# Determinants of Climate Smart Agriculture (CSA) Adoption among Smallholder Food Crop Farmers in the Techiman Municipality, Ghana

Samuel Weniga Anuga[1]*
Chris Gordon[2]
Emmanuel Boon[3]
Justice Musah-Issah Surugu[4]

## Abstract

*Climate change is already influencing crop production and distribution, and exacerbating the risks associated with farming. Smallholder farmers, especially from developing countries, have been identified as the most vulnerable to climate hazards due to prevalence of low adaptive measures. Climate Smart Agriculture (CSA) has therefore been presented as an alternative form of agriculture that can help to improve food security and reduce poverty, especially in developing countries. In Ghana, efforts are being made to build farmers adaptive capacity in various agro-ecological zones to enable them to effectively adapt to climate change through various CSA practices. However, inadequate attention has been paid at the institutional and academic levels to facilitate comprehensive understanding of the push and pull factors of CSA adoption in rural communities, and to scale-up CSA blueprints. The paper examines CSA among smallholder food crop farmers in the Techiman municipality in Brong Ahafo Region of Ghana. The results of the data analysis indicate that the CSA practices implemented by most of the farmers include using personal experience to predict weather events, reliance on radio/television to access weather information, minimum tillage, use of organic manure and afforestation. Economic, environmental, socio-cultural and institutional factors influenced CSA adoption. The paper concludes that, to ensure a smooth transition to climate-sensitive agricultural practices in Ghana, development actors need to vigorously support the inculcation of indigenous knowledge in modern agricultural technologies. It is also important for the government of Ghana and the Ministry of Food and Agriculture to develop and execute more elaborate capacity building programmes at the local level to influence farmers' personal attitudes towards pro-environmental behaviour.*

**Keywords:** agriculture, capacity building, climate, food security, impacts, innovation

[1]Climate Change and Sustainable Development Programme, University of Ghana
[2]Institute of Environment and Sanitation Studies, University of Ghana
[3]Vrije University, Belgium
[4]Department of Public Admistration and Health Services Management, University of Ghana

*Corresponding author's email: samuelanuga@rocketmail.com

## Introduction

Climate Smart Agriculture (CSA) has been presented as an alternative form of agriculture for conserving the environment while addressing the food needs of the world's population (Food and Agriculture Organisation, FAO, 2014). The concept was originally put forth in 2010 by FAO after the Hague Conference on Agriculture, Food Security and Climate Change in 2009 (FAO, 2010; World Bank, 2010). According to FAO (2010), the main aim of CSA is to repackage agriculture in the context of a changing climate, to assure a 'triple win', thus, adaptation, mitigation and development. CSA has therefore been defined as a form of agriculture that sustainably increases agricultural productivity and incomes; enhances adaptation and building resilience to climate change, reducing or removing Greenhouse Gases (GHGs) where possible, and enhancing the achievement of national food security and the sustainable development goals (FAO, 2014). Collier and Dercon (2014) opine that it is an approach to develop technical, policy and investment conditions to achieve sustainable development and food security. In a related view, Shea (2014) suggests that CSA is a focus-based concept that involves developing new technologies that can help farmers transition from current strategies to more climate-aware practices and encourage farmers to abandon or lessen reliance on methods that increase GHGs.  CSA adopts some form of sustainable land management practices that engage farmers in sustainable intensification measures such as agroforestry, conservation tillage, residue management, green manuring and improved water management to improve agricultural performance (DeLonge *et al*., 2016; Palombi & Sessa, 2013).  It also enables farmers to use their knowledge and skills more effectively, share information, opt for more efficient pro-environmental technologies and build stronger associations to facilitate effective negotiation of better market prices (Branca *et al*., 2011). In most developing countries, a majority of smallholder farmers are still reliant on rain-fed agriculture, thereby increasing their vulnerability to the consequences of climate change (Louhichi & Paloma, 2014). The impacts of climate change have not been fully understood by these farmers resulting in poor adaptation mechanisms (Vignola *et al*., 2015; Aggarwal *et al.,* 2013; FAO, 2010; World Bank, 2010). CSA therefore provides adaptation strategies that can help avoid or ameliorate the negative impacts of climate change on production, incomes and well-being of smallholder farmers. It provides a conceptual basis for enhancing agricultural adaptation and mitigation to support food security under a changing climate (Warner *et al*., 2015). The World Bank climate smart village model gives a comprehensive and broader perspective to farmers' CSA practices. The model categorised these practices as carbon, water, nitrogen, energy weather, and knowledge smart (World Bank, 2010). Our paper adopts this model as its theoretical underpinning.

In Ghana, efforts are being made to promote CSA in most agro-ecological zones by local, national and international development actors. The German Development Cooperation (GIZ), Ministry of Food and Agriculture (MoFA), Environmental Protection Agency (EPA) and Centre for Scientific and Industrial Research (CSIR) are among the numerous organisations encouraging CSA (Ecumenical Association for Sustainable Agriculture and Rural Development (EASARD), 2013; Ministry of Food and Agriculture, 2014). For instance, GIZ, in collaboration with MoFA, is engaged in the training and development of farmers' skills in composting, use of drought tolerant seeds, rainwater harvesting, tree planting, weather information access, and formation of farmer associations in the Northern Ghana and Brong-Ahafo Region in Ghana (Anuga & Gordon, 2016). Care Gulf Agriculture and Natural Resources (CGGANR) has also intensified the use of organic manure, agroforestry, mulching and minimum tillage. Access to weather information through radio and mobile phones is being promoted by Radio International in parts of the Techiman municipality (Ministry of Food and Agriculture [MoFA], 2014). Knowledge about CSA interventions is widely available in the municipality. Ghana has also launched the National Climate Smart Agriculture Policy (NCSAP), which presents pragmatic steps to develop agriculture through sustainable pathways (MoFA, 2014). Nonetheless, the dynamics of CSA adoption at the local level have not been fully conceptualised (Anuga & Gordon, 2016; MoFA, 2014; EASARD, 2013). Information on what determines smallholder farmers' decision to engage in CSA practices in the local communities in the country is meagre. Carmona *et al*., (2015) argue that farmers' economic status, personal behaviours and socio-cultural background can influence CSA adoption. Similarly, Van Thanh and Yapwattanaphun (2015) established that extension courses, economic status, education and perception of sustainable agriculture influence the adoption of sustainable agriculture. In order to effectively implement CSA in Ghana and recoup maximum benefits, it is imperative to uncover the determinants of CSA adoption process. It is against this background that the paper sought to answer the following two questions: (a) What are the CSA practices adopted by smallholder food crop farmers in the Techiman municipality? and (b) What are the factors influencing the adoption of CSA by smallholder food crop farmers? It is hoped that the results of the analysis will be inculcated into national and international CSA policies and facilitate attainment of the Sustainable Development Goals (SDGs).

## Literature Review

The World Bank in its 2010 development and climate change report indicated that CSA could be a means to address climate change and help achieve global sustainable development goals. It outlined a comprehensive model to develop and measure CSA activities. For farmers to be climate smart, the model recommends that they need to be engaged in the following six components; carbon, water, nitrogen, energy, weather, and knowledge smart practices (World Bank, 2010). This model has also been used by Aggarwal *et al* (2013) under the Consultative Group for International Agriculture Research (CGIAR) to develop Climate-Smart Villages in most developing countries. Farmers' carbon smart practices are farming practices that help the soil to store carbon, capture and/or prevent GHG emissions. According to Starritt (2010), soil contains twice as much carbon as terrestrial vegetation (primarily trees) and the atmosphere combined. Exposure of soil to oxygen leads to $CO_2$ emission. For instance, afforestation, minimum/zero tillage, organic/green manuring and composting are smart practices that can increase soil organic matter and enhance soil potential for carbon storage (Wang *et al*., 2016). Trees and shrubs serve as a buffer against weather-related production losses (Nyanga *et al*., 2016), prevent erosion, stabilise soils, raise infiltration rates and bring nutrients from deeper soil layers to enhance plants growth (Schwab *et al*., 2015; Lu *et al*., 2015). Tillage management and organic manuring play a significant role in GHG reduction. Organic fertilizers derived from animal matter, human excreta or vegetable matter contain carbon-based compounds that increase the productivity and growth quality of plants (Bajeli *et al*., 2016; Shimizu *et al*., 2015), and minimum/zero tillage prevents $CO_2$ emissions through the avoidance of soil carbon and oxygen reaction; it does not expose soil carbon to oxygen (Hösl & Strauss, 2016; Kuhn *et al*., 2016).

Water smart practices present opportunities for farmers to mitigate climate-induced water stress. Innovative technologies and pro-water conservation behaviours create water efficiency and enable access to water during water scarcity periods (Quiroga *et al*., 2015). Rainwater harvesting, mulching, on-farm water management, terracing and contouring can save costs and provide high quality water for production all year round; consequently, increasing yields and incomes of farmers (Botha *et al*., 2015; Karpouzoglou & Barron, 2014; Mul *et al*., 2011). Weather occurrences— including floods, storm surges and prolonged drought—can be devastating to crop productivity. Farmers can minimise climate change impacts by adopting weather smart practices; use of mobile phones or internet access of weather information, Index-Based Insurance (IBI), usage of radio/television for weather information (Shannon & Motha, 2015; Conradt *et al*., 2015; Hochrainer-Stigler *et al*., 2014). IBI for instance, is an innovative approach to insurance provision that pays out benefits or compensate clients on the basis of a predetermined index (example, rainfall level or temperature variation) for loss of assets and investments, resulting from weather and catastrophic events (Conradt *et al*., 2015). Mobile phones and internet enable farmers to receive information from colleagues, meteorological stations and other interest groups on weather events through voice messages or direct web access. They help to increase farmers' preparedness for climate change events and enable them to act accordingly (Aker & Ksoll, 2015). Knowledge and awareness of sustainable agriculture practices and climate events are essential in climate change adaptation and mitigation (Keshavarz & Karami, 2014). Farmer-to-farmer knowledge sharing and formation of farmer-based associations help to improve the management of yields and act as a conduit to bring farmers' knowledge to researchers (Bournaris *et al*., 2016; Keshavarz & Karami, 2014). Knowledge of kitchen gardening, terracing and contouring, as well as awareness of market prices of farm produce and inputs contribute to farmers' knowledge smartness. Kitchen gardening for instance provides temporary emergency food needs of farmers during climate events before long-term response mechanisms are put in place (Nwajiuba *et al*., 2015). Knowledge on market prices of farm produce/inputs enables farmers to decide on the type of inputs to buy and when to sell farm produce. This results in cutting down investment cost, hence, profit maximisation for expansion of farms (Ogutu *et al*., 2014).

## *Factors influencing CSA adoption*

Socio-cultural factors, including customs, beliefs and values within a community influence farmers' adoption of CSA practices (Kangee, 2015; Simbizi *et al*., 2014). Land tenure, for instance defines ownership and access to land. Ownership sometimes exerts influence as to what land can be used, and for what purpose(s). In Africa, customary ownership gives clan heads, community leaders and families the right to manage lands (Nyanga *et al*., 2016; Simbizi *et al*., 2014). Associates of these groups are able to use land for an extensive period without external conflicts. Land degradation due to long periods of land use, deforestation, bush burning and over grazing are prone to impede sustainable agriculture growth (Yaro, 2010; Owusu, 2008). In addition, custodians of lands can be lured by great financial investors to offer lands for activities that have significant negative impacts on the environment (Eren & Günay, 2015). Conversely, Nyanga *et al*. (2016) argue that people with permanent tenure tend to invest in long term conservation practices. Antwi-Agyei *et al*. (2015) observed that households with secure tenure did more agroforestry with different tree diversity than households that rented land (insecure tenure). Conflicts and chieftaincy disputes constitute major threats to sustainable agricultural development. Destruction of lands and vegetation, demolishing of houses and properties, loss of lives and displacement of people were found to have a significant relationship with conflicts and chieftaincy disputes (Kangee, 2015; Ochieng, 2011). Cost/availability of CSA technologies, farmer-based insurance opportunities, access to labour and increase incidence of weeds and pest occurrence can reinforce environmental and economic determinants of CSA adoption (Rochecouste *et al*., 2015; Feliciano *et al*., 2014). High costs associated with CSA technologies can also serve as a hindrance to farmers, especially smallholders that are largely associated with low levels of income (Carter *et al.,* 2016; Conradt *et al*., 2015). In some instances, the technologies are not available at the local level, therefore limits farmers' ability to access them. Insurance companies also provide Index-Based Insurance (IBI) to safeguard smallholder farmers against climate risks. In the absence of these facilities, farmers become more vulnerable to devastating climate events due to lack of compensation (Carter *et al.,* 2016; Conradt *et al*., 2015). At the personal level, farmers' perception about CSA is an influencing factor to the adoption of CSA practices. Individual farmers consider the benefits of CSA, especially with regard to productivity, before venturing into this form of agriculture (Takahashi *et al*., 2016; Lybbert & Carter, 2015). According to Green *et al*. (2014), farmers who hold the view that CSA has a potential of enhancing productivity positively are more likely to adopt than those who do not. Personal values and morals can also determine CSA adoption. Farmers who believe in a symbiotic relationship between man and environment are more likely to adopt farming practices that create harmony with nature and more likely to consider conservation agriculture to be more important and not just for higher yields but to protect the environment as well (McDonald *et al*., 2015; Halbrendt *et al*., 2014).

## Methodology

### *Geographical Scope of the Research*

The research was conducted in the Techiman municipality, which is one of the 27 District Assemblies in the Brong-Ahafo Region, and its capital is Techiman. The municipality lies between longitudes 2°5'0" and 1°47'30" West and latitudes 7°25'30" and 7°39'0" North. It shares common boundaries with Wenchi municipality and Techiman North District in the north, the Sunyani municipality and Offinso North District in the south, Nkoranza South District in the east and Tain District in the west. Techiman municipality's population is about 147,788. It also has a bi-modal rainfall system and experiences humid temperatures for most parts of the year which allow for two seasons farming (Ghana Statistical Service, GSS, 2010). The municipality is a major agriculture zone in Ghana, especially for food crops such as maize, cassava, cocoyam, potatoes and vegetables (MoFA, 2014). According to the Ghana Statistical Service (GSS, 2010), about 78.1% of the population are farmers with the majority being smallholder farmers. This implies that, the livelihood of the people is predominantly dependent on agriculture.

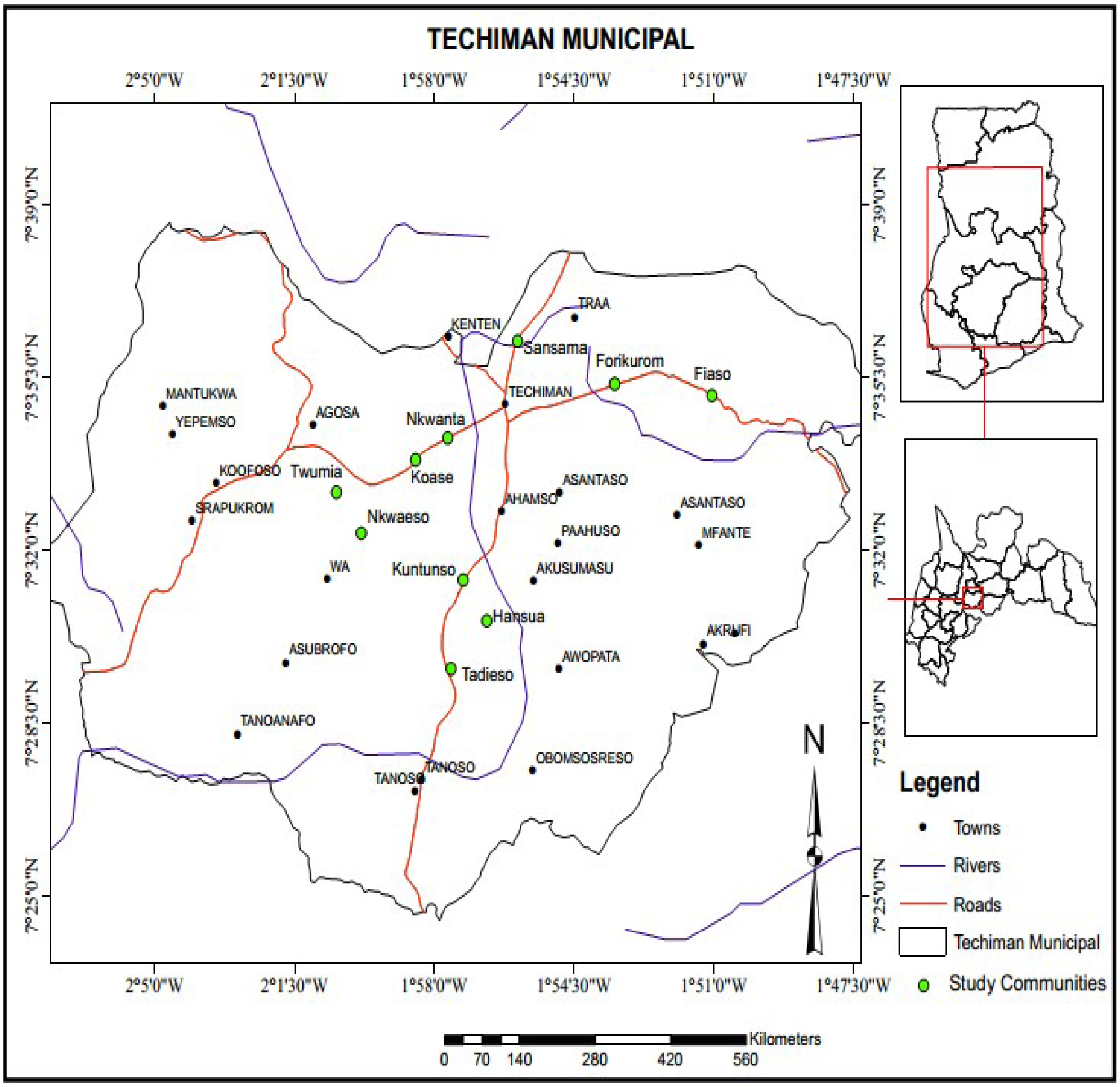


Figure1: Study Location Map
*Source: Geographic and Information Services, University of Ghana, 2016*

## *Sampling and data analysis*

The study employed a quantitative research design. Data was sourced from smallholder maize and yam farmers in the study location. This is because maize and yam constitute the major food crops produced in the area and are highly affected by climate change (MoFA, 2014). Maize and yam farmers were therefore used as a proxy for food crop farmers. For the purpose of this study, the FAO's (2010) definition of smallholder farmers is adopted; smallholder farmers are farmers who farm plots of 2 hectares or less and rely exclusively on family labour. Data collection was done by the principal researcher and five (5) well trained field assistants. This lasted for three months (January to March, 2016). A convenience sampling technique was used to select 320 smallholder maize and yam farmers from purposively selected 10 communities within the municipality. The reason for the convenience sampling technique was that, the informal nature of the occupation did not provide access to a sample frame for probability sampling techniques to be employed. Even though, some of the organisations working with the farmers had a list of the farmers they work with, the study deemed the available lists to be inaccurate and therefore did not use them. Most of the organisations were dealing with a section of farmers and did not have a list of all farmers that can be valid to be used in the study. The selection of the 10 communities was based on a documented evidence of climate change impacts and CSA practices by organisations working in these areas (Anuga & Gordon, 2016; MoFA, 2014). It was therefore prudent to use these communities (*Nkwaeso, Sansama, Tadieso, Forikurom, Fiaso, Nkwanta, Twimia, Koase, Hansua* and *Kuntunso*).

Data was collected through the administration of a structured questionnaire. The questionnaire was divided into three sections. Section A collected information on CSA practices of farmers based on the World Bank model. In this section, respondents were asked to indicate (yes/no) to the stated CSA practices. This was to give an overview of the nature of acceptance of CSA and the individual practices farmers were mostly employing. The individual variables were then computed to form the overall CSA dichotomous variable, thus, yes (1/adopting) and no (0/not adopting) for the purpose of the binary logistic regression. Section B focused on farm level issues. Respondents were asked to indicate their extent of agreement to listed statements based on a scale 1=strongly disagree, 2=disagree. 3=moderately agree, 4=agree & 5=strongly agree. The statements were listed under the themes; economic, environmental, socio-cultural, personal and institutional. Subsequently, the individual variables were computed to form the overall value of the themes(economic, environmental, socio-cultural, personal and institutional) which was analysed against the overall CSA adoption. Section C dwelled on the socio-demographic characteristics of the respondents. Data processing and analyses were done using the Statistical Product for Service Solution (SPSS), version 22.

The regression model applied is stated below:

$$CSA=\beta_0+ \beta_1E+ \beta_2EE+ \beta_3SC+ \beta_4P+ \beta_5I +\varepsilon_i$$

Where CSA represents climate smart agriculture adoption; E, Economic; EE, Environmental, SC, Socio-cultural; P, Personal; I, Institutional and ε the error margin.

## Presentation of Results

As presented in Table 1, majority (85.0%) of the farmers were relying on their own personal experience to predict weather events, 75.3% depended on radio/television to access weather information, 30.6% did Index-Based Insurance while (19.3%) used mobile phone to access weather information. Mulching (93.4%), regulation/control of water used in watering crops (82.8%) are the major water smart practices and minimum tillage (94.7%), organic manuring (94.7%) and afforestation (81.6%) all received an overwhelming “Yes” response as carbon smart practices. However, many (70.0%) indicated “No” to site specific nutrients application. Farmer-to-farmer knowledge sharing recorded 87.2% “ Yes” response while only 40% indicated “Yes” to receiving access to information on market prices of produce and inputs. At the broader farm level, farmers encountered several issues in relation to their farming activities (see Table 2). With regard to economic issues, farmers agreed they had access to labour (Mean=4.09) and to sustainable agriculture technologies (mean=4.64). Experience of bush fires (mean=4.02), drought occurrence (mean=4.89) and experience with weeds and pesticides (mean=4.02) were acknowledged as environmental factors. Taboos and values of community were not accepted (mean=2.56), whereas encroachment of farmlands (mean=4.30) and land tenure system (mean=4.42) were regarded as socio-cultural farm level experiences.

Table 1: CSA practices adopted by farmers

| Practices | Yes (%) | No (%) |
|---|---|---|
| **Weather smart** | | |
| Use personal experience to predict weather events | 85.0 | 15.0 |
| Usage of radio/tv for weather information | 75.3 | 24.7 |
| Received education/training on how to access weather information by an organisation | 54.4 | 45.6 |
| Received weather information through community information centre | 50.6 | 49.4 |
| Take Index-Based Insurance (IBI) to protect my farm | 30.6 | 69.4 |
| Use mobile phone to access weather information | 19.3 | 80.4 |
| Access to weather information on the internet | 11.8 | 88.2 |
| **Water smart** | | |
| Engage in mulching to reduce excessive use of water | 93.4 | 6.6 |
| Regulate/control the water used in watering crops | 82.8 | 17.2 |
| Plant at early season to make use of rain water | 76.8 | 23.2 |
| Plant cover crops to maintain soil moisture | 43.4 | 56.6 |
| Harvest and store rainwater to be used on my farm | 12.5 | 87.5 |
| **Carbon smart** | | |
| Use less heavy equipment on my farm (minimum tillage) | 94.7 | 5.3 |
| Use plants and animal manure on my farm (Organic manuring) | 94.7 | 5.3 |
| Plant different type of crops together (Mix cropping) | 94.7 | 5.3 |
| Plant trees in and around my farm (afforestation) | 81.6 | 18.4 |
| Change the type of crop planted on this land in some seasons (Crop rotation) | 72.8 | 27.2 |
| **Nitrogen smart** | | |
| Plant legumes among crops | 82.5 | 17.5 |
| Estimate the amount of fertilizer/manure needed at a time (Precision fertilization) | 53.7 | 46.3 |
| Use specific fertilizer/manure based on the type of soil (Site specific nutrients application) | 30.0 | 70.0 |
| **Energy smart** | | |
| Use of less fuel consuming vehicles | 92.5 | 7.5 |
| Compost my residue after harvesting | 70.6 | 29.4 |
| Convert my residue into bioenergy | 14.0 | 86.0 |
| Use solar equipment in farming | 10.9 | 89.1 |
| **Knowledge smart** | | |
| Share one-on-one information with colleagues (Farmer-to-farmer knowledge sharing) | 87.2 | 12.8 |
| Belong to farmer associations | 86.9 | 13.1 |
| Store seeds for next season/emergency (Seed banking) | 84.4 | 15.6 |
| Have a backyard garden in addition to my farm | 74.4 | 25.6 |
| Get access to information of market prices of produce & inputs | 40.0 | 60.0 |

*Source: Field work, 2016*

Table 2: Farm level issues

| Statements | Mean | Std. | S.E |
|---|---|---|---|
| **Economic** | | | |
| There is demand for farm produce | 2.21 | 0.81 | 0.05 |
| Access to farmer-based insurance companies | 3.63 | 1.07 | 0.06 |
| Access to labour | 4.09 | 0.92 | 0.05 |
| Access to sustainable agriculture technologies | 4.64 | 0.71 | 0.04 |
| **Environmental** | | | |
| Experience of bush/forest fires | 4.02 | 1.28 | 0.07 |
| Infertile soil | 3.62 | 1.05 | 0.06 |
| Drought occurrence | 4.89 | 0.69 | 0.04 |
| Experience of weeds & pesticides | 4.02 | 0.89 | 0.04 |
| **Socio-cultural** | | | |
| Taboos and values of community | 2.56 | 0.91 | 0.05 |
| Occurrence of tribal conflicts | 3.74 | 1.49 | 0.07 |
| Encroachment of farmlands | 4.30 | 0.89 | 0.05 |
| Land tenure system | 4.42 | 0.92 | 0.05 |
| **Personal** | | | |
| Perceptions of climate smart agriculture | 4.93 | 0.93 | 0.05 |
| Demand for time | 3.90 | 0.88 | 0.05 |
| Family needs | 4.92 | 0.69 | 0.04 |
| Personal values on the environment | 4.54 | 0.93 | 0.05 |
| **Institutional** | | | |
| Government support with farm inputs | 3.48 | 1.41 | 0.08 |
| Access to extension services | 3.90 | 1.22 | 0.07 |
| Availability of CSA funds by government | 4.25 | 0.72 | 0.04 |
| Access to roads and markets | 4.34 | 0.71 | 0.04 |

*Based on a scale 1=strongly disagree, 2=disagree. 3=moderately agree, 4=agree & 5=strongly agree.*

*Source: Field work, 2016*

A binary logistic regression was used to examine the influence of the economic, environmental, socio-cultural, personal and institutional issues on farmers' CSA adoption. Sweet (1999), Hosmer *et al.* (2013) and Adongo, Anuga and Dayour (2015) posit that logistic regression is the most appropriate tool for a dichotomous dependable variable and measurements of varying levels.

Characteristics of the model (Table 3) include the Exp (B) which denotes the odds of the outcome event, the Wald and the significance (P) which shows the power that each independent variable has on the entire model, and the B represents the unstandardized beta. To be considered significant in the logit model, a predictor variable should have odds of more than 1 and a P=0.05 (Sweet, 1999; Varin *et al.*, 2011). Odds ratio less than 1 means increasing value of the variable is parallel to decreasing odds of the event's occurrence and the reverse. With an Omnibus tests model coefficient of ($\chi2$= 85.56, P<0.05) and Hosmer and Lemeshow test of ($\chi2$=209.49, P>0.05), a statistically significant relationship was established between the determinants and CSA adoption. The model was fitted at a Hosmer and Lemeshow P value greater than 0.05 (Hosmer *et al.*, 2013; Pallant, 2005).The results show that the set of the independent variables combined to explain about 31% of the variation of the influence on CSA adoption. Specifically, the socio-cultural factor had a strong significant influence on food crop famers' adoption of CSA. This implies that farmers who faced socio-cultural challenges in their farming activities have 20% chance of engaging in CSA. Another factor that positively predicted CSA adoption was institutional. The associated odds indicate that farmers who had institutional support have 18% likelihood of adopting CSA. Economic and environmental factors also had a significant relationship with CSA adoption. The personal factor did not determine CSA adoption in any way. This presupposes that farmers' personal issues did not have any influence on whether they adopt CSA or not.

Table 3: Determinants of CSA adoption among smallholder food crop farmers

| Determinants of CSA adoption | B | Odds | Sig (p). | S.E | Wald |
|---|---|---|---|---|---|
| Economic | 0.16 | 1.42 | 0.00** | 0.34 | 0.07 |
| Environmental | 3.17 | 1.20 | 0.01** | 0.42 | 35.35 |
| Socio-cultural | 2.70 | 2.02 | 0.00** | 0.40 | 22.07 |
| Personal | 1.81 | 0.60 | 0.12 | 0.40 | 7.14 |
| Institutional | 2.35 | 1.83 | 0.03* | 0.37 | 10.80 |
| Constant | -0.25 | -9.62 | 0.00* | 2.40 | 0.06 |

Nagelkerke $R^2$= 0.31; Hosmer and Lemeshow Test: $\chi^2$= 209.49, df = 8, P = 0.14 Omnibus Tests of Model Coefficients: $\chi^2$=85.56, df=5 P=0.00 Significant at *p<0.05.

*Source: Field work, 2016*

## Discussion

In this era of climate change, weather events determine farmers' ability to cultivate and achieve the desired yields (Long *et al*., 2016). Our study found that smallholder food crop farmers relied on their own personal experience and use of radio/television for weather information. Experience is a crucial element in farming as farmers with vast experience and in-depth knowledge can also predict changes in weather events (Carmona *et al*., 2015; Branca *et al*., 2011). Farming is the main occupation in Africa and highly associated with most rural folks; it is considered an inheritance passed down to younger generations (Gandure, 2013; Galhena *et al*., 2013). Parents and relatives provide coaching to prepare their wards to be custodians of the trade. Averring the existence of modern sophisticated technologies for the estimation of weather events to be limited or difficult to access, farmers depend on their personal experience through indigenous knowledge to predict weather events (Ogutu *et al*., 2014; FAO, 2010). It is therefore not strange that personal experience was a main conduit for weather smartness. Index-Based Insurance (IBI) and use of internet for weather information are still emerging concepts in rural communities in Ghana, especially in the Techiman Municipality. This is one of the reasons for the low number of farmers engaging in the practice (Anuga & Gordon, 2016). Hochrainer-Stigler *et al*., (2014) avers that IBI is an exploratory concept in most developing countries, especially in Africa. The application of the concept still lacks clear understanding among most smallholder farmers and some organisations, especially regarding the payment of benefits or compensation for the occurrence of a predetermined risk (Fonta *et al*., 2015). A good understanding of the concept by insurance companies and farmers is necessary to ensure its easy adoption.

Minimum tillage, organic manuring and afforestation, were adopted by most of the farmers. Nyanga *et* *al*., (2016) indicate that trees and shrubs serve as a buffer against weather-related production losses by diminishing the effects of extreme weather events like heavy rains, droughts and wind storms. As observed by some scholars (Antwi-Agyei *et al*., 2015; Owusu *et al*., 2015; Sraku, 2012), farmers in the transition zone of Ghana, which includes our study location, have become more aware of climate change associated storm surges. Hence, they are motivated to engage in tree planting (afforestation) as a defensive mechanism. Apart from climate related benefits, trees are also used as a demarcation strategy to avoid land ownership disputes. Moreover, leaf litter from trees decompose to increase soil carbon. Other carbon smart practices like organic manuring and minimum tillage are also less expensive and less sophisticated, making it possible for farmers to easily use them.

Farmers can acquire information on weather events, market prices of goods and services, insurance and welfare services for their health and security through farmer-to-farmer knowledge sharing and farmer-based associations (Ogutu *et al*., 2014). The common characteristics of smallholding agriculture are the high dependence on family labour and other relatives for various farming activities (Owusu *et al.,* 2015; Anuga & Gordon, 2016). This feature creates a strong bond between farmers and allows for easy information transmission. Emphasis on peasant associations, as a catalyst for farmers' information sharing and yield promotion, has increased in recent times, both nationally and internationally (FAO, 2010; World Bank, 2010). Local and international NGOs are promoting farmers associations and re-echoing the need for farmer-to-farmer knowledge sharing through financial support and capacity building projects, thereby contributing to farmers' the formation of peasant associations for one-on-one information transimission.

As mentioned earlier, the four determinants of CSA adoption are economic, socio-cultural, environmental and institutional (Table 3). A indicated in Table 2, economic related issues which include financial availability, demand for farm produce, access to labour as well as available sustainable agriculture technologies (economic factor) influenced farmers adoption of CSA. CSA often requires substantial initial investments, but the range of costs can be very wide depending on the investment type. For instance, technologies for the successful implementation of CSA practices are often expensive, thereby limit smallholder farmers' ability to access and use them (Rochecouste *et al*., 2015; Feliciano *et al*., 2014). Branca *et al*. (2011) state that buying a special no-till drill to simultaneously seed and fertilize annual crops can be as twice expensive as hiring a tractor. The farmers in the study location acknowledged they have access to labour and sustainable agriculture technologies and moderate access to farmer-based insurance companies. This presupposes that the availability of these factors created an enabling environment for farmers to adopt CSA. For instance, micro-credit and insurance organisations provide low or interest free loans to farmers to invest in their farms and expand their businesses. Insurance companies also provide IBI to safeguard smallholder farmers against climate related risks (Carter *et al.,* 2016; Conradt *et al*., 2015). Farmers' admission of having access to these facilities is also an indication that, they could have access to financial support, farm equipment and available technological support. In other words, the economic factor is a significant determinant.

Issues including prolonged drought, bush/forest fires as well as weeds and pest occurrence together constitute the environmental factor. These are powerful forces that can influence farmers' behaviour towards adopting sustainable agricultural practices (Duval *et al*., 2016; Hill & Whitham, 2014). Weeds and pests for instance limit smallholder farmers' from realising their desired crop yields. To respond to pests and weeds incidence requires the use of biological control methods. Even though Hill & Whitham (2014) and Humbert (2013) established a hegemony of synthetic methods such as weedicides and pesticides among smallholder farmers, it is evident that the majority of farmers still resort to natural ways such as pest control hedges, elimination of infected crops and introduction of disease control crops (Night *et al*., 2011). Prolonged drought also influences farmers' pro-water management attitudes. For example, farmers analyse the rainy season and make the necessary preparations for early planting to avoid being disappointed by the rains. Some also engage in rainwater harvesting to irrigate their farms. Farmers also become more responsible and make judicious use of the available water. Clearly, the environmental factor positively influenced CSA adoption in the study areas.

Institutional and socio-cultural factors were also significant determinants of CSA adoption in the study location. In Sub-saharan Africa (SSA), institutions play a significant role in agricultural development. Famers need support at various levels to be able to embrace CSA. Government's support with regard to provision of farm inputs, access to extension services and availability of CSA funds were found to be the major variables of the institutional factor. In Ghana's rural areas, Agricultural Extension Agents (AEAs) play a pivotal role to enable farmers to adopt CSA practices. AEAs provide training, education, demonstration, monitoring and evaluation to ensure that farmers adopt CSA practices. Government's provision of CSA inputs to farmers and the availability of funds to promote CSA investments are essential. Under these conditions, farmers will not only learn but get the opportunity to practise and utilise CSA equipment, and hence, the ability to expand and/or increase their production capacities. This finding supportsother views (Nyanga *et al*., 2016; Aggarwal *et al*., 2013; Palombi & Sessa, 2013; and Pretty *et al*., 2011) on socio-cultural and institutional determinants of CSA adoption, especially afforestation, terracing and contouring, and seed banking.

## Conclusions and Policy Implications

The findings of our paper support the notion that CSA is a comprehensive and an all-encompassing package that promotes climate change adaptation, mitigation, food security and sustainable development. Using the World Bank climate smart village model, the paper provides a deeper perspective of CSA practices that are adopted by smallholder food crop farmers in the Techiman Municipality in Ghana. Based on the World Bank categorisation of CSA practices (weather, water, carbon, nitrogen, energy and knowledge practices), the CSA practices implemented by most of the farmers included using personal experience to predict weather events, use of radio/television to access weather information, regulation/control of water used in watering crops, minimum tillage, organic manuring and afforestation. Index-Based Insurance, use of mobile phones to access weather information, access to weather information on the internet and site specific fertilization were not commonly used by farmers. The major determinants of CSA adoption were economic, environmental, socio-cultural and institutional. It is important that both local and international organisations help to strengthen the nexus between indigenous knowledge and modern agricultural practices. The blending of indigenous knowledge and modern CSA knowledge will help to ensure a smooth transition to the application of climate smart agricultural technologies. Modern smart practices such as IBI, use of mobile phones to access weather information, access to weather information on the internet, and site specific fertilization should be well developed and anchored on ingenious knowledge to promote easy understanding and adoption of CSA practices. Agricultural Extension Agents (AEAs) serve as the first point of contact with rural farmers and by extension exert a stronger influence on what farmers do. To achieve the objective of CSA, the concept of agriculture extension should be strengthened to promote easier and faster assimilation of CSA. Therefore, it is important that the Government of Ghana and MoFA revisit the concept and prioritise their focus. To facilitate general acceptance, easy adoption of CSA practices with their up-scaling at all levels, financial and intuitional support, and the socio-cultural factors should be properly integrated in CSA blueprints. International policies and organisations should also practicalise the implementation of CSA and make more financial commitments to the achievement.

## References

Adongo, C. A., Anuga, S. W., & Dayour, F. (2015). Will they tell others to taste? International tourists' experience of Ghanaian cuisines. *Tourism Management Perspectives*, *15*, 57-64.

Aggarwal, P., Zougmoré, R., & Kinyangi, J. (2013). Climate-Smart Villages: A community approach to sustainable agricultural development. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Retrieved from www.ccafs.cgiar.org on *Monday January 4, 2016 at 09: 35pm.*

Aker, J. C., & Ksoll, C. (2015). Can mobile phones improve agricultural outcomes? Evidence from a randomized experiment in Niger. *Food Policy*, *60*, 44-51.

Antwi-Agyei, P., Dougill, A. J., & Stringer, L. C. (2015). Impacts of land tenure arrangements on the adaptive capacity of marginalized groups: The case of Ghana's Ejura Sekyedumase and Bongo districts. *Land Use Policy*, *49*, 203-212.

Anuga, S. W., & Gordon, C. (2016). Adoption of climate-smart weather practices among smallholder food crop farmers in the Techiman municipal: Implication for crop yield. *Research Journal of Agriculture and Environmental Management, 5*(9), 279-286.

Bajeli, J., Tripathi, S., Kumar, A., Tripathi, A., & Upadhyay, R. K. (2016). Organic manures a convincing source for quality production of Japanese mint (Mentha arvensis L.). *Industrial Crops and Products*, *83*, 603-606.

Botha, J. J., Anderson, J. J., & Van Staden, P. P. (2015). Rainwater harvesting and conservation tillage increase maize yields in South Africa. *Water Resources and Rural Development*, *6*, 66-77.

Bournaris, T., Moulogianni, C., Arampatzis, S., Kiomourtzi, F., Wascher, D. M., & Manos, B. (2016). A knowledge brokerage approach for assessing the impacts of the setting up young farmers' policy measure in Greece. *Environmental Impact Assessment Review*, *57*, 159-166.

Branca, G., McCarthy, N., Lipper, L., & Jolejole, M. C. (2011). Climate-smart agriculture: a synthesis of empirical evidence of food security and mitigation benefits from improved cropland management. *Mitigation of climate change in agriculture series*, *3*, 1-42.

Carmona, I., Griffith, D. M., Soriano, M. A., Murillo, J. M., Madejón, E., & Gómez-Macpherson, H. (2015). What do farmers mean when they say they practice conservation agriculture? A comprehensive case study from southern Spain. *Agriculture, Ecosystems & Environment*, *213*, 164-177.

Carter, M. R., Cheng, L., & Sarris, A. (2016). Where and how index insurance can boost the adoption of improved agricultural technologies. *Journal of Development Economics*, *118*, 59-71.

Collier, P., & Dercon, S. (2014). African agriculture in 50 years: Smallholders in a rapidly changing world?. *World development*, *63*, 92-101.

Conradt, S., Finger, R., & Spörri, M. (2015). Flexible weather index-based insurance design. *Climate Risk Management*, *10*, 106-117.

DeLonge, M. S., Miles, A., & Carlisle, L. (2016). Investing in the transition to sustainable agriculture. *Environmental Science & Policy*, *55*, 266-273.

Duval, M. E., Galantini, J. A., Martínez, J. M., López, F. M., & Wall, L. G. (2016). Sensitivity of different soil quality indicators to assess sustainable land management: Influence of site features and seasonality. *Soil and Tillage Research*, *159*, 9-22.

Ecumenical Association for Sustainable Agriculture and Rural Development (ECASARD, 2013). Retrieved from http://www.ghananewsagency.org/science/food-research-urges-mofa-tointensify-education-on-farming-practices-61886 on January 2, 2016 at 4:00pm.

Eren, Ş. G., & Günay, A. S. (2015). Analyzing the transfer of immovable property rights for urban resilience: An alternative land management model for the Karaburun–Cesme–Seferihisar Peninsula. *Ocean & Coastal Management*, *118*, 139-157.

Feliciano, D., Hunter, C., Slee, B., & Smith, P. (2014). Climate change mitigation options in the rural land use sector: stakeholders' perspectives on barriers, enablers and the role of policy in North East Scotland. *Environmental Science & Policy*, *44*, 26-38.

Fonta, W. M., Sanfo, B. I., & Barry, B. (2015). Farmers' awareness, perception of climate hazards and their willingness to participate in crop insurance schemes in Southwestern Burkina Faso. *Procedia Environmental Sciences*, *29*, 7-8.

Food and Agriculture Organisation. (2010). *The state of food insecurity in the world 2010*. Retrieved from www.fao.org/docrep *on Tuesday 2nd February, 2016 at 8:45am.*

Food and Agriculture Organisation. (2014). *The state of food and agriculture (SOFA) 2014*. Retrieved from www.fao.org/3/a-i4040e.pdf *on Thursday 10th March, 2016 at 02:34pm.*

Galhena, D. H., Freed, R., & Maredia, K. M. (2013). Home gardens: A promising approach to enhance household food security and wellbeing. *Agriculture & Food Security*, *2*(1), 1.

Gandure, S., Walker, S., & Botha, J. J. (2013). Farmers' perceptions of adaptation to climate change and water stress in a South African rural community. *Environmental Development*, *5*, 39-53.

Ghana Statistical Service (2010). *2010 Population and Housing Census*. Retrieved from http//:www.statsghana.gov.gh/.../2010phc/Census2010_Summary_report on Monday December 4, 2016 at 08: 59 am.

Green, J. F., Sterner, T., & Wagner, G. (2014). A balance of bottom-up and top-down in linking climate policies. *Nature Climate Change*, *4*(12), 1064-1067.

Halbrendt, J., Gray, S. A., Crow, S., Radovich, T., Kimura, A. H., & Tamang, B. B. (2014). Differences in farmer and expert beliefs and the perceived impacts of conservation agriculture. *Global Environmental Change*, *28*, 50-62.

Hill, J. H., & Whitham, S. A. (2014). Control of virus diseases in Soybeans. *Control of Plant Virus Diseases: Seed-Propagated Crops*, *90*, 355-390.

Hochrainer-Stigler, S., van der Velde, M., Fritz, S., & Pflug, G. (2014). Remote sensing data for managing climate risks: Index-based insurance and growth related applications for smallholder-farmers in Ethiopia. *Climate Risk Management*, *6*, 27-38.

Hösl, R., & Strauss, P. (2016). Conservation tillage practices in the alpine forelands of Austria: Are they effective?. *CATENA*, *137*, 44-51.

Hosmer Jr, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied logistic regression* (Vol. 398). John Wiley & Sons.

Humbert, R. P. (2013). *The growing of sugar cane*. Elsevier.

Kang'ee, E. (2016). Transforming Land Conflicts into Sustainable Development: The Case of the Taita Taveta of Kenya. In *Land Restoration* (pp. 259-270). Academic Press.

Karpouzoglou, T., & Barron, J. (2014). A global and regional perspective of rainwater harvesting in sub-Saharan Africa's rain fed farming systems. *Physics and Chemistry of the Earth, Parts A/B/C*, *72*, 43-53.

Keshavarz, M., & Karami, E. (2014). Farmers' decision-making process under drought. *Journal of arid environments*, *108*, 43-56.

Kuhn, N. J., Hu, Y., Bloemertz, L., He, J., Li, H., & Greenwood, P. (2016). Conservation tillage and sustainable intensification of agriculture: Regional vs. global benefit analysis. *Agriculture, Ecosystems & Environment*, *216*, 155-165.

Long, T. B., Blok, V., & Coninx, I. (2016). Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: Evidence from the Netherlands, France, Switzerland and Italy. *Journal of Cleaner Production*, *112*, 9-21.

Louhichi, K., & Paloma, S. G. (2014). A farm household model for agri-food policy analysis in developing countries: Application to smallholder farmers in Sierra Leone. *Food Policy*, *45*, 1-13.

Lu, S., Wang, F., Meng, P., & Zhang, J. (2015). Simultaneously protecting the environment and its residents: The need to incorporate agroforestry principles into the ecological projects of China. *Ecological Indicators*, *57*, 61-63.

Lybbert, T. J., & Carter, M. R. (2015). Bundling drought tolerance and index insurance to reduce rural household vulnerability to drought. *Sustainable Economic Development: Resources, Environment, and Institutions, Elsevier Academic Press, USA*.

McDonald, R. I., Chai, H. Y., & Newell, B. R. (2015). Personal experience and the psychological distance of climate change: An integrative review. *Journal of Environmental Psychology*, *44*, 109-118.

Ministry of Food and Agriculture (2014). *Agriculture in the Techiman Municipality*. Retrieved from http://www.ghanadistricts.com/districts on *December 14, 2015 at 9: 45am.*

Mul, M. L., Kemerink, J. S., Vyagusa, N. F., Mshana, M. G., Van der Zaag, P., & Makurira, H. (2011). Water allocation practices among smallholder farmers in the South Pare Mountains, Tanzania: The issue of scale. *Agricultural water management*, *98*(11), 1752-1760.

Night, G., Asiimwe, P., Gashaka, G., Nkezabahizi, D., Legg, J. P., Okao-Okuja, G., & Munyabarenzi, I. (2011). Occurrence and distribution of cassava pests and diseases in Rwanda. *Agriculture, ecosystems & environment*, *140*(3), 492-497.

Nwajiuba, C., Emmanuel, T. N., & Bangali Solomon, F. A. R. A. (2015). State of Knowledge on CSA in Africa: Case Studies from Nigeria, Cameroun and the Democratic Republic of Congo. In *Forum for Agricultural Research in Africa, Accra, Ghana ISBN* (pp. 978-9988).

Nyanga, A., Kessler, A., & Tenge, A. (2016). Key socio-economic factors influencing sustainable land management investments in the West Usambara Highlands, Tanzania. *Land Use Policy*, *51*, 260-266.

Ochieng, C. M. (2011). *Toolkit and guidance for preventing and managing land and natural resources conflict: Conflict prevention in resource-rich economies*. Retrieved from http://works.bepress.com/cosmas_ochieng/11/ on Friday 24th June, 2016 at 11:20am.

Ogutu, S. O., Okello, J. J., & Otieno, D. J. (2014). Impact of information and communication technology-based market information services on smallholder farm input use and productivity: The case of Kenya. *World Development*, *64*, 311-321.

Owusu, G. (2008). Indigenes' and migrants' access to land in peri-urban areas of Accra, Ghana. *International Development Planning Review*, *30*(2), 177-198.

Owusu, K., Obour, P. B., & Asare-Baffour, S. (2015). Climate Variability and Climate Change Impacts on Smallholder Farmers in the Akuapem North District, Ghana. In *Handbook of Climate Change Adaptation* (pp. 1791-1806). Springer Berlin Heidelberg.

Pallant, J. (2005).SPSS Survival Manual: A Step by Step Guide to Using SPSS for Windows.

Palombi, L., & Sessa, R. (2013). *Climate-smart agriculture: sourcebook*. Food and Agriculture Organization of the United Nations (FAO).

Pretty, J., Toulmin, C., & Williams, S. (2011). Sustainable intensification in African agriculture. *International journal of agricultural sustainability*, *9*(1), 5-24.

Quiroga, S., Suárez, C., & Solís, J. D. (2015). Exploring coffee farmers' awareness about climate change and water needs: Smallholders' perceptions of adaptive capacity. *Environmental Science & Policy*, *45*, 53-66.

Rochecouste, J. F., Dargusch, P., Cameron, D., & Smith, C. (2015). An analysis of the socio- economic factors influencing the adoption of conservation agriculture as a climate change mitigation activity in Australian dryland grain production. *Agricultural Systems*, *135*, 20-30.

Schwab, N., Schickhoff, U., & Fischer, E. (2015). Transition to agroforestry significantly improves soil quality: A case study in the central mid-hills of Nepal. *Agriculture, Ecosystems & Environment*, *205*, 57-69.

Shannon, H. D., & Motha, R. P. (2015). Managing weather and climate risks to agriculture in North America, Central America and the Caribbean. *Weather and Climate Extremes*, *10*, 50-56.

Shea, E. C. (2014). Adaptive management: The cornerstone of climate-smart agriculture. *Journal of Soil and Water Conservation*, *69*(6), 198A-199A.

Shimizu, M., Limin, A., Desyatkin, A. R., Jin, T., Mano, M., Ono, K., & Hatano, R. (2015). Effect of manure application on seasonal carbon fluxes in a temperate managed grassland in Southern Hokkaido, Japan. *Catena*, *133*, 474-485.

Simbizi, M. C. D., Bennett, R. M., & Zevenbergen, J. (2014). Land tenure security: Revisiting and refining the concept for Sub-Saharan Africa's rural poor. *Land Use Policy*, *36*, 231-238.

Sraku, E. (2012). *The effect of conflicts on the attainment of sustainable land use systems in Tamale Metropolis, Tolon-Kumbungu, Sefwi Wiawso and Kwahu South Districts* (Doctoral dissertation), Kwame Nkrumah University of Science and Technology, Kumasi.

Starritt, A. (2010). *Carbon sequestration in farming systems*. A report for farming scholars, Nuffield Australia. Retrieved from http://nuffieldinternational.org/rep_pdf on Friday 24th June, 2016 at 11:37am.

Sweet, S. (1999).Data Analysis with SPSS.Massachusetts: Allyn and Bacon.

Takahashi, K., Ikegami, M., Sheahan, M., & Barrett, C. B. (2016). Experimental evidence on the drivers of Index-Based livestock insurance demand in Southern Ethiopia. *World Development*, *78*, 324-340.

Van Thanh, N., & Yapwattanaphun, C. (2015). Banana farmers' adoption of sustainable agriculture practices in the Vietnam Uplands: The Case of Quang Tri Province. *Agriculture and Agricultural Science Procedia*, *5*, 67-74.

Varin, C., Reid, N.M., & Firth, D. (2011). An overview of composite likelihood methods.

Vignola, R., Harvey, C. A., Bautista-Solis, P., Avelino, J., Rapidel, B., Donatti, C., & Martinez, R. (2015). Ecosystem-based adaptation for smallholder farmers: Definitions, opportunities and constraints. *Agriculture, Ecosystems & Environment*, *211*, 126-132.

Wang, Z. B., Zhang, H. L., Lu, X. H., Wang, M., Chu, Q. Q., Wen, X. Y., & Chen, F. (2016). Lowering carbon footprint of winter wheat by improving management practices in North China Plain. *Journal of Cleaner Production*, *112*, 149-157.

Warner, B. P., Kuzdas, C., Yglesias, M. G., & Childers, D. L. (2015). Limits to adaptation to interacting global change risks among smallholder rice farmers in Northwest Costa Rica. *Global Environmental Change*, *30*, 101-112.

World Bank (2010). *Development and climate change*. Retrieved from siteresources. worldbank.org*/INTWDR2010/.../WDR10 on Monday January 4, 2016 at 07: 59am.* Food and Agriculture Organisation. (2013). *FAO statistical year book 2013*. Retrieved from www.fao. org/docrep *on Friday March 11th 2016 at 7:23pm.*

Yaro, J. A. (2010). Customary tenure systems under siege: contemporary access to land in Northern Ghana. *GeoJournal*, *75*(2), 199-214.