In Awutu-Senya District, Mr. Benstil explained how personal network has helped him. According to him, personal network has shaped his vison and he is determined to win another best farmer award in the coming years. The retired general and a farmer explained:

> *I am well known when it comes to oil palm tree (Elaeis guineensis) production in the districts. I have a friend who is into pineapple production. He tells new and improved variety of pineapple in most of the times we meet. Fortunately, I share a boundary with him. The way he goes about his farming practices, application of chemicals and fertilizers made me learn a lot from him. He developed my interest and now I have two acres of pineapple farm….*

Mr. Benstil has added pineapple production to oil palm and staple crop production due to his personal network. According to him, the climate has changed and one must strategise his/her farming practice. He also explained how he goes into Coconut (*Cocos nucifera* L.) production:

> *I have a friend who a soil scientist in one of the research institute. He told me there is new variety of coconut which takes 3 years to mature as compare to mine which take 8 years to mature. He has asked me to do the nursery and he will come and do the budding for me.*

In Granovetter's (1985) language, both strong and weak ties have influences the decision of Mr. Bentsil to adapt to the changing climate through crop diversification and improved varieties. It is difficult to predict the kind of social relation (be it bonding, bridging or linking) between Mr. Bentsil and his friends on qualitative basis. However, the findings indicate that his connections have not only aided the flow of information but changed his behaviour by taking the decision to adopt those practices. The relational concept of social capital has many positive implications on the development of a given society. In the rural areas of Northern India, poor villagers utilize social relations and groups for risk management, protection and solidarity functions (action (Woolcock & Narayan, 2000:230). I still argue that in the phase of harsh climatic conditions, inadequate extension personnel and the quest to increase productivity and ensure food security in rural households, smallholder farmers rely on their personal networks. To this, those who are connected with relevant occupational prestige will take advantage of the resource that is embedded in their network to help overcome such barriers. One interesting future study that

could be investigated is to look at individual social capital and productivity at the household level. Productivity, I believe, is likely to be higher with those who are connected with more relevant occupational prestige, all things being equal.

In sum, individual social capital may affect economic sustainability of farmers. As revealed in this section, the networks of individual have the potential of influencing adoption decision. Farmers who are well connected have a high propensity to adopt improved varieties and breeds, diversify their cropping system, and other farming practice to reduce the adverse effect caused by climate change.

5.5.2.2 Empirical Econometrics Results

Respondents were asked if they receive or give information with regard to farming practice and/or climate change. Most of them indicated yes to some of the network members. It must be stressed that network members were not contacted to verify the information provided by the respondents. This is of two reasons: (i) there was no enough resources (time and money) to contact alters who are scattered in the country other than the location of the ego; and (ii) the occupational prestige used assumed to be relevant enough to aid in climate change adaptation strategies. It must also be stressed that ties that are less than two years were excluded from the model estimation (about 1.4 percent). This reason is that the study referred adaptation practice of the previous planting season (not the current season). Thus, relationships less than two years were assumed not to have any significant impact on the decision and behaviour of respondents.

Estimation of each of the two models was preceded by the normalization of one of the adaptation category. This is often called the reference category. In both models estimation, no adaptation was used as reference category since it is the dominant among all the adaptation categories. Prior to the running of the model, the problem of multicollinearity among the explanatory variables were tested. By this, Pearson correlation among the continuous independent variables was run. The result is attached in appendix A3. Furthermore, the ordinary least square (OLS) model was run with all the independent variables following Variance Inflation Factor (VIF). The result (see appendix A4) shows that multicollinearity is not a serious problem in the model estimation as all the values for the VIF were less than 10 (1.09 – 2.11). The test for IIA shows that the assumption has not been violated (see appendix A5 and A7).

It must be noted that the MLM does not share the monotonic behaviour of the probability of binomial logit model. Thus, the literature usually focuses on the coefficient or parameter estimates rather than marginal effects. The marginal effect estimate depends on the point of evaluation and due to the non-monotonic nature, the sign depends on the value of the dependent variable (Cramer, 1991:46-47; Greene, 1993:667). Thus, the application of MLM results in potential confusion as the coefficient of the marginal effect need not to have the same sign as the model or parameter coefficients. This is reflected in the study as the coefficients of the marginal effect are different from the parameter estimates coefficient. Nevertheless, both the parameter estimates and the marginal effects are presented in this section.

The parameter estimate or coefficient of both indigenous and introduced adaptation strategies as well as their level of significance are presented in table 5.9 and 5.10 respectively. The marginal effects of both models are attached, respectively, in appendix A6 and A8. The marginal effects predict the probability of a choice of a particular adaptation mechanism with respect to a unit change an explanatory variable. The Wald statistics for both indigenous adaptation (Wald chi (42) = 98.48) and introduced adaptation strategies (Wald chi (42) = 90.05) is highly significant ($p < 0.0004$) and ($p < 0.0000$) respectively. This means that the models as whole have a strong explanatory power.

Bonding Social Capital

The estimated coefficient of bonding social is significant and positive related to crop diversification strategy and soil and plant related strategies. The significant level is 5 percent for both crop diversification (table 5.10) and soil and plant related strategies (table 5.11). Taking crop diversification (indigenous adaptation strategy), the coefficient of 0.328 means that one unit increase in the number of ties with bonding social capital (similar social status) is associated with 0.328 increase in the relative log of odds of adapting crop diversification versus no adaptation, holding all variables in the model constant. The marginal effect of crop diversification means that one percentage point increase in the number of ties with bonding social capital increases the predicted probability of adapting crop diversification strategy by 0.0296 ceteris paribus (see appendix A6).

Bonding$_{link}$ Social Capital

Bonding link social capital represents respondents connected with network members of similar social status but through a strong tie. Surprisingly, bonding$_{link}$ social capital has a positive and significant effect on all the indigenous adaptation strategies but none of the introduced adaptation strategies. The level of significant is 1 percent for both soil and water conservation and crop diversification, and 10 percent for both livestock diversification and diversification to non-farming activities. It can be argued that indigenous adaptation strategies within a particular geographical location (or community) easily diffuse among smallholder farmers in that location. The marginal effect of 0.0326 means that one percentage point increase in the number of ties with bonding$_{link}$ social capital increases the predicted probability of crop diversification adaptation by 0.0326, all variables in the model being held constant.

Bridging Social Capital

Bridging social capital depicts egos with alters of different (lower social status). For instance, a farmer connected with a network member who owns agro-chemical shop. Though such alters have low social status their role in innovation diffusion cannot be looked down. Such occupational prestige can be argued to have the relevant information on agricultural innovations, especially with regard to introduced adaptation strategies such as improved seeds, new pesticides and fertilizers among others. Delineating from one's social circle aids in the acquisition of necessary information needed to adapt to the changing climate.

In the case of introduced adaptation strategies, bridging social capital has a positive effect of soil and plant related strategies and improved variety and breed at a significant of 10 and 5 percent respectively. The marginal effect of 0.0265 means that one percentage point increase in the number of ties with bridging social capital increases the predicted probability of adapting improved variety and breeds by 0.0256 (see appendix A8).

Bridging$_{link}$ Social Capital

Bridging$_{link}$ social capital has no significant effect on any of the indigenous adaptation strategies (see table 5.10). In the case of introduced adaptation strategies, the estimated coefficient of bridging$_{link}$ social capital has a positive effect on improved variety and breed and recommended agricultural practice. The significant level is at 5 percent for both strategies (table 5.11). The marginal effect of 0.0351 indicates that one percentage point increase in the number of ties with

bridging$_{link}$ social capital (egos connected with alters of higher social status but through weak tie) increases the predicted probability of adapting improved variety and breed by 0.0351, ceteris paribus.

Table 5.10: Parameter Estimate of the Multinomial Logit Model _ Indigenous Adaptation Strategies

VARIABLES	Soil and Water Conservation	Crop Diversification	Livestock Diversification	Diversify to non-farming activities
Bonding SC	0.201	0.328**	0.161	0.00512
	(0.144)	(0.137)	(0.160)	(0.159)
Bonding$_{link}$ SC	0.505***	0.556***	0.331*	0.335*
	(0.192)	(0.168)	(0.173)	(0.182)
Bridging SC	0.337*	0.587***	0.136	0.353*
	(0.205)	(0.189)	(0.226)	(0.213)
Bridging$_{link}$ SC	0.346	0.301	0.335	0.0693
	(0.230)	(0.229)	(0.225)	(0.237)
Age	0.00428	0.00453	-0.0547*	0.0314
	(0.0240)	(0.0232)	(0.0323)	(0.0305)
Sex	-0.866	-1.551**	0.374	-0.313
	(0.613)	(0.666)	(0.679)	(0.565)
SIOPS	-0.0184	-0.134*	0.00623	-0.126
	(0.0704)	(0.0698)	(0.0802)	(0.0887)
Farming Experience	0.0655**	0.0353	0.135***	0.0525
	(0.0318)	(0.0343)	(0.0409)	(0.0413)
Land Size	-0.00930	0.0599	0.337	-0.583**
	(0.205)	(0.214)	(0.212)	(0.251)
Farm Income	0.000245**	0.000261**	0.000196	0.000311***
	(0.000123)	(0.000123)	(0.000129)	(0.000121)
Leadership role	1.027*	1.072*	0.397	0.540
	(0.538)	(0.562)	(0.564)	(0.646)
Market Distance	-0.0767	-0.287	0.218	0.270
	(0.237)	(0.262)	(0.249)	(0.272)
Assin South	0.536	0.0960	-0.355	0.566
	(0.758)	(0.771)	(0.759)	(0.651)
Mfantseman	0.204	1.349*	-1.016	-0.325
	(0.758)	(0.811)	(0.801)	(0.800)
Constant	-4.476	-0.126	-4.133	-0.112
	(3.107)	(2.995)	(3.423)	(3.938)

Base category:	No Adaptation	Wald Chi2 (42):	98.48
Number of observations:	225	Prob > Chi2:	0.0004
Log pseudolikelihood:	-278.89194	Pseudo Chi2:	0.2148

Source: Field Survey, 2015.

NB: Values in parenthesis are the robust standard errors

*; ** and *** implies significant at 10; 5 and 1 percent respectively

In the case of indigenous adaptation strategies, bridging social capital has a positive and significant effect on crop diversification (10 percent) and soil and water conservation strategy (1 percent).

Age of the household head

The result of the effect of age on climate change adaptation strategy does not conform to expectation. This finding is not strange as the literature identified mixed effect of age on the decision of household head to adapt to climate change. On one hand, age could be attributed to the experience of the household head with regard to climate change over time. Thus, an increase in age has been found to increases the probability of adapting to climate change (see Tazeze, *et al*., 2012; Osei, 2015). While some studies did not find age to be significant in adaptation decision (Hassan and Nhemachena, 2006) others found out to be negatively related to adaptation decision (Anley, *et al.,* 2007; Nyangena, 2008). The latter assumed young farmers to take up long term adaptation strategies. The result in this study shows that age is significant and negatively related to livestock diversification. Thus, young farmers are more likely to diversify livestock versus no adaptation compared to old farmers.

Sex of the household head

Once again, the literature identifies mixed effect of sex of the household head on climate change adaptation decision. According to Ajao and Ogunniyi (2011) most of the farming activities are undertaken by males while females are more into post-harvesting activities. This trend puts males in a better position to get experience and relevant information on various management practices that help them to cope and adapt to the instability in climate. The result in this study shows that sex is significant (10 percent) and negatively related to crop diversification. Thus, female-headed household are more likely to practice crop diversification compared to male-headed household. To this, the marginal effect of 0.1748 means that the predicted probability of male-headed household to adapt crop diversification decreases by 17.48 percent point compared to female-headed household.

The study shows opposite trend in the case of introduced adaptation strategies. The parameter estimate indicates that sex is significant and positively related to soil and plant related strategies and improved variety and breed. The significant level is 1 percent for both strategies. Thus,

male-headed household are more likely to adapt soil and plant related strategies and improved variety and breeds than female-headed household. The marginal of 0.2302 means that the predicted probability of male-headed households to adapt improved variety and breed increases by 23.02 percent point compared to female-headed households, ceteris paribus (see appendix A8). This result is consistent with Mulwa *et al*. (2015), who found out that male smallholder farmers in Malawi have high probability of adopting improved (diseases/pest resistant variety) than female.

SIOPS of the household head

One common issue with regard to social capital construction is the problem of unobserved correlation. For instance, the social status of an ego can influences the ability to access information and the network size. Following Dinh *et al*. (2012), social status is controlled by inclusion of the SIOP of the respondent. The SIOPS of a respondent is likely to be associated with higher education which can lead to higher income. The Pearson correlation coefficient between SOIPS and education is about 40 percent (see appendix A3). The coefficient of SIOPS turns out to be negatively related to crop diversification at a significant level of 10 percent.

Farming Experience of the household head

Generally, farmers who are more experienced in agriculture can be assumed to be more familiar with the environment and can even anticipate some events such as time of raining, time of planting, among others. Based on this many scholars are of the view that the more experienced a farmer is the higher the probability of responding to the climate change adaptation mechanisms (Kebede, *et al.,*1990; Gbetibouo, 2009). The parameter estimate of this study indicates that farming experience is positively related to soil and water conservation and livestock diversification. This is significant at 5 percent for soil and water conservation strategy and 1percent for livestock diversification. In the case of introduced adaptation strategies, farming experience is significant and positively related to all adaptation strategies. This is significant at 10 percent for soil and plants related strategy and 5 percent for both improved variety and breed and recommended agricultural practice. Thus, farming experience increases the predicted probability of adapting to the change in climate.

Table 5.11: Parameter Estimates of the Multinomial Logit Model: Introduced Adaptation Strategies

VARIABLES	Soil and Plant Related Strategies	Improved Varieties and Breeds	Recommended Agricultural Practices
Bonding SC	0.326**	0.230	0.202
	(0.135)	(0.145)	(0.142)
$Bonding_{link}$ SC	0.303	0.312	0.00968
	(0.189)	(0.195)	(0.177)
Bridging SC	0.282*	0.375**	0.153
	(0.169)	(0.179)	(0.183)
$Bridging_{link}$ SC	0.360	0.618**	0.487**
	(0.247)	(0.275)	(0.227)
Age	-0.00348	-0.0207	-0.0332
	(0.0230)	(0.0228)	(0.0211)
Sex	1.973***	2.822***	-0.102
	(0.662)	(0.783)	(0.615)
SIOPS	0.0785	0.105	0.0711
	(0.0793)	(0.0841)	(0.0743)
Farming Experience	0.0587*	0.0874**	0.0781**
	(0.0354)	(0.0356)	(0.0325)
Land Size	-0.235	-0.513**	-0.122
	(0.228)	(0.253)	(0.256)
Farm Income	0.000197**	0.000244**	0.000192**
	(9.47e-05)	(9.89e-05)	(9.48e-05)
Leadership role	1.448**	0.660	1.502**
	(0.632)	(0.700)	(0.632)
Market Distance	0.243	0.310	0.257
	(0.294)	(0.296)	(0.282)
Assin South	0.350	0.237	-0.309
	(0.710)	(0.750)	(0.624)
Mfantseman	0.159	-0.0776	1.410*
	(0.839)	(0.876)	(0.720)
Constant	-9.846***	-11.69***	-6.477*
	(3.765)	(4.072)	(3.422)
Base category:	No Adaptation	Wald Chi2 (42):	90.35
Number of observation:	225	Prob > Chi2:	0.0000
Log pseudolikelihood:	-220.44689	Pseudo Chi2:	0.2877

Source: Field Survey, 2015.
NB: Values in parenthesis are the robust standard errors
*; ** and *** implies significant at 10; 5 and 1 percent respectively

Size of the land Cultivated

According to Gbetibouo (2009), large scale farmers have a broad capital base and resources and therefore easy for such farmers to invest in strategies that demand a high investment cost and

such are climate change adaptation mechanisms. The parameter estimate indicate that size of land cultivated is significant (5 percent) and negatively to diversification to non-farming activities. Thus, an additional hectare of land cultivated decreases the predicted probability of diversifying to non-farming activities, ceteris paribus. Among the introduced adaptation strategies, size of land cultivated turned out to be negatively related to improved variety and breed which is off expectation.

Farm Income

According to Shiferaw and Holden (1998), wealth is believed to reflect past achievement of households and their ability to bear risks. Thus, one can argue that respondents with less social capital (network size) are not able to access relevant information needed to adapt to climate change. Respondents in this arena, according to Dinh *et al*. (2012), are more vulnerable to climate change and therefore income can create simultaneity bias. In an attempt to reduce this bias only farm income (not household income) was used. Thus, households with higher income and greater assets are in a better position to adopt new farming technologies. The results of this study showed that farm income is positively related to all adaptation strategies except livestock diversification. This result is credence to the report of Deressa*et al*., (2009) and Tazeze, *et al*., (2012). Thus, wealthy farmers are able to invest in productivity smoothening option such as crop soil and water conservation, diversification, soil and plant related strategies, improved varieties and breeds and recommended agricultural practice.

Leadership position of the household head

Leadership position of the household head was incorporated to deal with the issues of correlation arising among unobserved variables. In the construction of social capital indicators, it is possible that household heads with a leadership role in an organization may have stronger social capital and better access to relevant information to aid adaptation of a particular strategy. In this regard, a dummy variable was use to proxy leadership role in an organization. Surprisingly, leadership role has a positive effect on the adaptation of soil and water conservation strategy (significant at 10 percent) and crop diversification (significant at 10 percent).

In the case of introduced adaptation strategies, leadership role has a positive effect on the adaptation of soil and plants related strategies (5 percent significant level) and recommended agricultural practice (5 percent significant level). The marginal effect of 0.1031 implies that the

predicted probability of a household head with a leadership role in an organisation to adapt soil and plants related strategy increases by 10.31 percent point more than those who do not hold any leadership position, all things being equal.

As revealed in the FGD in Mfantseman Districts, community leaders and leaders in other associations have strong connection with local government officials, institutions and Member of Parliament. Thus, such leaders establish strong network with the state and local communities or organisation (Purdue, 2016). The potential effect is that leaders will have higher probability of unlocking the benefits manifested in network.

Market Distance

According to Maddison (2006) proximity to market enhances the likelihood of adapting to climate change, presumably because farmers tend to meets at the market centres and exchange information. Better access to markets is also assumed to reduce transport and other market related transaction costs which translate to uptake of climate change adaptation strategy. Unfortunately, the parameter estimate of this study shows that closeness to market does not significantly influence climate change adaptation strategy.

Location

The introduction of the districts or location in the model is expected to capture elements such as temperature, rainfall, and other environmental factors which cannot be explicitly included in the model. Since the magnitude of such factors differs, different authors obtain different results. For instance, in Babilie District of Ethiopia, Tazeze, *et al*. (2012) revealed that farming in the arid areas increases the probability of changing planting date. The result of this study indicates that when one farms at Mfantseman District, the relative log odds of adapting crop diversification and recommended agricultural practice versus no adaptation increases when moving from Awutu-Senya District (Location==1) to Mfansteman District (Location==3) and both are significant at 10 percent. This result confirms the reason why maize output in Mfantseman district is increasing, though rainfall pattern is decreasing over time. Thus, farmers in this district take up adaptation measures to ensure that an increase in output.

In sum, this study basically shows that social capital at the individual level plays a significant role in the choice made by household head to adapt to the changing climate. Thus, among the

strong determinants of climate change adaptation strategies, this study argues that individual social capital cannot be ignored. Recent studies have presented plethora of evidence that economic performance and welfare of households have a strong positive correlation with social capital (Narayan & Pritchett 2000). Adding these discussions to the results of this studies show that individual farmers make use of their personal netowrk, gain relevant information and mitgate the effect of climate change through approprate adaptation strategy. The results of the study support research hypothesis two which states that individual social capital affluences climate change adaptation strategies.

CHAPTER SIX
CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

6.1 Conclusion

This thesis set out to investigate social capital as a relational concept and its influence on climate change adaptation strategies among smallholder farmers in the Central region of Ghana. It puts into a single framework-social network analysis and econometric estimation techniques. Moreover, it distinctly shows how the individual farmers make use of the opportunities of embedded social relations, both in qualitative and quantitative realm, to adapt to the changing climate. Thus, social relations do not only facilitate the flow of information but behavioural change to manage risk. The results of the study show that smallholder farmers in the study areas have networked with different people of different socio-economic status. Using position generator, the study unveiled that most of the network members relate to ego as friends and acquaintances. On the contrary, the name generator shows the opposite as almost all alters relate to ego as family members with very few as friends. This support Van Der Gaag's (2005) view that the first name that comes into mind when asking name generator questions is that of family members or close friends. According to Granovetter (1973), strong ties are established among family members while weak ties are found among friends and acquaintance. Moreover, strong ties are characterised by high level of trust than weak ties. As strength, the study computed weak ties and strong ties not only on the basis of role relation (i.e. family member or friend, etc.) but with other relevant indicators. Thus, weak ties and strong ties between ego and alter differ in terms of role relationship, years of relationship, frequency of contact, closeness of alter to ego, and level of trust.

Using relevant climate related occupational prestige (SIOPS), social distance between respondents and network members was constructed. Four clusters were generated using K-means cluster analysis. These clusters unveiled egos who relate to alters of the same socio-economic status (bonding social capital), egos who relate to alters of the same social status but through a strong tie ($bonding_{link}$ social capital), egos who relate to alters of different socio-economic status (bridging social capital) and finally, egos who relate to alters of different socio-economic status but through a weak tie ($bridging_{link}$ social capital). The number of ties of each individual social capitals was aggregated and an independent *t* tested was computed to determine if the mean difference differ across sex of the respondents. The results indicate that men possess large

individual social capital as compared to women. This was significant across all the four individual social capital identified in the study.

Using 20 year period of rainfall data and output of maize the study shows that there is intra and inter annual variation in the pattern of both rainfall and maize outputs. The rainfall pattern in Mfantseman district, which represent transitional zone, shows a decreasing trend over the 20 year period. Maize output in the district, however, tends out to show an increasing trend. The empirical econometric model offers strong evidence to this dynamics. Thus, farmers in the district have high probability of taking up adaptation measures such as crop diversification and recommended agricultural practice. The rainfall pattern and maize output in Assin South district (Forest zone) shows an increasing trend over the period. The association between maize and rainfall in Awutu-Senya district (Coastal zone) is not distinct as there is high inter annual variability over the period. Overall, there is a moderate positive association between rainfall pattern and maize output the in Central region of Ghana. Moreover, there is a negative association between dry spell (in days) and maize output in the region.

The variability of rainfall and other climatic elements is confirmed by the perception of smallholder farmers in the study area. The majority of the respondents have noticed a decreased in rainfall patterns, and increased periods of drought. To most of the respondents (about 80 percent), precipitation has been unpredictable. About 85 percent perceive that there has been delay in the onset of the wet season. Moreover, about 75 percent perceive that the temperature has been hot over the past 20 years. Thus, smallholder farmers perceive a sharp change in rainfall and temperature than any other elements of the weather. Incidence of flood and bush burning has not been on the rise on the study area over the 20 year period. Non-parametric tests indicate that perception indicators used in the study do not differ across sex of the respondents but location. Thus, almost all the perception indicators differ across the study districts. This result is in line with recent findings of Osei, (2015). The FGDs and the Key Informant Interviews carried out show that the variability of climatic condition has negatively impacted the households of smallholder farmers. Most farmers have experienced crop failure and famine, an outbreak of diseases to livestock, an increase in poverty, and rural to urban migration of youth. These results show that smallholder farmers in the study area are more vulnerable to the changing climate.

There is the need to identify coping strategies used by smallholder farmers and the factors that influence that adaptation of the identified strategies.

The study found out that smallholder farmers have embraced both indigenous and introduced adaptation strategies. Indigenous adaptation strategies, according to FAO (2009) are perceived to have accumulated over generations living in a particular environment. Thus, farmers developed their own indigenous adaptation strategies due to their experience in the changing climate. Introduced adaptation strategies are those developed through scientific research. The majority of smallholder farmers have embraced indigenous adaptation strategies compared to introduced adaptation strategies to cope with the impacts of changing climate. The identified indigenous adaptation practice include soil and water conservation (about 20 percent), crop diversification (about 23 percent), livestock diversification (about 17 percent) and diversification to non-farming activities (about 13 percent). The introduced adaptation practices identified include soil and plants related strategies (about 26 percent), improved varieties (20 percent) and recommended agricultural practices (24 percent). The proportion of farmers who did not embrace any indigenous adaptation strategies (27.56 percent) is less than those who did not embrace any introduced adaptation strategies (30.22 percent). This could possibly mean smallholder farmers in the study area have not heard of or do not have the technical know-how of some of introduced adaptation strategies.

The findings from the empirical econometric estimation and the FGDs and key informant interviews are consistent with theory regarding climate change adaptation practices. Social capital and other controlled variable influence climate change adaptation strategies. Individual social capital such as bonding, $\text{bonding}_{\text{link}}$, bridging and $\text{bridging}_{\text{link}}$ have a significant positive influence on the adaptation of both indigenous and introduced adaptation strategies. The sex of the respondents has significant negative influence on the crop diversification strategy and a positive influence on the adaption of introduced strategies. Age, SIOPS, and land size of the land respondents has a negative influence on climate change adaptation strategies in the model. Other variables such as farming experience, farm income, leadership position and location positively influence climate change adaptation strategies. Thus, aside the individual social capital variables the controlled variables play a significant role in shaping the choice of adaptation strategies among households of smallholder farmers.

6.2 Limitations and Suggestions for future research

This study is not without limitations. First of all, the study is likely to overlook some occupational prestige relevant to climate change adaptation strategies. For example, in the domain of agriculture, there could be soil scientist, plant breeder, entomologist, pathologist, and others. These occupational prestigious jobs, however, are not included in the study as they do reflect on the standard international occupational prestige as developed by Ganzeboom & Treiman (1996). Thus, future research should find the possibility of widening the scope of the position generator items used in study.

Secondly, there was a potential confusion in the use of name generator techniques. In most Ghanaian societies each individual has two distinct names: local name (i.e. individuals are named after a relative and on the day s/he was born) and an English name. Depending on the kind of friendship and location, an individual can be called by different names by different network members. Though this was not the focus of the study, it would be more appealing to map respondents and network members generated within a particular location. This can even be linked against the adaptation practices. This is because, the study unveiled that some names (network members and respondents) in a particular district were found very common as most respondents came out with those names during the name and position generator question. The issue of different names was discovered during the latter part of the study in one of the districts. Some local leaders and extension officers were found out to be called by different names by different people. Future research can stick to either local or English name or should probe further if the respondent knows alter by another name.

Lastly, it is not without doubt that income variable is likely to create simultaneity bias. As explained earlier several attempts were made to minimize this bias. Future research can include secondary data (income) of the respondents if it is obtainable.

Social capital was also found to be very poor among women and this gives a direction of new research into gender and social capital and its implication with regards to climate change adaptation.

6.3 Policy Recommendations

Social capital and climate change adaptation assessment study comes with a challenging policy recommendation especially to government. This is because such policies have the potential of creating unintended side effects that will threaten the development process of a developing country. The study shows that individual social capital influences both indigenous and introduced adaptation strategies. Base on this finding it would be interesting, on one hand, to call for the promotion of social capital such as bonding, linking, and bridging by government and other relevant institutions and organisations.

The econometric estimation shows that leadership role in an organization or a community positively influences adaptation practices. Based on the result obtained from both position and the name generator technique, it can be argued that relay of climate change adaptation techniques or technology to smallholder farmers need not only be accomplished through the usual technology transfer network of agricultural researchers and extension agents. Rather, it will be imperative to increased contact with a wide variety of local actors who provide information and resources for agricultural production. These could be teachers, religious leaders, owners of agro-chemical shops in the communities, and local women and farmer group leaders. In doing so the transaction cost associated with obtaining the relevant information will be reduced. The danger here is that in designing such a policy, however, caution needs to be taken as it has the potential of excluding people from getting access to relevant resources and thereby increasing social inequality.

Moreover, as emerged from the FGD and the key informant interview, such leaders should be involved in training programmes and workshops so that they can reach out to other people in the community. This will also reduce the work load of the Agricultural Extension Agents while reaching most smallholder farmers within a particular geographical location. The empirical results also show that young farmers have probability of diversifying livestock. Thus, young farmers (youth) should be target and involved in such training programmes and workshops related to climate change. This will not only guarantee the future of food security status but also reduce youth unemployment in the country.

The trend analysis shows that rainfall is decreasing in the region and an increase in the number of dry spell days goes hand in hand with a decrease in the annual maize output. Moreover,

irrigation as an adaptation strategy is not common among smallholder farmers in the Central region of Ghana. This presupposes that farming in the region is rainfall dependent. The study recommends that government channel more resources into the investment of soil and water conservation strategies. Inter cropping should be encouraged with minimal reliance on natural rainfall and other external inputs yet guaranteed food security. This concept called 'climate smart agriculture' has been adapted in few districts in the country (GIZ, 2014). There is the need to extend this project to other regions and district of the country.

Lastly, perception indicators used in the study differ across all the three agro ecological zones. The study therefore recommends that in the designation of projects and adaptation technologies, policy makers or donors should not only concentrate on the technical aspect but also the social dimension such as how smallholder farmers perceive the changing climate. This, first of all, will create an avenue whereby perception of resource users can be integrated into climate change adaption projects. Also, it will enhance the flow of climate change information between smallholder farmers and donors or implementers of the project.

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APPENDICES

Appendix A: Statistical Results

Appendix A1: Correlation Coefficient between annual maize output (Mt/HA) and annual rainfall (mm) parameters

	Awutu Senya District	Assin South District	Mfantseman District	Regional (Average)
Correlation between Annual Maize output [Y] and Average annual rainfall [X]				
Pearson correlation coefficient	-0.0882	**0.3398**	-0.0557	**0.4246**
Correlation between Annual Maize output [Y] and Average Dry Spell Days [X]				
Pearson correlation coefficient	0.0022	0.0840	**-0.3017**	**-0.2127**

Appendix A2: Association between perception indicators and sex and location: Non-parametric test

Test Statistics	Precipitation has been unpredictable during the past 20 years	There has been delay in the onset of the wet season over the past 20 years	Incidence of flood has increased in the past 20 years	Temperature has been hot over the past 20 years	There has been prolong drought in the past 20 years	Bush burning has been rampant over the past 20 years
Mann-Whitney U Test; Grouping Variable: Sex of respondents						
Mann-Whitney U	5613.000	5683.000	5808.000	5211.500	5631.500	5527.500
Wilcoxon W	9441.000	9511.000	15399.000	9039.500	9459.500	9355.500
Z	-0.883	-0.735	-0.425	-1.774	-0.812	-1.130
Asymp. Sig. (2-tailed)	0.376	0.462	0.671	0.076	0.417	0.258
Kruskal Wallis Test; Grouping Variable: Sampled Districts						
$\chi 2$	6.336	38.372	4.712	16.272	15.577	25.690
DF	2	2	2	2	2	2
Asymp. Sig	**0.042**	**0.000**	0.095	**0.000**	**0.000**	**0.000**

Appendix A3: Pearson correlation coefficient among the continuous independent variables

```
. cor BondingSC BondinglinkSC BridgingSC BridginglinkSC AGE SIOPS EDUC_Years FAMEXPE LANDSIZE FARMINCOME MRKTDIST LOCATION
(obs=225)
```

	Bond~gSC	Bond~kSC	Brid~gSC	Brid~kSC	AGE	SIOPS	EDUC_Y~s	FAMEXPE	LANDSIZE	FARMIN~E	MRKTDIST	LOCATION
BondingSC	1.0000											
Bondinglin~C	0.1026	1.0000										
BridgingSC	0.1640	-0.2943	1.0000									
Bridgingli~C	0.1447	0.4412	0.0258	1.0000								
AGE	0.0563	-0.0243	0.0612	-0.0748	1.0000							
SIOPS	0.1125	-0.3049	0.6426	-0.1066	-0.0210	1.0000						
EDUC_Years	0.0843	-0.0143	0.3133	0.2023	-0.1408	0.3992	1.0000					
FAMEXPE	0.2446	0.1436	0.0584	0.0375	0.5276	-0.0632	-0.2054	1.0000				
LANDSIZE	0.0668	-0.0140	-0.0074	0.0735	0.2504	-0.1016	-0.0911	0.3184	1.0000			
FARMINCOME	0.0891	0.0356	0.0227	0.0247	0.1503	0.0101	-0.0127	0.1729	0.2310	1.0000		
MRKTDIST	-0.0080	0.1535	-0.1921	-0.0324	0.0391	-0.2325	-0.1123	0.0759	0.0872	-0.0189	1.0000	
LOCATION	0.1577	0.1768	-0.0275	0.0802	0.1128	-0.1139	-0.0997	0.3206	0.2015	-0.0030	0.2034	1.0000

Appendix A4: Test of Multicollinearity - VIF

```
. vif
```

Variable	VIF	1/VIF
Cluster_1	2.11	0.474368
SIOPS	1.86	0.538436
FAMEXPE	1.73	0.576804
Cluster2	1.55	0.643402
SEX	1.55	0.646556
AGE	1.47	0.679511
LOCATION	1.37	0.728575
Cluster4	1.37	0.729377
LANDSIZE	1.36	0.737571
LEADER	1.26	0.793872
Cluster3	1.21	0.829166
MRKTDIST	1.15	0.872833
FARMINCOME	1.09	0.918953
Mean VIF	1.47	

Appendix A5: Hausman Tests of IIA Assumption: Indigenous Adaptation Strategies

Ho: Odds are independent of other alternatives

Omitted	Chi2	DF	P > Chi2	Evidence
Soil and Water Conservation	2.46	42	1.0000	For Ho
Crop Diversification	0.12	42	1.0000	For Ho
Livestock Diversification	4.26	41	1.0000	For Ho
Diversify to Non-Farming Activities	13.32	42	1.0000	For Ho

Appendix A6: Marginal Effect of the Multinomial Logit model _ Indigenous Strategies

VARIABLES	Soil and Water Conservation	Crop Diversification	Livestock Diversification	Diversify to non-farming activities
Bonding SC	0.0064338	0.0296743**	0.0009501	-0.0138408
	(0.013289)	(0.011283)	(0.0127151)	(0.0130711)
$Bonding_{link}$ SC	0.025582	0.032605*	-0.0028801	0.004205
	(0.0199142)	(0.0167417)	(0.0145979)	(0.013977)
Bridging SC	0.0058869	0.0515977 ***	-0.0209976	0.0124416
	(0.0172584)	(0.0129086)	(0.0184728)	(0.0136489)
$Bridging_{link}$ SC	0.02139	0.0112786	0.0160283	-0.0130814
	(0.0226867)	(0.0206222)	(0.0185843)	(0.0193713)
Age	0.001617	0.0014845	-0.0072095**	0.003852
	(0.0024817)	(0.002388)	(0.0029337)	(0.0025677)
Sex	-0.0515151	-0.1748541**	0.1296005**	0.0155885
	(0.0669496)	(0.0680072)	(0.0641566)	(0.0488259)
SIOPS	0.0068914	-0.0149921**	0.0078415	-0.0093212
	(0.0060757)	(0.00539)	(0.0069015)	(0.0067911)
Farming Experience	0.0017916	-0.0040357	0.0113866***	0.0006865
	(0.002615)	(0.0031356)	(0.003258)	(0.0031921)
Land Size	-0.0034524	0.010576	0.0476639**	-0.0645631**
	(0.021326)	(0.0226487)	(0.0185344)	(0.0224192)
Farm Income	8.31e-06	0.0000102	5.25e-07	0.0000164**
	(6.98e-06)	(6.33e-06)	(7.38e-06)	(5.52e-06)
Leadership role	0.067749	0.0703305	-0.0337634	0.0006454
	(0.0543571)	(0.0546379)	(0.0483262)	(0.0526726)
Market Distance	-0.0098366	-0.0486707*	0.0328263	0.0309167
	(0.0262377)	(0.0282402)	(0.0224808)	(0.0222936)
Assin South	0.0763494	-0.011283	-0.0884964	0.0541819
	(0.0808238)	(0.0585431)	(0.07991)	(0.0593502)
Mfantseman	-0.0022094	0.2316166**	-0.164654**	-0.0441873
	(0.0633277)	(0.0789293)	(0.0664705)	(0.0475283)

Appendix A7: Hausman Tests of IIA Assumption: Introduced Adaptation Strategies

Ho: Odds are independent of other alternatives

Omitted	Chi2	DF	P > Chi2	Evidence
Soil and Plant Related Strategies	3.37	28	1.0000	For Ho
Improved Varieties and Breeds	1.90	28	1.0000	For Ho
Recommended Agricultural Practice	7.00	28	1.0000	For Ho

Appendix A8: Marginal Effect: Introduced Adaptation Strategies

VARIABLES	Soil and Plant Related Strategies	Improved Varieties and Breeds	Recommended Agricultural Practices
Bonding SC	0.0257561*	-0.0003604	0.0016771
	(0 .0148957)	(0.0120394)	(0.0144132)
$Bonding_{link}$ SC	0.0278783	0.019026	-0.0284804
	(0.0204389)	(0.0174751)	(0.0186225)
Bridging SC	0.0120586	.0226531*	-0.008692
	(0.0169667)	(0.0133539)	(0.0211206)
$Bridging_{link}$ SC	-0.0108115	.0351219*	0.0262579
	(0.0232765)	(0.0203355)	(0.019593)
Age	0.0027265	-0.0010723	-0.0038594
	(0.0029342)	(0.0022539)	(0.0026638)
Sex	0.1387704*	0.2301721**	-0.2406227***
	(0.0781962)	(0.0715294)	(0.0596449)
SIOPS	0.0016527	0.0052604	0.0017473
	(0.006602)	(0.0058622)	(0.0069166)
Farming Experience	-0.0008052	0.0040877	0.0046138*
	(0.0033832)	(0.002585)	(0.0027242)
Land Size	0.0028754	-0.0444264**	0.0159598
	(0.0218306)	(0.0201321)	(0.0250508)
Farm Income	4.53e-06	0.0000103*	7.13e-06
	(6.99e-06)	(5.57e-06)	(6.79e-06)
Leadership role	0.1031115*	-0.0711059	.1103914*
	(0.0558215)	(0.0513201)	(0.0603631)
Market Distance	0.0038495	0.0129635	0.0115092
	(0.0318356)	(0.025023)	(0.0272446)
Assin South	0.0526242	0.0105839	-0.0564153
	(0.0944123)	(0.0821506)	(0.0576754)
Mfantseman	-0.0569609	-0.0756217	0.2289176**
	(0.0793934)	(0.0671827)	(0.0723518)

Appendix A9: Occupational Sample used in the analysis

SIOPS	OCCUPATION TITLE*
71	National government official including minister
63	National local government official
50	Radio, television & other announcers
72	Meteorologists
61	Agricultural veterinary officer
56	Agricultural extension officer
32	Machinery renter
32	Shop sales person (agro chemical shop)
78	Higher education Professionals (University professor, lecturer, etc).
60	Secondary education teacher
57	Primary education teacher
58	Authors, journalists & other writers
40	Farmer (crop production)
40	Animal producer (farmers into livestock and poultry production)
50	Trader
54	Health inspector
60	Pastor
31	Driver (van)

Source: Ganzeboom & Treiman (1996). As pointed out by Ganzeboom and Treiman (1996), the SIOPS scale was generated by averaging the national prestige scores, appropriately rescaled to a common metric. Prestige scales reflect the classical sociological hypothesis that occupational status constitutes the single most important dimension in social interaction

*Occupation title was defined in the study as the most income source

Appendix B1: Check List for Focus Group Discussion

Questionnaire ID/ Household Number:	Date: …. /……. /2015
Climate Zone:	Climatic zone Code:
District:	District Code:
Community:	Community Code:
Facilitator 1:	
Facilitator 2:	

A. DEMOGRAPHIC INFORMATION

Categories	Total	Male	Female	Number of hectares of land cultivating	
				$\geq 2\ ha$	$< 2\ ha$
Interview Group Composition					
No. of female head household					

B. CONCEPT AND PERCEPTION OF CLIMATE CHANGE

B1.What is your understanding about climate change? During your lifetime (over the past 20 years), have you noticed any changes in climate? How?

B2. How do you perceive the change in climate in terms of frequency and distribution of the following?

i. rainfall ii. temperature iii. drought iv. flood and storm iv. bush fire

C. IMPACT AND ADAPTATION TO CLIMATE CHANGE

C1. How does this change in climate affect you and your community? What kinds of problems do you have to face because of impacts of Climate change?

(**Facilitator:** Farmers attention can be drawn to crop and livestock production, water availability, food availability (food security), migration, livelihood, poverty, etc.).

Is there any benefit or advantage of Climate Change as well? If so, what are those?

C2. What do you do to cope or adapt to the impact of Climate Change you have observed on your:

i. Farm? ii. Community?

How effective are these coping mechanisms? Will they help you in the future (long term use?)

D. INDIVIDUAL SOCIAL CAPITAL (NETWOKING ACTIVITIES)

D1. Where do you receive information about these changes in climate and the coping mechanism? (e.g. Extension officers, group members, interaction with friends and acquaintances, companies, NGOs, etc.).

D2. Do the information help you to make decision in farming practices? How reliable are these sources of information? Do women face any problem getting that information?

D3. What are the most important or effective groups or organizations in this village? How effective is the group meeting its objective? Do you think this organization or group help the farmers to cope or adapt to climate change impact discussed earlier? What about learning from your friends?

D4. How do you perceive the effectiveness of Agricultural Extension Services in this community?

D5. Has there been any workshop that addresses the effect of climate change on livelihood for farmers in this community or district?

D6. If yes in any of the above, complete the table below

Name of organization/ institution	Type 1=Government, 2=NGO, 3=Private, 4= An Individual, 99 = Don't know	How many of you attended?	
		Male	Female

D7. Does the Government have any rule/ regulation that you know which support adaptation to climate change?

D8. Do you receive any agricultural technical support from the Government in implementing adaptation?

D9. If yes, what kind of technical support do you receive?

D10. If no, what kind of support would you want to receive?

Appendix B2: Check List for Key Informants Interview

Questionnaire ID/ Key Informant Number:	Date: …. /……. /2015
Climate Zone:	Climatic zone Code:
District:	District Code:
Community:	Community Code:
Facilitator 1:	
Facilitator 2:	
Name of the Respondent (expert):	

A. PERCEPTION, IMPACT AND ADAPTATION OF CLIMATE CHANGE

A1. In your opinion, do you see any changes associated with climate over the past 20 years? *If too difficult for you, has the following element increases, decreased or remain the same?*

a). Rainfall b). Temperature c). Drought d). Flooding

A2. What are some of the effects of these changes you have observed in this community? How do you perceive these effects in the future?

A3. Are you into farming? How have you adapted/coped with the change in climate? What are some of the adaptation strategies you have adopted?

B. INDIVIDUAL SOCIAL CAPITAL (NETWORKING AMONG FARMERS)

B1. How do you perceive the effectiveness of extension services in the community?

B2. What are some of the challenges have you experience with extension services in this community?

B3. In your opinion do you think farmers based organization (FBO) is good enough? Is every farmer able to join these groups? Have you experience any challenges with FBO?

B4. How do you perceive the relevance of networking among farmers?

B5. Do you think by networking with friend, and acquaintances, farmers can learn from one another and adopt innovation practices that can help mitigate the effect of climate change? Have you had any personal experience by learning from friends?

Appendix B3: Household level questionnaire

PROJECT TITLE: *SOCIAL CAPITAL AND CLIMATE CHANGE ADAPTAION STRATEGIES: THE CASEOF SMALLHOLDER FARMERS IN THE CENTRAL REGION OF GHANA.*

The main objective of this study is to assess the influence of individual network-based social capital on the climate change adaptation strategies of smallholder farmers in the central region of Ghana. The study is a partial fulfillment for the award of Master Degree in Development Studies (University of the Western Cape, South Africa). Please respond to the following survey items by checking the appropriate response next to each question/item. All information is confidential. Your co-operation is needed and will greatly be appreciated.

HOUSEHOLD LEVEL QUESTIONNAIRE

Questionnaire ID/ Household Number:	Date: …. /……. /2015
Name and Initial of Interviewer:	
Climate Zone:	Climatic zone Code:
District:	District Code:
Community:	Community Code:

E. DEMOGRAPHIC INFORMATION

1. Name of the household head (respondent). [_ _]

2. What is your sex? [ ] 1 = Male 0 = Female

3. What is your age? [_ _ _ _ _ _]

4a. What is the highest level of formal education?[ ] 0 = None 1 = Basic (Primary/JHS/Middle) 2=Secondary (Secondary/Vocational/O/A level) 3=Tertiary (Training college/Polytechnic/University) 4 = Koranic 5 = Others, specify: _ _ _ _ _ _ _ _

4b. What is the highest level of formal educationin years? [_ _ _ _ _ _]

5. Marital status of respondent: [ ] 0 = Single 1=Married 2=Divorced/Separated 3 = Widowed

6. What is your major occupation (most income earning source)? [_ _ _ _ _ __ _ __ _ _ _ _ _ _ _ _]

7. How many years of farming experience do you have? [_ _ _ _ _ _]

8. What is your household size (number of people who eat from the same pot)? [_ _ _ _ _ _]

9. What is your residential status? [ ] 1 = Indigene 0 = Migrant

10. Do you belong to any association? [ ] 1 = Yes 0 = No

10b. If 'Yes', what type of association is it? | | | | | | |

(Multiple associations allow)

1 = Farmer Based Organization 2 = Finance/Credit Association 3 = Business or Traders group 4 = Religious/spiritual group 5 = Others (specify): _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

11. Do you hold any leadership position in any of these associations? [ ] 1= Yes 0=No

F. INFORMATION ON THE PERSONAL NETWORK OF RESPONDENTS

In this section I would like to know your personal relation including the kind of occupation you meet and have contact with. The first part contains a list of occupations that people can have. Does anyone in your family, among your friends or acquaintance have one of these occupations?

11. Position Generator

Job		**Nobody [0]**	**Core Family [1]**	**Extend-ed Family[2]**	**Friend [3]**	**Acqua-Instance [4]**
J1	National government official including minister	[ ]	[ ]	[ ]	[ ]	[ ]
J2	National local government official	[ ]	[ ]	[ ]	[ ]	[ ]
J3	Radio, television & other announcers	[ ]	[ ]	[ ]	[ ]	[ ]
J4	Meteorologists	[ ]	[ ]	[ ]	[ ]	[ ]
J5	Agricultural veterinary officer	[ ]	[ ]	[ ]	[ ]	[ ]
J6	Agricultural extension officer	[ ]	[ ]	[ ]	[ ]	[ ]
J7	Machinery renter	[ ]	[ ]	[ ]	[ ]	[ ]
J8	Shop sales person (agro chemical shop)	[ ]	[ ]	[ ]	[ ]	[ ]
J9	Higher education Professionals (University professor, lecturer, etc).	[ ]	[ ]	[ ]	[ ]	[ ]
J10	Secondary education teacher (SHS, JHS, etc.)	[ ]	[ ]	[ ]	[ ]	[ ]
J11	Authors, journalists & other writers	[ ]	[ ]	[ ]	[ ]	[ ]
J12	Farmer (crop production)	[ ]	[ ]	[ ]	[ ]	[ ]
J13	Animal producer (farmers into livestock and poultry production)	[ ]	[ ]	[ ]	[ ]	[ ]

NB: Interviewer: *begin with asking if ego knows a family member in that occupation. If **yes**, then move to the next occupation. **If not**, then ask about friends in that occupation …If ego says somebody is both a family member and a friend, s/he should be counted as a family member.*

12. Now I would like to know the following on each of the people named in Q11.

	A	B	C	D	E	F	G	H	I	J
Job	Name of the person known	Sex **(Use Codes)** 1=Male 0= Female	Age	Marital status **(Use Codes)** 1=single 2=married 3=divorce /separated 4=widow	How often do you usually have contact with the person in a month? (**use Codes**) 0 = Nile 1 = Once 2 = Twice 3 = Thrice 4 = Four time or more	How long have known this person (in years)?	How close are you to this person? (**Use Codes**) 1=Not close at all 2= Not close 3=Somehow Close 4=Close 5=Very close	Can you indicate how much you trust this person? **(Use Codes)** 1 = Do not trust at all 2 = Do not trust 3 = Somehow trust him/her 4 = trust him/her 5 = Trust him/her very much	Do you receive inform-ation about climate change or farming from any of these? 1=Yes 0=No	Do you give inform-ation about climate change or farming to any of these? 1=Yes 0=No
J1		[ ]		[ ]	[ ]		[ ]	[ ]		
J2		[ ]		[ ]	[ ]		[ ]	[ ]		
J3		[ ]		[ ]	[ ]		[ ]	[ ]		
J4		[ ]		[ ]	[ ]		[ ]	[ ]		
J5		[ ]		[ ]	[ ]		[ ]	[ ]		
J6		[ ]		[ ]	[ ]		[ ]	[ ]		
J7		[ ]		[ ]	[ ]		[ ]	[ ]		
J8		[ ]		[ ]	[ ]		[ ]	[ ]		
J9		[ ]		[ ]	[ ]		[ ]	[ ]		
J10		[ ]		[ ]	[ ]		[ ]	[ ]		
J11		[ ]		[ ]	[ ]		[ ]	[ ]		
J12		[ ]		[ ]	[ ]		[ ]	[ ]		
J13		[ ]		[ ]	[ ]		[ ]	[ ]		

13. Name Generator Questions

I would like you to mention a maximum of two people in your network whom you are likely to attend to in each of the following domain.

NG1-11	Name of first person NG1	Name of second person NG2
In times of need whom would you ask for external agricultural inputs such as chemical fertilizer, manure, seeds, and seedlings?		
Whom would you ask to lend you farm machinery, like mower, sprayer, plowing machine?		
If you have a problem on your farm whom would you ask for advice/information concerning this problem?		
If you need any information about rainfall and temperature, whom would you ask?		
During harvesting season whom will you ask to help you on your farm?		
If you need information about irrigation whom will you consult?		
Whom would you ask for a small sum of money as a credit? (approximately, GHs 200)		
Whom would you ask for a huge sum of money as a credit? (approximately, GHs 500)		
Whom would you ask to help you on farm (example, weeding, application of fertilizer, etc.)?		
Whom would you ask to borrow drought animal such as buffaloes or cattle?		
If you need any information about improved variety and breeds, whom would you ask?		
Whom do you discuss important agricultural matter?		

14. Is there anyone who is important to you whose name is not yet in the list? [ ]
1=Yes, 2=No
I would like to add this person to the list. What is/are the activities you usually share with this person?

Name of this person: _

Activities you share with _

15. With these people you have named in Q13 and Q14, answer the following question about each of them [**INTERVIEWER**: Codes for column **E**, **G** and **H** used in **Q12** apply to **Q15**)

	A	B	C	D		E	F	G	H	
NG	Name of the person known	Sex 1=Fem-ale 0= Male	Age	What is the main occupation of this person (most income source)?	How do you relate to this person? 1=core family 2=Extended family 3=friend 4=Acquintance	How often do you usually have contact with the person? (in a month)	How long have known this person (in years)?	How close are you to this person?	Please indicate how much you trust this person?	Do you give information about farming to any of these? 1=Yes; 0=No
NG1-1		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-2		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-3		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-4		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-5		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-6		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-7		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-8		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-9		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-10		[ ]				[ ]		[ ]	[ ]	[ ]
NG1-11		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-1		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-2		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-3		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-4		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-5		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-6		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-7		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-8		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-9		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-10		[ ]				[ ]		[ ]	[ ]	[ ]
NG2-11		[ ]				[ ]		[ ]	[ ]	[ ]

Farm and Other Characteristics

16. What is the size of your total land? Any unit allow [_ _ _ _ _ _ _ _ _ _ _ _ _ _ _]

17. What is the total area under cultivation? [_ _ _ _ _ _ _ _ _ _ _ _ _ _]

18. Have you received any extension services in the past 12 month? [ ] 1=Yes, 2=No

19. How many times did you receive these services in the past 12 month? [_ _ _ _ _ _ _]

19b. List any comment you have on extension services

i) _

ii) _

iii) _

20. Which of these productive assets do you own? (Multiple answers possible)

1 = Tractor 2 = Oxen plough 3 = Water Pump 4 = Wheel Barrow 5 = Cutlass 6 = hoe

7 = Knapsack 8 = Other (specify) _ _ _ _ _ _ _ _ _ _ _ _ _

21. Which of these household assets do you own?

1 = TV sets 2 = Radio 3 = Bicycle 4 = Motorcycle 5 = Car

6 = Other (specify): _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

22. What is the main source of water for drinking and for household chores? [ ]

1=Pipe borne 2=Dam 3=Rain 4=River, lake, stream 5=Wells/Borehole

6 = Other (specify): _ _ _ _ _ _ _

23. a). Do you have access to irrigation water? [ ] 1 = Yes, 0 = No

24. b). If 'yes' what is the source of this water? [ ] 1 = river/lake/stream,

2 = Dam/pond 3 = Well/borehole 4 = pipe borne 5 = other (specify): _ _ _ _ _ _ _ _

25. What is the distance from the nearest market? [ ]

[INTERVIER: respondents can give the answer in **miles**: __ _ _ _ _ _ _ _ _ _ _]

1 = Less than 1 km 2 = 1 – 5 km 3 = 6 – 10 km 4 = Over 10 km

26. This question seeks to obtain production history during the last season. Which of these crops did you cultivate for cash?

A What crop did you cultivate in the previous season?	**B** Area cultivated	**E** Quantity harvested (**Use codes**) 1 = Basket 2 = Bowl 3 = Pan 4 = Bags 5 = bunch 6 = count		**D** Quantity sold (**Use codes**) 1 = Basket 2 = Bowl 3 = Pan 4 = Bags 5 = bunch 6 = count		**E** Price per unit sold (GHs)
		QTY	**CODE**	**QTY**	**CODE**	
Maize						
Rice						
Cassava						
Yam						
Plantain						
Pineapple						
Vegetables:						
Groundnut						

27. a). Did you harvest cocoa last year? [ ] 1 = Yes 0 = No

27. b). If yes, how many bags (kilograms) did you harvest and sold? _ _ _ _ _ _ _ _ _ _ _ _

28. This question seeks to obtain production history of your livestock

Type of livestock	Quantity	Quantity sold last year	Price per unit
Cattle			
Sheep			
Goat			
Fowl			
Turkey			
Guinea Fowl			
Pig			
Others:			

29.a) Are any members of your household (family) currently living outside the village and financiallysupporting your household (i.e. providing remittance income)? [ ]

1 = Yes 0 = No

29. b). If "yes" over the past 12 months how much (an estimate) did you receive from the family member outside this village? GHs_ _ _ _ _ _ _ _

30. Apart from farming, do you engage in any activity that generates income to support the household? 1 = Yes 0 = No

30b. On average, how much do you receive from the activity(ies) mentioned in Q30 per month or year? Month: GHs_ _ _ _ _ _ or Year: GHs_ _ _ _ _ _

D. CLAIMATE CHANGE INFORMATION: PERCEPTION AND ADAPTAION STRATEGIES

30. Comparing 1990s with the recent past 10 years, i.e. 2000s, have you notice any change in any of the following? (INTERVEIWER: if respondent finds it difficult, jump to Q31)

a).	Rainfall pattern	[ ]	1 = Yes	2 = No	3 = Don't know
b).	Temperature	[ ]	1 = Yes	2 = No	3 = Don't know
c).	Drought	[ ]	1 = Yes	2 = No	3 = Don't know

31. Looking back to the past 10 years, have the following weather elements increased, decreased or remain the same)?

a).	Rainfall pattern	[ ]	1 = Increased	2 = Decreased	3 = remained the same
b).	Temperature	[ ]	1 = Increased	2 = Decreased	3 = remained the same
c).	Drought	[ ]	1 = Increased	2 = Decreased	3 = remained the same

32. Please respond to the following questions using the scale of **1=Strongly Disagree** and **5=Strongly Agree.**

		Strongly disagree [1]	Disagree [2]	Neutral [3]	Agree [4]	Strongly Agree [5]
a).	Precipitation has been unpredictable during the past 20 years	[ ]	[ ]	[ ]	[ ]	[ ]
b).	there has been delay in the onset of the	[ ]	[ ]	[ ]	[ ]	[ ]

	wet season over the past 20 years					
c).	incidence of flood has increased in the past 20 years	[ ]	[ ]	[ ]	[ ]	[ ]
d).	temperature has been hot over the past 20 years	[ ]	[ ]	[ ]	[ ]	[ ]
e).	there has been prolong drought in the past 20 years	[ ]	[ ]	[ ]	[ ]	[ ]
f).	bush burning has been rampant over the past 20 years	[ ]	[ ]	[ ]	[ ]	[ ]

33. Have you made any adjustment in your farming practices to climate variability and change?

[ ] 1= Yes, 0=No

	Indigenous Adaptation Strategies	1 = Yes 0 = No
The following are some of the indigenous practices identified in the literature. Which of these have you adjusted in your farming practices to mitigate the long term shift in temperature and rainfall?	Soil and water conservation strategies	[ ]
	Changing planting date and period	[ ]
	Crop diversification (i.e. multiple cropping)	[ ]
	Livestock diversification strategy	[ ]
	Diversification to non-farming activities	[ ]
		[ ]
	Introduced Adaptation Strategies	
	Irrigation	[ ]
	Crop Insurance	[ ]
	Soil and plant related strategies (pesticides, fertilizer application)	[ ]
	Improve variety and breeds	[ ]
	Recommended Agricultural Practice (i.e. recommended spacing, planting distance, etc.)	[ ]

3***Soil and water conservation strategies**: Cover crops and legumes, planting of trees, mulching,

……..*End of Interview*……..

Thank You!

Appendix C: Summary of Research Report

PROBLEM STATEMENT	OBJECTIVES	METHODS	RESULTS	CONCLUSIONS	RECOMMENDATIONS
Climate modelling predicts that rainfed maize output in Ghana will decrease below 25 percent by 2020 if nothing is done. Adaptation measures need to be taken to mitigate the effect. The process of adaptation involves the interdependence of agents through their relation with each other. This concept usually termed social capital is lacking especially in Ghana.	1&2. To identify the type of social relations and analyse the strength of ties among smallholder farmers.	i. Descriptive statistics with application of independent sample t test ii. K-means cluster analysis	Smallholder farmers have networked with people (family members, friends and acquaintances) of different socio-economic status. The four individual social capital identified (based on tie strength and socio-economic status) are bonding, bridging, $bonding_{link}$, and $bridging_{link}$	The kind of social relations (i.e. the four individual social capital identified) differ significantly by sex of the respondents (ego).	-
	3. To analyze the trend of rainfall pattern over the past 20 years and its association (correlation) with annual maize output.	Trend analysis with application of Pearson Correlation Test	There is high intra and inter annual variations in the annual pattern of rainfall and maize output in all the three districts in the Central region of Ghana	There is a positive correlation between rainfall pattern and maize output. There is also a negative correlation between number of dry spell days and maize output.	Government and smallholder farmers should channel more resource into the investment of soil and water conservation strategies while encouraging inter cropping with minimal reliance on natural rainfall.
	4. To ascertain the perception of the smallholder farmers on climate change and their coping strategies	Descriptive statistics, FGDs & interview. Application of Mann-Whitney U and Kruskal Wallis test	Smallholder farmers have perceived a change in the climate especially with regard to delay in the onset of wet season, unpredictability of rainfall and rising temperature	Smallholder farmers have perceived a change in the climate and their perception differs across location.	In the designation of projects and adaptation technologies, policy makers or donors should not only concentrate on the technical aspect but also the social dimension such as how smallholder farmers perceive the changing climate
	5.To analyse the effect of individual social capital and other controlled factors on the adaptation strategies of the smallholder farmers	Multinomial Logit Model & FGDs as well as key informant interviews	Individual social capital has a significant positive influence on the adaptation of both indigenous and introduced adaptation strategies. Sex has a mixed influence. While age, SIOPS, and land size have a negative influence farming experience, farm income, leadership position, and location have positive influence on climate change adaptation strategies.	Individual social capital such as bonding, bridging, $bondingl_{ink}$ and $brridging_{link}$ have a significant positive influence on climate change adaptation strategies. Other variables such as sex, age, SIOPS, land size, farming experience, farm income, leadership position, and location have a significant influence on climate change adaptation strategies.	i. Climate change adaptation technology to smallholder farmers need not only be accomplished through the usual technology transfer network of agricultural researchers and extension agents. Rather, it will be imperative to increased contact with a wide variety of local actors who provide information and resources for agricultural production ii. Such leaders and young people should be involved in training programmes and workshops so that they can reach out to other people in the community.

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