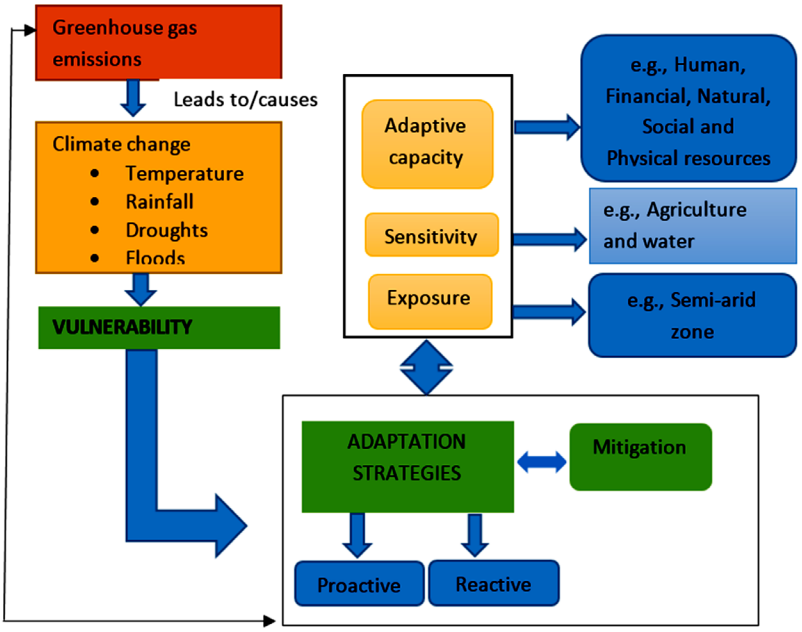

Figure 1: Framework for Adaptive Capacity situated within a vulnerability context

Materials and methods

Study area

The Kassena Nankana Municipality is located in the Upper East Region of Ghana (Figure 2). Temperatures in Kassena Nankana Municipality have been increasing at an annual rate of 0.02°C in the last 30 years. The Municipality records the highest annual temperatures in Ghana and hence, the most likely to be affected by the adverse effects of climate change in the near future. The monthly average temperatures range from 27.9ºC to 32.6ºC (Stanturf et al. 2011). Increases in temperature could lead to increases in evaporation and evapotranspiration rates and these together reduce soil moisture, create heat stress and reduce the quality and quantity of farm commodities, thus likely to have large impacts on crop and livestock production (Assan & Obeng, 2009). The rainfall amounts/ distribution during the rainy season has also declined over the last three decades with implications for available soil moisture for crop production, as crops are sensitive to moisture for growth and optimal yield (Assan & Obeng, 2009). As a result of the variability; erratic and declining rainfall amounts; and decrease in the number of rainy days, as well as rising temperature over the decades, the region is contending with annual intermittent droughts and floods that has impacts on agriculture and livelihoods.

The area is covered mainly by the Sahel and Sudan-Savannah types of vegetation which consist of open savannah grassland and deciduous trees. The topography of the municipality is low-lying and undulating with isolated hills rising up to about 300 metres in the western and southern parts (UNDP, 2010). The climatic conditions of the municipality are characterized by the dry and wet seasons which are mainly influenced by the North-East Trade winds (*Harmattan* air mass) and the South-Westerlies (Tropical Maritime). During the *Harmattan*, rainfall is virtually absent due to low relative humidity of less than 10mb (UNDP, 2010). Day temperatures during the *Harmattan* can be as high as 42°C (especially in February and March), while night temperatures can be as low as 18°C (KNMA, 2014). However, the tropical maritime air mass brings rainfall averaging

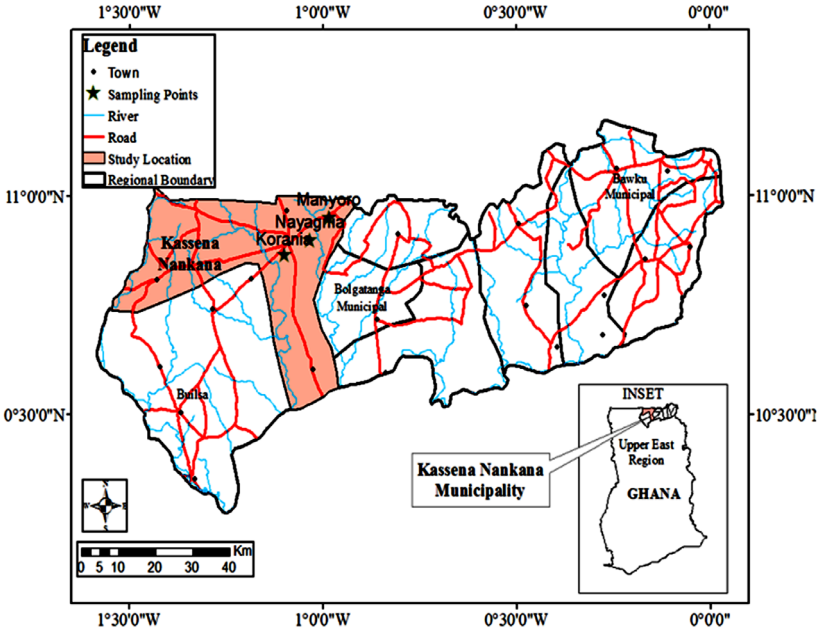

Figure 2: Map of study area

about 950mm per annum between May and October (KNMA, 2014). A tributary of the Asibelika River called the "Tono" has been dammed to provide irrigation services to farmers during the long dry period.

Data Collection Methods: Sample Size and Sampling Procedure

To obtain a cross section of typical capacity needs in the Kassena Nankana Municipality, the research used a mixed-method approach for data collection. Data were collected from secondary and primary sources.

Three communities, namely, Korania (a rural community), Nayagnia (a semi-urban community) and Manyoro (an urban community) were purposely selected. According to the 2012 population census, an urban area is any locality with 5,000 or more persons and a locality with less than 5,000 persons is classified as rural (GSS, 2012). This means that aside Navrongo, Manyoro and a few other settlements that record populations of over 5,000 residents, most of the population in the municipality live in rural and semi-urban settlements (KNMA, 2014). The three communities were purposely selected based on their dependence on rain-fed agriculture, access to irrigation, dry season gardening and accessibility to roads. This selection allowed for in-depth analyses and comparisons to be made so that policy makers can prioritize resources during policy interventions in the Municipality and other communities living within the same climatic zone.

Simple random sampling techniques were employed to select respondents for the study. First, the 97 communities within the municipality were divided into three subpopulations, called strata: rural, semi-urban and urban. One community was selected from each strata for sampling. A total of 155 questionnaires were administered to respondents. The rationale for this sample size was based on homogeneity of population, timeframe of the work, large number of factors to be analyzed and the precision level required. The study was conducted during the off-farm season (December-April). This timeframe was chosen because it is during this period season that farming activities are reduced.

Data Management and Analysis

Data were processed and analyzed using Statistical Package for the Social Science (SPSS) version 20 software. Data were entered and organized on scale either as parametric (numeric, e.g., age of respondent, and household size) or non-parametric (ordinal or coded, e.g. sex, educational status, and gender) for each of the respondents. Farmers' adaptive capacities were categorized into five capitals (i.e. human, financial, social, physical and natural).

For each category, critical elements were identified and scored, 1 for "yes" and 0 for "no". The scores were based on attributes such as accessibility to a particular capital. Table 1 shows the main indicators that were considered in this study and a brief description of how the assets were characterized in relation to household's ability to adapt to climate variability. The development of the adaptive capacity index (AC) used criteria weighing. The overall adaptive capacity (AC) was obtained by dividing the total score of the attributes for the ith respondent by the sum of the most desirable score of all attributes, thereby reducing the adaptive capacity to a scale of $0 \leq AC \leq 1$ (Asante et al., 2012). It has been suggested that an index of $0 < AC < 0.33$ should be considered as low, $0.33 < AC < 0.5$

as moderate and AC≥0.5 as high (Asante et al., 2012). For this particular application, the overall adaptive capacity index is expressed in equation one (1):

$$AC = \frac{\Sigma (H.Hw) + (F.Fw) + (S.Sw) + (P.Pw) + (N.Nw)}{N} \quad (1)$$

Where, *H* is the human capital score and *Hw* is the human capital weighing; *F* is the financial score and *Fw* is the financial capital weighing; *S* is the social capital score and *Sw* is the social capital weighing; *P* is the physical score and *Pw* is the physical capital weighing; *N* is the natural capital score and *Nw* is the natural capital weighing, and "n" is the number of observations, in this case the five attributes (Asante et al., 2012). The difference in the means was analyzed using ANOVA (F tests and p-values) and Tukey post hoc tests at 0.01 and 0.05 significance levels.

Results

Socio-demographic characteristics of respondents

The age group that was most actively engaged in farming was between 35-54 years. Records on educational status revealed that majority of the respondents were illiterates (59.4%) and only 3.9% had some level of tertiary education. Mixed farming (crop and livestock) was common among respondents in Korania and Manyoro while crop farming was widespread

TABLE 1
Main indicators and a brief description of how the assets were characterized

Component	**Indicators**	**Questions posed during data collection to obtain information on this indicator**
Human capital	Information on farm issues/extension services	Do you have access to information on farming issues?
	Early warning on weather-related issues	Do you receive any warning about weather-related issues?
	Access to modern farm implements/inputs	Do you have access to modern agricultural inputs?
Financial capital	Engagement in alternative livelihood	Do you have a non-farm source of income?
	Access to credits/micro-finance/traditional saving methods	Do you have access to credits/loans/ insurance?
Social capital	Association with Farmer Based Organisations (FBOs)	Do you belong to any FBO?
	Remittance	Have you received any form of help from friends/relatives in the last 12 months?
Physical capital	Access to irrigation and dry season gardening	Do you have access to irrigation or dry season gardening?
	Ownership of television, radio or mobile phone	Do you own a television, radio set or mobile phone?
	Access to potable water	Do you have to potable water sources such as pipe-borne or bore-holes?
	Access to electricity	Do you have electricity in your home?
	Access to good roads and modern storage infrastructure	Do you have access to good roads and modern storage facilities for agricultural commodities?
	Access to gas (LPG) for cooking	Do you use gas for cooking?
Natural capital	Ownership of land	Do you own a land?
	Accessibility to other peoples' lands	Do you have access to cultivate land that is not your own?

in Nayagnia. Rain-fed agriculture was most common in Manyoro. The mean farm size was 3.14 ± 4.45 hectares.

Level of Farmers' Adaptive Capacity

To identify and measure the factors that may have contributed to the adaptive capacity of households, respondents highlighted indicators linked to each form of capital asset (i.e. human, financial, social, physical and natural capitals). This information was used to develop the overall adaptive capacity of respondents.

An index of $0<AC<0.33$ was considered as low, $0.33<AC<0.5$ as moderate and $AC\geq0.5$ as high. The overall adaptive capacity (AC) level of the three communities studied was 0.43 thus, moderate. The mean score for Korania was 0.43; that of Nayagnia was 0.42 and Manyoro was 0.442. As shown in table 2, the lowest score (0.21) and highest score (0.68) were associated respectively, with financial capacity and natural capitals in Korania.

Access to information on farming varied significantly from one community to the other (F test=5.280, $p<0.05$) in the study area. The Tukey post-hoc test revealed that receiving farm information significantly varied between respondents in Korania and Nayagnia (F test=5.280, $p<0.05$) whiles access to early warning information on weather-related issues was high in all three communities (Table 3).

The Analysis of Variance (ANOVA) test showed that engagement in a non-farm job varied significantly from one community to the other (F test=6.642, $p<0.01$). Access to credits/loans was low in all three communities. Although, more respondents in Korania accessed credits as compared to those in Nayagnia and Manyoro, the difference was

TABLE 2
Differences in the five capitals levels among the three communities studied

Variable	**Measurement**	**Communities**		
		Korania	Nayagnia	Manyoro
Human capital	Index of three factors	0.614	0.519	0.538
Financial capital	Index of two factors	0.206	0.250	0.500
Social capital	Index of two factors	0.441	0.289	0.250
Physical capital	Index of ten factors	0.257	0.402	0.289
Natural capital	Index of two factors	0.676	0.654	0.635
Total Adaptive Capacity (AC)		0.434	0.423	0.442
Mean AC for the three communities=0.433.				

TABLE 3
Human capital situation of households in the study area

Capital elements	Percentage response			F test	P>Z
	Korania	Nayagnia	Manyoro		
Access to information on farming issues	58.8	34.6	36.5	5.280	0.023**
Early warning on weather-related events	74.5	63.5	75.0	1.065	0.347
Access to modern agricultural inputs	51.0	57.7	50.0	0.360	0.698

**The mean difference is statistically significant at 0.05

TABLE 4
Human capital situation of households in the study area

Capital elements	Percentage response			F test	P>Z
	Korania	Nayagnia	Manyoro		
Engagement in non-farm sources of income	23.5	40.4	57.7	6.642	0.002***
Access to credits/loans/insurance	13.7	9.6	3.8	1.546	0.216

***The mean difference is statistically significant at 0.01

not statistically significant (p>0.05) (Table 4). Remittances in the last 12 months was moderate in all three communities. Membership to an FBO varied significantly from one community to the other (F test=8.817, p<0.01). The Tukey post-hoc test revealed that being a member of an FBO varied significantly between respondents in Korania and Nayagnia (F test=8.817, p<0.01); and Korania and Manyoro (F test=8.817, p<0.05) (Table 5).

Respondents in Nayagnia had high access to good road infrastructure compared to those in Korania and Manyoro. The use of an irrigation facility for farming was highest in Korania. Access to electricity and television in houses were low in all three communities. Access to potable water was high in Nayagnia and Manyoro but low in Korania. There was no access to modern storage facilities in the study area. Although engagement in dry season gardening was low in all three communities, the F-test showed proved that engagement in dry season gardening varied significantly from one community to the other (F test=12.695, p<0.01). Ownership of radio sets were high in all the three communities. Ownership of a mobile phone varied significantly among the three communities (F test=3.577, p<0.05). (Table 6).

TABLE 5
Social capital situation of households in the study area

Capital elements	Percentage response			F test	P>Z
	Korania	Nayagnia	Manyoro		
Association with FBO	43.1	21.2	9.6	8.817	0.000***
Access to remittance from family/friends in the last 12 months	45.1	36.5	40.4	0.386	0.680

***The mean difference is statistically significant at 0.01

TABLE 6
Physical capital situation of households in the study area

Capital elements	Percentage response			F test	P>Z
	Korania	Nayagnia	Manyoro		
Access to irrigation	66.7	9.6	0	63.928	0.000***
Engagement in dry season gardening	0	36.5	21.2	12.695	0.000***
Access to electricity	7.8	19.2	19.2	2.242	0.137
Access to potable water	15.7	80.8	96.2	85.049	0.000***
Access to good road infrastructure	29.4	100	38.5	0.771	0.381
Access to modern storage facility	0	0	0		
Access to television	21.6	32.7	17.3	1.811	0.167
Access to mobile phone	52.9	59.6	34.6	3.577	0.030**
Access to radio set	60.8	55.8	59.6	0.144	0.866
Access to gas for cooking	2.0	7.7	0	2.700	0.070

**The mean difference is statistically significant at 0.05;
***The mean difference is statistically significant at 0.01

Although the ownership of lands for agricultural activities were generally high in all communities, ownership of a land varied significantly among the three communities (F test=4.493, $p<0.05$). A high percentage of respondents in Korania had access to cultivate other peoples' lands as compared to Nayagnia and Manyoro (Table 7).

Discussion

Manyoro, an urban community, recorded the lowest literacy which could be attributed to its trans-border affiliation. Most respondents drop out of school to seek greener pastures in neighboring Burkina Faso rather than staying back home to finish their education. Similarly, Egyir et al. (2015) reported that when people cannot seek alternative livelihoods outside agriculture, they migrate. Policy interventions should be geared towards creating alternative livelihood sources in the area to reduce the trans-boundary migration in the region. Continuous migrations will affect the social and economic growth in the area and this is likely to have implications for national development.

Manyoro recorded the highest adaptive score which implies that urban respondents were better adapted to climate change than rural and semi-urban. Generally, farmers in the study area had moderate capacity to adapt and low financial capital was the biggest contributor to vulnerability. Regardless of whether a household is located in a resilient or vulnerable community, low financial capital leads to a rise in the vulnerability index, thereby increasing vulnerability (Antwi-Agyei et al., 2012). Thus, access to credits and engagement in alternative livelihoods are key to reducing climate change vulnerability among farmers.

Human capital: Although studies such as that by Etwire et al. (2013) indicate that the majority of farmers in the three Northern regions of Ghana do not receive any warning about impending natural disaster such as floods or droughts, respondents indicated otherwise. The respondents have access to early-warning information on weather issues although the use of information at the farm level was minimal due to mistrust in the source of information as previous weather forecasts had not been accurate, leading to under- and over cultivation of crops. One farmer in Manyoro lamented that:

"In 2009, we were told that the rains will start in April and so I planted early but the rains never came. When the rains finally arrived, all the seeds were rotten in the soil and did not germinate. I lost everything and had to rely solely on my livestock to sustain my family. Now, instead of relying on meteorological reports I depend on the knowledge that was passed on to me by my late father."

Thus, for farmers to trust and use information given by the meteorological department forecasts should be more accurate and timely to allow farmers to prepare and respond adequately.

There was a relatively higher involvement of respondents in Korania, the rural community in Farmer-Base Organizations compared to Manyoro and Nayagnia. This was because, the all-year farming through irrigation made it quite easy to mobilize farmers in the farms to disseminate information and access credits compared to the other two communities. This goes to prove that the use of irrigation facilities had a positive significant influence on participation in FBOs discussions and hence adaptive capacity.

Financial capital: The high financial capital score in the urban area, Manyoro was connected to the high involvement in alternative livelihoods. A market center situated in Manyoro encouraged farmers to engage in activities such as petty trading and selling of local alcohol. The involvement of respondents in non-farm activities reduced vulnerability since total dependence on farm production may put a greater risk on income when a farmer encounters adverse climatic conditions (Antwi-Agyei et al., 2012). A critical examination of the results revealed that engagement in specific non-farm activities were influenced by sex. Petty trading was dominated by women whiles masonry, carpentry and painting were dominated by males. Since the findings in the study have proved that alternative off-farm jobs contribute greatly to increasing the adaptive capacity of urban dwellers, it is important that policy interventions in the area prioritize creation and encouragement in alternative livelihoods sources as a means of increasing the adaptive capacity of famers in the rural and semi-urban areas.

According to Coker and Audu (2015), access to credits are important means of adjusting income deficit in times of low harvest and drought. The existence of only three formal operating banking institutions (Agricultural Development Bank, Ghana Commercial Bank and the Naara Rural Bank) and a few savings and loans companies (all located in the municipal capital, Navrongo) may have accounted for the low patronage of the savings and credit systems by respondents. During the focus group discussions, it was discovered that high interest rate charges (as high as 12.5%) and ploughing of income into business or household welfare items such as food, child education, and social events discouraged participants from saving. One farmer in Korania emphasized:

"I don't even have money to buy food, how much more, money to save. My food needs come first before savings."

Building the adaptive capacity of rural, semi-urban and urban farmers in Northern Ghana also means private and government institutions should come up with measures that provide easy and accessibility credits among farmers. It must be noted that whiles the offer of credits to farmers will improve farmers' adaptive capacity, there is also the caution on the amount to be given as too much credit value will be diverted for other uses rather than to the agriculture business (Amaza et al., 2006).

Social capital: The low social capital score in the communities was consistent with that of Stanturf et al. (2011) that Northern regions had the highest overall social vulnerability to climate change in Ghana. Remittances from relatives living outside the communities was moderate, thus signifying the importance of family/community bonds in decreasing vulnerability to climate change since remittances play a significant role in lessening the burden associated with climate impacts (Etwire et al., 2013).

Physical capital: Irregular rainfall had drastically reduced the amount of water available for irrigation. This pattern led to a halt in irrigation for the 2014/2015 dry season. Engagement in dry season gardening was therefore low which affected crop yields and rendered farmers in Korania dormant. Construction of more irrigation systems and consistent maintenance of the Tono dam will

go a long way to deal with unreliable and unpredictable rainfall patterns (IPCC, 2007).

Poor access to electricity may have accounted for the limited access to weather-related information since such weather information is usually disseminated through the media such as radio and television which is largely powered by electricity. School children had to travel long distances (approx. 10km or more) to gain access to light for night studies.

Gas for cooking was less patronized due to its high cost and the long distances people travelled to gain access to the commodity-as far as Paga and Bolgatanga. Although, modern storage facilities play very significant roles in enhancing the adaptive capacity of farmers to climate change and provide insurance against local supply (Godfray et al., 2010), these facilities were absent in the Kassena Nankana Municipality. Cereals were stored in traditional storage facilities called "tuula" (constructed with mud) while others stored fumigated crops in bedrooms and kitchens which could pose threats to human lives. A key informant farmer in Korania explained such a situation in the community by saying that:

"Last year, an entire family made up of a man, his wife and two (2) children were found dead the following morning due to excessive inhalation of chemicals used in fumigating cereal crops. This tragedy would not have happened if the family had a better storage facility for their crops other than the bedroom".

Vegetables which could not be stored for lengthy periods were sold at very low prices to avoid spoilage and attack by pests and diseases, causing huge income losses.

Access to mobile telephones and televisions have the potential to improve linkage of farmers to holders of technical information and serve as effective tools for communication and accessing information on changing weather patterns (Egyir et al., 2015). However, these connections are yet to be fully explored by respondents in all the communities. Low purchase of television sets and mobile phones was linked to poverty, while the high ownership of radio sets was linked to its cheap cost.

Most boreholes were uncovered and others dried-up during the long dry-season. Female respondents complained that during the dry season, long hours were spent to access water. This exacerbated the burden of females as it reduced the time spent on other productive activities but more especially caused truancy in school attendance among young girls. This confirmed the studies of Etwire et al. (2013) who observed a similar phenomenon among girls in the northern parts of Ghana. Nayagnia is located on a highway hence were equipped with better road facilities compared to Korania and Manyoro. It is therefore important that considerations are given to improving the road networks in Korania and Manyoro.

Natural capital: As would be expected for communities in the northern parts of Ghana, access to natural capital was high. This is due to the vast availability of agricultural lands in the North and the importance of lands as an asset on which food production and security status depends (Kuwornu et al., 2013). Friends and other relatives freely allowed farmers who were less opportune to own lands to farm on their lands. This meant that in terms of vulnerability, the Kassena Nankana Municipality may have low vulnerability with regards to accessibility to land resources. This notwithstanding, during drought and

delayed onset of rains, lands dried up and became difficult to plough which in turn, led to weakening of oxen, and this affected agricultural activities.

Conclusion and recommendations

The overall mean adaptive capacity of the study area was moderate. Manyoro recorded the highest adaptive score due to their high engagement in alternative livelihood options. Hence, the study proved that urban settlements were better adapted to climate change than rural and semi-urban. Access to irrigation had a positive significant influence on adaptive capacity. In general, the more accessible a resource was to a farmer, the more adaptable that farmer was to climate change. Following the findings of this study, it is important that policy interventions in the area prioritize creation and encouragement in alternative livelihoods sources as a means of increasing the adaptive capacity of famers in the rural and semi-urban areas. Also, private and government institution should invest in irrigation and credits facilities as measures for economic growth and adaptation to the effects of climate change on agriculture. Farmers should be empowered through better extension and agro-climatic information and other affordable modern technologies.

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