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Economic Implications of a Changing Climate on Smallholder Pineapple Production in Ghana

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Abstract
Pineapple production in Ghana plays a major role in developing the economy through socioeconomic impacts and export. Climatic variations contribute to variable yield and subsequently affect pineapple productivity. Direct dependence on climate for pineapple production could have significant economic implications. This study examined the economic impact of a changing climate on smallholder pineapple farming in Ghana. Data from 400 pineapple farmers was obtained from four pineapple growing districts using a two-stage sampling technique. Ricardian regression approach was used to estimate the relationship between farmer's net farm revenue per hectare, climate and other control variables such as soil and socio economic characteristics. The results revealed negative economic effect between rainfall and net revenue during vegetative stage of pineapple production as well as temperature and net revenue during the flowering stage. A positive effect between net revenue and temperature during yield formation stage was also observed. The study again discovered a fall in net revenue if temperature increases by 1°C and a rise in net revenue if rainfall increases by 1mm during production. The other variables that were key to net revenue were production on Dystric Planosols soil type, access to credit and membership of farmer-based associations. Given the role of pineapple production in the Ghanaian economy, supporting and promoting adaptation options to address issues of climate variability and change is recommended for improved productivity to sustain the pineapple industry economically.
Keywords: Net revenue, temperature, rainfall, pineapple production, Ghana

1. Introduction

Demand for tropical fruits has increased globally. Developing countries now account for about 98% of production of fruit imports in developed countries (Sthapit et al. 2012). Production of high-value horticultural products in Africa has therefore received considerable attention due to its perceived potential to improve poor farmers' economic welfare by providing opportunities for foreign markets (Danielou & Ravry, 2005; World Bank, 2008; Suzuki et al. 2011). Pineapple is an important non-traditional horticultural export crop in Ghana and contributes significantly to the growth of the agricultural sector in the country. It is the leading horticultural export crop in Ghana (Wardy et. al. 2009). In 2013, the total value of exported pineapple was $40 095 385.00 and still maintained its position as the leading exported horticultural crop (ISSER, 2015). Large and medium scale producers and many small-scale farmers cultivating between 1 to 10 acres of land characterise Ghana's pineapple production. Smallholder famers sell their fruits on the local market, to processors or to exporters for export. Pineapple export in Ghana is predominantly organized by export companies or processors but according to Kleeman (2014) about 40% of all the exported pineapples come from smallholders.

At present, Ghana's pineapple production is mainly rain-fed and mostly not irrigated. Temperatures are expected to increase over the period 2010 to 2050 in all regions of Ghana with variable rainfall across all ecological zones (Asante and Amuakwa-Mensah, 2014). Rainfall and temperature are the most important climatic variables that play crucial role in agricultural production and are the most important climatic factors for pineapple production in Ghana (MoFA, 2013). As in most developing countries, climate variability and change introduces numerous uncertainties over the livelihoods and economic output of farming communities that depend on climate (Mawunya and Adiku, 2013). This is particularly important for pineapple farming which, as other agricultural sectors, is influenced by a changing climate particularly challenging the livelihood of vulnerable smallholder farmers who dominate the industry.

Within the agricultural sector, horticulture's high production value per unit would provide an opportunity for smallholder farmers. It differs from staple crops smallholders traditionally cultivate, especially in the high standard of product quality, types of production inputs, perishability and limited marketing channels (World Bank 2008; Suzuki et al. 2011). Fruit acidity and sweetness are two major factors of fruit eating quality with other measures such as shell color, fruit size and shape, fruit weight, aroma, crown size, crown to fruit ratio and the absence of disease and blemishes (Paull and Chen, 2003). Variation of pineapple fruit acidity and sweetness are mainly associated with the pineapple fruit maturation and growing conditions (Bartolome et al., 1995) where environmental and field management practices are known to alter pineapple fruit acid accumulation (Paull and Chen, 2003; Dorey et. al. 2016). A recent study on pineapples indicated that, climate variability in the form of prolonged droughts associated with high temperatures with delayed and poor rainfall distributions affected yield, fruit quality and increased cost of production as more inputs were required in the poor climatic conditions (Mugumbra, 2014). Even though pineapple plant has xerophytic features and can tolerate some dryness, severe drought is reported to cause early withering of the peduncle and fruits produced under such conditions have corky micro-fissures (Carr, 2012). In addition, sugar content is also observed to reduce under such condition, thus affecting the taste (Dorey at el. 2016). In effect, the market value of fruits produced under severe drought reduces and cannot compete effectively with other imports (Suzuki et al. 2011).

In the light of increasing climate variability, the direct reliance on rainfall and temperature, pineapple production in Ghana is expected to bare significant economic implications for the smallholder farmers challenging sustainable production and poverty reduction. There is limited knowledge on the magnitude of changing climate impacts on pineapple farming economy in Ghana. This knowledge however is necessary to cost the consequences of a changing climate, to guide policy for adaptation and ultimately for farmer's socioeconomic development. We explore those economic consequences using the Ricardian model approach, which integrates climate variables, soil and socioeconomic factors to estimate the relationship between farmer's income and climate variables. It evaluates as well the expected marginal impact of rainfall and temperature on farmer's net revenue.

2.0 Methodology

2.1 Study area, data and method of collection

Pineapple production is mainly cultivated in four out of the ten regions of Ghana. A survey of pineapple growing areas in one leading pineapple growing district in each of the four growing regions was considered for the study. These were Ga East, Akatsi North, Nsawam Adoagyiri and Gomoa West districts representing Greater Accra, Volta, Eastern and Central regions of Ghana respectively (Figure 1). The four districts have bimodal rainfall pattern indicating two main growing seasons per year, a major season (March to August) and a minor season (September to February) with dry periods lasting between 3 and 7 months when rainfall amount is relatively low. Both qualitative and quantitative data were collected in a survey. A two-stage sampling technique was employed to collect cross sectional data from 400 smallholder pineapple farmers. The first stage involved purposive sampling of the study areas and the second stage used simple random sampling technique to select about 100 pineapple farmers proportionate to each district. Data collection methods consisted structured questionnaire, Key Informant Interviews (KII) and Focus Group Discussions (FGDs).

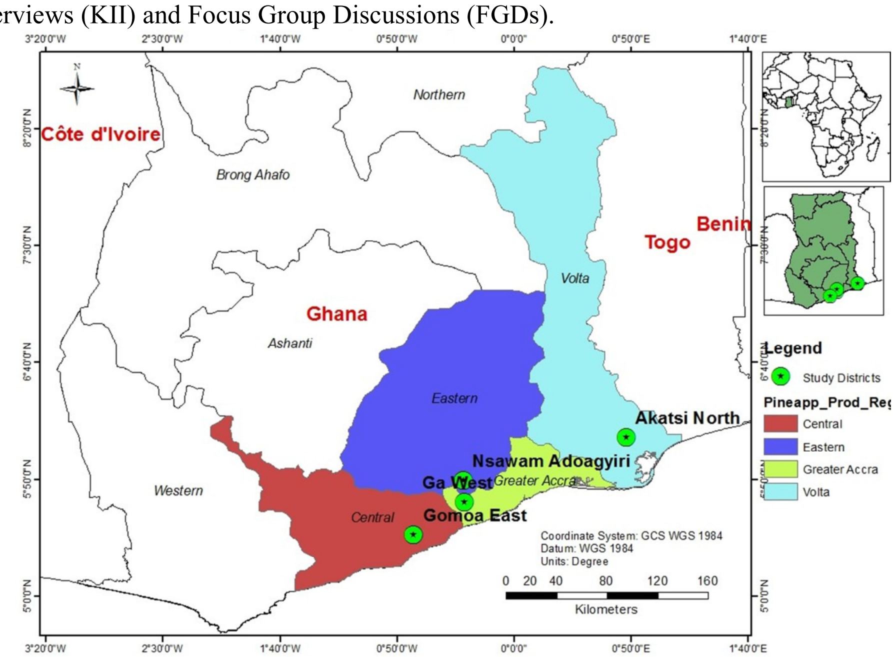

Figure 1: Map of study areas

The targeted respondents were members of cooperative pineapple growers and marketing associations in the four districts as well as staff at Ministry of Food and Agriculture (MoFA) district offices to get in-depth understanding of climate and pineapple production in Ghana. The questionnaire was pre-tested to prevent inconsistencies before administering. Socio-economic characteristics were collected, including farmer's educational level, age, training received, household size, farm size, access to agricultural extension services, membership of Farmer Based Organization (FBO) and access to credit among others. Complementary information on inputs and costs of production, marketing and production revenue were collected to estimate net revenue. With respect to secondary sources of data, monthly rainfall as well as mean monthly minimum and maximum temperatures from 1984 to 2014 in a representative weather station in each of the four study districts was obtained from Ghana Meteorological Services Agency (GMet). Pineapple growing cycle is longer than an annual cycle, and annual pineapple yield is as a consequence of conditions during the two preceding years. Climate analysis hence relied on the 21 consecutive months running period prior to harvest year. Furthermore, disaggregation of the climate data was made based on the various pineapple growth stages as shown in Figure 2.

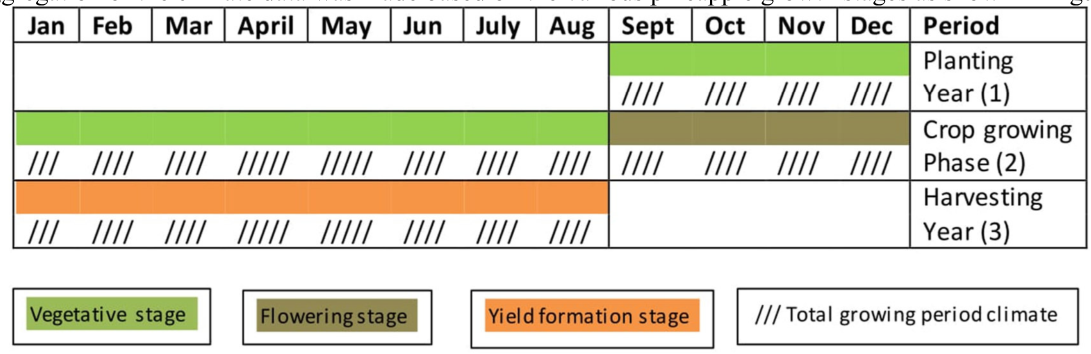

Figure 2: Crop calendar for pineapple production in Ghana

The major soil types identified in the study districts were obtained from the Soil Research Institute of the Council for Scientific and Industrial Research in Ghana. These were Ferric Luvisols, Dystric Planosols, Haplic Lixisols and Umbric Leptosols. Based on FAO classification on soil types, Luvisols have mixed mineralogy, high nutrient content, and good drainage making them suitable for a wide range of agriculture al production but with a horizon of clay minerals and can also be found on poorly drained mineral soils. Planosols are characterized by slowly permeable subsoil with significantly more clay than the surface horizon but is cultivated for various crops under careful management practices. Lixisols are more suitable for perennial crops as they are developed on old landscapes in a tropical climate with relatively low levels of plant nutrient but possible for agricultural production under careful management practices. Leptosols are soils with a very shallow profile depth (indicating little influence of soil-forming processes) and typically susceptible to erosion or waterlogging depending on climate.

2.2 Data analysis: Analytical model

The Ricardian method is a cross-sectional approach for investigating the economic impact of changing climate on farm value. It was named after David Ricardo (1772–1823) because of his original contribution to economic thought by essentially observing that the value of land would imply its net productivity (Jain, 2007). Depending on availability of data, the dependent variable can either be the annual net revenues or capitalized net revenues (land values). The absence of a well-functioning land market in Ghana makes it difficult to determine the land value. Hence we used the net revenue as in earlier studies (Mendelsohn and Williams, 2004; Eid et. al., 2006; Molua and Lambi, 2007; Mendelsohn et. al., 2007 and Ajetomobi et al. 2010). Farmland net revenue (V) reveals net productivity and the Ricardian principle is explicitly captured in the following equation:

$$V = \Sigma P_i Q_i(X, F, Z, G) - \Sigma P_x X \quad (1)$$

Where P_i is the market price of pineapple, Q_i is the output of pineapple, X a vector of purchased inputs (other than land), F a vector of climate variables, Z a vector of soil variables, G a vector of socio-economic variables and P_x is a vector of input prices (Mendelsohn et al., 1994). It is assumed that the farmer chooses X to maximize net revenues given the characteristics of the farm and market prices. The Ricardian model is reduced and basically a model that examines how independent variables F, Z and G affect net revenues. It relies on a quadratic formulation of climate and both linear and quadratic terms of the climate are introduced. The quadratic term shows the nonlinear shape of the impact of climate on farm value (equation 2) and shown below:

$$V = \beta_0 + \beta_1 F + \beta_2 F^2 + \beta_3 Z + \beta_4 G + \varepsilon \ (2)$$

Equation (2) shows the relationship between farm value (V) in equation (1) and climate (F), soil (Z) and socio-economic variables (G) where: V represents net revenue per hectare; Climate variables (F) represent rainfall and temperature during pineapple growth stages; Soil types (Z) represents various soil types in study areas, thus, Ferric Levisol, Dystric Planosols, Haplic Lixisols and Umbric Leptosols; Socio-economic variables (Z) represents sets of socioeconomic characteristics such as age, educational level, type of training received, household size, farm size, access to credit, membership of farmer based organization and contact to agricultural extension agents whiles ε is the error term. The expected marginal impact of a single climate variable on farm net revenue evaluated at the mean, is given by Kurukulasuriya and Mendelsohn (2006) is stated as:

$$E\left(\frac{dV}{df_i}\right) = b_{1,i} + 2 * b_{2,i} * E(f_i) \quad (3)$$

Where f_i represents a climatic variable, $b_{1,i}$ is the coefficient of the regression from the linear relationship between f_i and V $b_{2,i}$ is the coefficient of the regression from the quadratic relationship between f_i and V and E (f_i) represents the sample mean f_i. This is to help predict the marginal impact of selected climate variables (temperature and rainfall) on pineapple production in Ghana since the coefficients for climate variables cannot be directly interpreted as the marginal effects.

Ordinary Least Square (OLS) estimation procedures using STATA 10.0 software was used to fit the model considering multicollinearity and heteroscedasticity as cross-sectional data is usually associated with such problems. To overcome these, robust estimation of the standard error was used to do automatic corrections and identified correlated variables were dropped from the model. Variables were dropped on the basis of low significance level and low contribution in improving the overall significance of the estimation model. The empirical analysis was estimated using the response of net farm revenue (V). The key response variable was the net revenue per hectare for pineapple farming. It was measured as the gross revenue per hectare less costs of production including costs of input variables such as fertilizer, insecticide, herbicide, labour, depreciation on machineries and other farming costs. The dependent variable was regressed on climate and the other control variables (soils and socioeconomic data).

2.2.1 Description of Variables

Temperature and rainfall were categorized into three distinct periods to reflect the 21- months climatic period required for pineapple production and depicted the three growth stages: vegetative stage (Sept. – August), flowering stage (Sept – Dec) and yield formation stage (Jan. – May). The 21 months long-term (1984–2014) mean for temperature and rainfall were computed. Assuming a quadratic relationship of climate variables with the net farm revenue, the square terms of the climate variables were also computed. Summary statistics for the climate variables used in the analysis is presented in Table 1.

Table 1: Summary statistics of climate variables

Variable	Minimum	Maximum	Mean	Standard deviation
Mean vegetative stage rainfall (Sept-Aug)/mm	64.6	110.3	77.724	18.896
Mean flowering stage rainfall (Sept – Dec)/mm	44.7	99.5	64.702	22.204
Mean yield formation stage rainfall (Jan –May)/mm	63.9	99.1	75.746	13.772
Mean vegetative stage temperature (Sept-Aug)/°C	26.4	27.7	27.131	0.486
Mean flowering stage temperature (Sept – Dec)/°C	26.5	27.8	27.206	0.494
Mean yield formation stage temperature (Jan –May)/°C	27.5	29.1	28.332	0.592

The descriptions of variables used in the empirical analysis and their expected effects on net revenues given by the expected sign are summarized in Table 2. The positive sign means that the variable is expected to affect net farm revenues positively and negative sign means otherwise. Socioeconomic characteristics of pineapple farmers have been proven to affect their income and productivity (Abdul Rahman et al., 2005). Past studies identified farm size, age, household size, education level, land type, capital source and extension contact as socioeconomic factors that affected income and productivity of horticultural and small holder pineapple farmers (Moloi, 2008; Serin et al., 2009 and MARDI, 2010).

Table 2: Description of dependent and explanatory variables and their a priori expectations

Variable	Description	Measurement	Expected sign
Farm_Rev	Farmers revenue	Ghana cedis (GHS)	
VS_RR	Mean vegetative stage rainfall (Sept-Aug)	Mm	+/-
FS_RR	Mean flowering stage rainfall (Sept – Dec)	Mm	+/-
YFS_RR	Mean yield formation stage rainfall (Jan – May)	Mm	+/-
VS_Temp	Mean vegetative stage temperature (Sept-Aug)	°C	+/-
FS_Temp	Mean flowering stage temperature (Sept – Dec)	°C	+/-
YFS_Temp	Mean yield formation stage temperature (Jan –May)	°C	+/-
VS_RR_SQ	Mean vegetative stage rainfall squared (Sept-Aug)	mm	+/-
FS_RR_SQ	Mean flowering stage rainfall squared (Sept – Dec)	mm	+/-
YFS_RR_SQ	Mean yield formation stage rainfall squared (Jan –May)	mm	+/-
VS_Temp_SQ	Mean vegetative stage temperature squared (Sept-Aug)	°C	+/-
FS_Temp_SQ	Mean flowering stage temperature squared (Sept – Dec)	°C	+/-
YFS_Temp_SQ	Mean yield formation stage temperature squared (Jan –May)	°C	+/-
Dys_Soil	Dystric Planosols soil	Dummy; Dystric=1, otherwise = 0	+/-
Hap_Soil	Haplic Lixisols soil	Dummy; Haplic=1, otherwise = 0	+/-
Umb_Soil	Umbric Leptosols soil	Dummy; Umbric=1, otherwise = 0	+/-
Age	Age of farmer	Years	+/-
Edu_Farmer	Educational level	Levels	+/-
Train_Type	Type of training received	Dummy; Received =1, otherwise = 0	+
HH_Size	Household size	Number	+/-
Farm_Size	Size of farm	Hectares	+
Credit_Access	Access to credit	Dummy; Yes=1, otherwise = 0	+
FBO_Mem	Farmer based association membership	Dummy; Yes=1, otherwise = 0	+/-
AEA_Access	Access to Agricultural Extension Agent	Dummy; Yes=1, otherwise = 0	+

3.0 Results and Discussions

3.1 Socio-economic characteristics of smallholder pineapple farmers in Ghana

Socioeconomic characteristics and descriptive statistics of the explanatory variables included in the estimation of the Ricardian model are depicted in Table 3. The results revealed that, majority (90%) of pineapple farmers in the study areas are economically active (18 - 60 years) and those 60 years and above constituted only 10 percent. The age distributions of the farmers imply that, on the average, pineapple producers consist of active labour force and the existence of the old and experienced as well as the young in the industry is encouraging, as it would ensure continuity of the business. This implies the aged would transfer their skills and expertise to the young. The farmers generally had attained some level of education. Out of the 400 producers interviewed, only 2.5 percent had no level of education in any form at all whereas 84.2 percent have had some form of basic and secondary education. About 13.3 percent had attained tertiary level of education.

Table 3: Socioeconomic and descriptive statistics of explanatory variables (N=400)

Variable	Frequency	Percentage
Age		
• 18 – 35	124	31.0
• 36 – 60	236	59.0
• > 60	40	10.0
Educational level		
• None	53	13.3
• Basic	80	20.0
• Secondary	257	64.2
• Tertiary	10	2.5
Type of training		
• None	54	13.5
• Formal	284	71.0
• Informal	62	15.5
Access to credit		
• Yes	80	20.0
• No	320	80.0
FBO membership		
• Yes	284	71.0
• No	116	29.0
Access to AEA		
• Yes	309	77.3
• No	91	22.7
Farm value (GHS/ha)		
• < 5000	123	30.8
• 5000 – 10000	193	48.3
• 10001 – 15000	67	16.7
• > 15000	17	4.2
Household size		
• 1 – 3	58	14.5
• 4 – 6	195	48.8
• 7 – 9	115	28.7
• > 9	32	8.0
Farm size (ha)		
• < 1.6	330	82.5
• 1.6 – 4.0	58	14.5
• > 4.0	12	3.0

Consistent with Kleeman et al. (2014) about 71.0 percent of the pineapple farmers in Ghana had informal training on pineapple production activities compared to 13.5% who had formal training and 15.5 with no training at all. Hence it transpires that pineapple farmers are more likely to have learned pineapple farming from friends or family members or as laborers on other farms compared to attending training courses. Kleeman et al. (2014) observed large and long term influence of the person from whom a farmer learned pineapple farming in terms of attitudes toward certain technologies or farming practices. Consequently, this affects farm management practices undertaken by farmers and eventually may contribute to the income of the farmer.

Most (80%) of the pineapple farmers interviewed had no access to credit support for their farming activities. Farmers were however mainly members of a local Farmer Based Organization (71%). Again, majority (77.3%) of the farmers have access to Agricultural Extension Agents (AEAs) contacts. Most (FBOs) are networks which are important for facilitating exchange of information, mutual help and access to credit and influence farmer's economic development (Badu-Gyan, 2015). However, farmer's inability to benefit from this social capital as few had access to credit may be attributed to the level of support one is able to obtain from the association, which clearly is inadequate and ineffective for members. Pineapple production involves high capital investment hence lack of access to credit may constrain farmers' production activities in terms of low input usage as total input costs account for a higher proportion of cost of production and negatively influence their net revenue.

The mean household size is of 6 persons and ranged from a minimum of 1 person to the maximum of 17 per household with majority (48.8%) of household size within the range of 4 to 6 persons per household. Most farming households rely on family members for farming activities (Badu-Gyan, 2015). Hence household size gives an indication of labour availability and consequent reduction of production cost.

The size of land may influence the level of input and output and in effect the productivity and economic returns (Onumah et al. 2014). Asante et al. (2016) also indicated that land sizes operated by smallholder farmers is important in serving as incentive to produce more for the market which may positively influence net income of farmers. However, most of pineapple farm holdings are less than 1.6ha with only a few (3.0%) greater than 4.0ha. Therefore to gain high income and output as well as properly maximize production, pineapple farmers need to optimally manage their production activities. The net farm revenue per hectare varied across pineapple farmers in Ghana mainly ranging between GHS 380 and above GHS 15 000. On average, producers earn about GHS 7 500, which is the amount of average income earned by pineapple farmers after 18 months of production.

3.2 Results from model

Estimates for the relationship between climatic, soil and socioeconomic variables and net farm revenue per hectare across pineapple farmers in Ghana are shown in Table 4. Net revenue of the farmers was significantly affected by climate variables, soil type and other socioeconomic variables. Rainfall for the period that coincides with vegetative stage (September – August) of pineapple production was the only linear climatic variable that positively influenced net revenue. The square term of flowering stage (September – December) temperature was negatively related to net revenue while the square terms of yield formation stage (January – May) temperature was positively related to net revenue indicating a quadratic relationship with temperature. Many of the climate coefficients were however not significant because some climate variables were correlated with each other. The nonlinear relationship between net farm revenue and climatic variables is consistent with a study conducted in Nigeria (Ajetomobi et al., 2010) and other Ricardian studies applied elsewhere (Jain, 2007; Mano and Nhemachena, 2007). The results imply that, the effect of quadratic climate variables on net farm revenues is not determined by looking at the coefficients. The implication from the sign of the quadratic term is whether the relationship with net farm revenue is hill-shaped (temperature affects net revenue positively up to a certain level after which it may negatively affect revenue) or inverse shaped (temperature affects net revenue negatively up to a certain level after which it may positively affect revenue) if the sign is positive or negative respectively. Negative quadratic coefficients for flowering stage temperature imply an inverse quadratic relationship between net revenue and temperature during this stage. As depicted in the results, an increase in flowering stage temperature tend to have adverse effect on farmer's revenue while increasing yield formation stage temperature tend to benefit farm net revenue. Further determination of the marginal effect of climate on net farm revenue is given in the subsequent section.

Table 4: Estimated regression coefficient of net farm revenue per ha.

Variable	Estimated coefficients	t-value	Significance level
Mean veg. stage rainfall (Sept-Aug)	-32.427	-1.930*	0.054
Mean flowering stage rainfall (Sept – Dec)	145.396	1.374	0.170
Mean yield form. stage rainfall (Jan –May)	496.036	1.292	0.197
Mean veg. stage temperature (Sept-Aug)	-7706.735	-1.005	0.197
Mean flowering stage temperature (Sept – Dec)	5043.562	0.882	0.282
Mean yield form. stage temperature (Jan –May)	-1489.293	-1.292	0.197
Mean veg. stage rainfall squared (Sept-Aug)	-2.402	-1.393	0.754
Mean flowering stage rainfall squared (Sept – Dec)	-0.179	-0.314	0.754
Mean yield form. stage rainfall squared (Jan –May)	-3.659	-1.271	0.282
Mean veg. stage temperature squared (Sept-Aug)	316.424	1.078	0.282
Mean flowering stage temperature squared (Sept – Dec)	-251.411	-3.695***	0.007
Mean yield form. stage temperature squared (Jan –May)	206.453	2.683***	0.008
Dystric Haplic soil	407.946	0.415	0.678
Haplic Lixisols soil	-1231.012	-1.670*	0.096
Umbric Leptosols soil	-2235.484	-0.651	0.516
Age of farmer	401.579	0.947	0.344
Educational level	-248.556	-0.960	0.338
Type of training received	319.344	1.310	1.191
Household size	-70.109	-0.725	0.469
Size of farm	174.528	0.870	0.385
Access to credit	1145.004	1.909*	0.057
Farmer based association membership	-1109.287	-1.895*	0.059
Access to Agricultural Extension Agent	756.089	1.218	0.224
Constant		2.487*	0.013
N = 400			
R^2 = 0.272			

The model estimation in addition assumed a linear relationship between net farm revenue and soil as well as socio-economic variables. Ferric Luvisol soil was dropped out of the model due to correlation. The coefficients of the remaining soil types negatively influenced farmer's net revenue except Dystric soil which usually has a positive impact on net revenue. Haplic Lixisols was the only soil type that had a significant relationship with net farm revenue though negative. The implication is that pineapple production on this soil is expected to be low and net returns per unit of land would be limited. This can be explained by the relatively low levels of nutrient resulting in low fertility level for this soil type and for most of the soils identified in the study districts. This shows the importance of improving soil nutrient during production as a useful adaptation strategy to improve net farm revenue in smallholder pineapple farming in the face of changing climatic conditions. The socioeconomic variables that significantly contributed to net farm revenue per hectare for pineapple farming in Ghana were access to credit and membership of FBOs. As expected a priori, the coefficient of access to credit was positive. Membership of an association had a negative impact on farmers' revenue. These findings support the discussion of the descriptive analysis on access to credit and FBO membership carried out in the previous section. The emphasis here therefore is for FBOs to put down strategic plans and measures that gear towards ensuring effective and better organization of farmers to access support as well as total development of its members. This will in effect improve the level of support one is able to obtain including facilitating access to credit and other support services to make significant impact as noted by other studies (Barham and Chitemi 2009; Grischow, 2008; Onumah et al. 2014)

Among the remaining socioeconomic factors considered in the model, as expected, training in pineapple farming and access to extension contact positively contributed to farm net revenue per hectare. The farmers who had access to Agricultural Extension Agents (AEAs) confirmed at least monthly contact, which enhances information sharing among the farmers. Ensuring increased farmer training with frequent contacts with agricultural extension agents is then appropriate for sensitization on the effects of a changing climate on farmer's productivity for strategies to be put in place to minimize adverse impacts and consequently positive output. Farmer's age and farm size also contributed positively to net revenue. The finding for age could be reasons on the age distributions earlier discussed. The result on farm size is also consistent with a study by Hasan et al. (2010) who proved that the relationship between pineapple farm size and income from pineapple was positive hence increasing scale of production would enhance positive economic returns. The results however revealed that, educational level and household size had a negative relationship with net farm revenue. Even though higher education level plays a role in ensuring that best practices are adopted and practiced for improved productivity in farming, pineapple farmers with higher education have secondary occupation and as a result dedicate less time and efforts to this activity which will likely affect ability to ensure effective management practices during production and negatively impact on their net revenue. Household size is important in supplying sufficient farm labour that is considered as an indicator of labour availability (Ouedraogo et al. 2006). Even though pineapple farmers in Ghana have family size mainly ranging between 4 and 9, the farmers interviewed do not generally consider family labour in their production activities but rely on hired labour, which relate to increased cost of production with negative economic implications.

3.3 Marginal impact analysis for net revenue:

The marginal effects of temperature and rainfall changes on the net revenue per hectare of smallholder pineapple farming in Ghana using the model are estimated in Table 5. From the results, the effect of 1°C increase in temperature results in GHS 7890.17 fall in net farm revenue per hectare whereas 1mm increase in rainfall results in GHS 775.77 increase in net farm revenue per hectare in Ghana. This result is important given that smallholder pineapple farming in Ghana is mainly rain fed without irrigation. Increased water will be critical for successful pineapple farming indicating need to consider irrigation for enhanced productivity, which will be beneficial to the smallholder farmers.

Table 5: Marginal effect of temperature and rainfall on net revenue per ha (GHS)

Climate Variables	Vegetative Stage (Sept – Aug)	Flowering Stage (Sept – Dec)	Yield Formation Stage (Jan – May)	Total growing period
Rainfall	405.81	428.23	-58.27	775.77
Temperature	-9463.06	-8636.21	10209.10	-7890.17

The results further show that, higher temperatures during vegetative and flowering stages had negative economic implications for farmers whiles higher temperatures were beneficial during yield formation stage. Conversely, even though the results indicate that increasing rainfall by 1mm has overall positive effects on revenue, increasing rainfall had negative economic implications particularly during yield formation stage. Farmers interviewed reported that, high rainfall during yield formation stage increases maturity and ripening rate resulting in high post-harvest losses and could be the reason for the resultant negative economic effects. It was also reported that, flowering stage is the critical stage in pineapple production process and high temperatures results in ineffective flower induction leading to non-uniform flowering and repeated application consequently increasing production costs and later affecting maturity and marketing. This could be the reason for the negative economic effect. It will therefore be reasonable for farmers to be sensitized on farming techniques and improved adaptation strategies to minimize adverse effects. In addition, it will be relevant for farmers to be provided with improved access to reliable climate information including forecasting to serve as guide to appropriately plan production activities to obtain optimum economic returns.

4.0 Conclusions

The study explored the economic impact of a changing climate on small holder pineapple farming in Ghana by regressing pineapple production net revenue per ha on climate and other control variables such as soil and socio economic characteristics which estimated the relationship between farmer's net farm revenue per hectare and climate. The study established a significant and negative economic effect between rainfall and net revenue during vegetative stage of production. Temperature during flowering and yield formation stages were significant with both negative and positive effect on net revenue respectively. The marginal impact of temperature on revenue showed a fall of GHS 7890.17 per hectare if temperature increases by 1°C and a rise of GHS775.77 per hectare if rainfall increases by 1mm. The findings are indicative of the importance of rainfall in pineapple production in Ghana and calls for the need to consider irrigation as a strategy to supplement pineapple crop water requirement during production and to further adapt to rainfall variability whiles ensuring improved productivity and economic returns. Moreover, it is also critical to consider strategies on adapting to temperature increases to minimize adverse impacts

Among the socio-economic variables identified, access to credit, training and extension contact as well as age and farm size had positive effects on net revenue and are important drivers for pineapple productivity hence the right support of these factors would improve economic returns in pineapple production. Another important factor was soil type on which pineapple is cultivated. The identified soil types and results reflect on the need to improve soil nutrient to provide good medium for production and this can be considered as an adaptation option in the face of changing climatic conditions to support pineapple production. Additionally, given the role pineapple production plays in the Ghanaian economy, supporting, promoting and improving existing adaptation options as well as developing new strategies through further studies to address climate variability and change is recommended for improved productivity and consequently sustain the pineapple industry.

References

Ajetomobi, J.O., Abiodun, A.O. and Hassan, R.A.S.H.I.D., (2010). Economic impact of climate change on irrigated rice agriculture in Nigeria". In *Contributed paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, S. Africa, Sept* (pp. 19-23).

Asante, F.A. and Amuakwa-Mensah, F. (2014). Climate change and variability in Ghana: Stocktaking. *Climate*, *3*(1), pp.78-99

Asante, S. B., Osei-Asare, Y. B., & Kuwornu, J. K. M. (2016). Smallholder Maize Farmers' Food Consumption Expenditures in Ghana: The Mediating Role of Commercialization. *AGRIS on-line Papers in Economics and Informatics*, *8*(3)

Badu-Gyan, F. (2015). *Factors affecting adoption of alternative pineapple production systems in Ghana*. Doctoral dissertation, University of the Free State.

Bartholomew, D. P., Paull, R. E. and Rohrbach, K. G. (2003). *The Pineapple: Botany, Production and Uses*. CABI Publishing UK, pp. 253-274

Carr, M. K. V. (2012). The water relations and irrigation requirements of pineapple (Ananas comosus var. comosus): a review. *Experimental Agriculture*, *48*(04), 488-501.

Danielou, M., and Ravry, C. (2005). *The rise of Ghana's pineapple industry: From successful takeoff to sustainable expansion*. Africa Region Working Paper Series 93, World Bank.

Dorey, E., Fournier, P., Léchaudel, M. and Tixier, P. (2016). Modeling sugar content of pineapple under agro-climatic conditions on Reunion Island. *European Journal of Agronomy*, *73*, pp.64-72

Eid, H. M., El-Marsafawy, S. M., and Ouda, S. A. (2007). *Assessing the economic impacts of climate change on agriculture in Egypt: a Ricardian approach*. World Bank Policy Research Working Paper 4293.

Cranfield, J., Blandon, J., Henson, S., Jaffee, S., and Siegel, P (2008). *Linking African smallholders to high-value markets: Practitioner perspectives on benefits, constraints, and interventions*. Policy Research Working Paper 4573, World Bank.

Howden, S. M., Soussana, J. F., Tubiello, F. N., Chhetri, N., Dunlop, M. and Meinke, H. (2007). *Adapting agriculture to climate change*. Proceedings of the national academy of sciences, 104(50), 19691-19696

ISSER (2015). *The State of the Ghanaian Economy in 2014.* ISSER, University of Ghana, Legon

Jain, S. (2007). *An empirical economic assessment of impacts of climate change on agriculture in Zambia*. World Bank Policy Research Working Paper, (4291)

Kleemann, L., Abdulai, A. and Buss, M. (2014). Certification and access to export markets: Adoption and return on investment of organic-certified pineapple farming in Ghana. *World Development*, *64*, pp.79-92

Mawunya, F.D. and Adiku, S.G.K. (2013). Implications of Climate Change for Agricultural Productivity in

Ghana: An Agrometeorological Perspective. *Ghana Policy Journal*, *5*. November 2013

Mano, R. and Nhemachena, C. (2007). *Assessment of the economic impacts of climate change on agriculture in Zimbabwe: A Ricardian approach*. World Bank Policy Research Working Paper Series

Mendelsohn, R. and Williams, L. (2004). Comparing Forecasts of the Global Impacts of Climate Change. Mitigation and Adaptation Strategies for Global Change, 9: 315-333.

Mendelsohn, R., Nordhaus, W. D. and Shaw, D. (1994). The impact of global warming on agriculture: A Ricardian analysis. *American Economic Review* 84: 753–771.

MoFA (2013) *Pineapple Production Manual*. Export Marketing and Quality Awareness Project (EMQAP), Ministry of Food and Agriculture; ISBN: 978-9988-8562-8-1.

Molua, E. L. and Lambi C. M. (2007). *The economic impact of climate change on agriculture in Cameroon*. World Bank Policy Research Working Paper Series 4364

Mugambwa, E. K. (2014). *Effects of Climatic Variability on Pineapple Growing in Uganda: A Case Study of Pineapple Growers in Kangulumira Sub-county, Kayunga District*. LAP Lambert Academic Publishing, ISBN: 978-8484-8828-5 OmniScriptum GmbH & Co. KG.

Onumah, J.A., Williams, P.A., Quaye, W., Akuffobea, M. and Onumah, E.E. (2014). Smallholder cocoa farmers' access to on/off farm support services and its effect on production. *Asian Journal of Agriculture and Rural Development*, 4(10): 484-495

Ouedraogo, M., Some, L., and Dembele, Y. (2006). Economic impact assessment of climate change on agriculture in Burkina Faso: A Ricardian Approach. *Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria*.

Paull, R.E. and Chen C. C. (2003). *Postharvest physiology, handling and storage of pineapple*. pp 253–279. In: Pineapple: Botany, Production and Uses. Bartholomew, D.P., Paull, R.E., Rohrbach, K.G., (eds.) CABI, Wallingford, UK.

Purseglove J. B. (1988). In: *Tropical Crops, Monocotyledons.* Longman Scientific & Technical. ISBN 0-582-46606-7 pp. 75-91

Sthapit B. R., Rao V. R. and Sthapit S. (2012). *Tropical fruit tree species and climate change*. Biodiversity International, New Delhi. 2012:15-26

Suzuki, A., Jarvis, L. S. and Sexton, R. J. (2011). Partial vertical integration, risk shifting, and product rejection in the high-value export supply chain: The Ghana pineapple sector. *World Development*, *39*(9), pp.1611-1623

United Nations Conference on Trade and Development (UNCTAD) (2008). Private-sector standards and national schemes for good agricultural practices: Implications for exports of fresh fruit and vegetables from sub-Saharan Africa. Experiences of Ghana, Kenya, and Uganda.

Wardy, W., Saalia, F.K., Steiner-Asiedu, M., Budu, A. S. and Sefa-Dedeh, S. (2009). A comparison of some physical, chemical and sensory attributes of three pineapple (Ananas comosus) varieties grown in Ghana. *African Journal of Food Science*, *3*(4), pp.094-099.

World Bank (2008). *World Development Report 2008*. Agriculture for development. Washington, DC: World Bank.