International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Climate Variability Related Impacts on Market Gardening Crop Production in Buea Urban Area, Cameroon: Inquiry and Policy Implications towards Urban Food Security

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Abstract: ***Climatic variability is a significant environmental factor affecting agriculture, particularly market gardening crop production in the Buea Urban Area. To investigate climate variability related impacts on market gardening crop production and propose policy implications, our study corroborates climatic data on scalar quantities (rainfall and temperature) of climatic variability and annual estimated yields in tons of 3 market gardening crops (tomato, pepper and leafy vegetables) for 12 years (2004-2015), complemented by reviewing relevant published sources. Bivariate associations between the two variables were done using the Pearson's Correlation coefficient, verified at a 0.05 level of significance. Microsoft Excel 2016 and Statistical Package for the Social Sciences (SPSS) version 21 were used to analyse the data, presented in graphs and a table. Findings showed that variability in rainfall and temperatures are precursors to the prevalence of insect pests and diseases decreasing market gardening crop production. There was a negative relationship between mean annual temperature and pest and disease effect on all three market gardening crops, though not to the same extent (-0.19, -0.182 and -0.248 respectively). A significant negative associations between rainfall and two of the market gardening crops; pepper (r = -0.622) and leafy vegetables (r = -0.646) was observed, while that of tomato was found to be negative but not statistically significant (r = -0.544). Policy implications of the results warrant the promotion of adaptive strategies such as crop diversification and multi-cropping system and the adoption of technological innovation by the market gardeners through the use of certified seed varieties that are more resistant to climatic variability and insect pests and diseases in order to ensure sustainability of market gardening crop production and long term urban food security.***

Keywords: Climatic variability, rainfall, temperature, insect pests and diseases prevalence, crop production, market gardening, Buea Urban Area, Cameroon

1. Introduction

Agriculture is still a major human economic activity across many areas of the world. As such, it remains indispensable to families or human populations in Africa. It is principally considered as the central economic activity for most of the Sub-Saharan Countries of Africa within which Cameroon is found (Bate, 2018; Bate *et al*., 2019). It remains the backbone of economic development, sustaining livelihoods in the continent in general. The role of agriculture in Cameroon cannot be underestimated as it provides employment, contributes to the gross domestic product, food sufficiency and security and also provides raw materials for agro-based industries. Agriculture incorporates about 70% of the total population in Cameroon and contributes to about 35% of the country's GDP (Molua and Lambi, 2006). Notwithstanding, the effects of climate change remain a major concern for farmers as it destabilizes farmer's livelihoods and their overall wellbeing.

Agriculture in the tropics is considered to be largely rain-fed and as such, tropical farming systems in general and Cameroon in particular have been considered as being vulnerable to the effects of climate change and variability (Molua and Lambi, 2006). Climate change is now a major environmental issue the world over. Simply defined as "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties that persists for an extended period, typically decades or longer" (IPCC, 2007), climate change affects agriculture in different ways. According to the IPCC (2001), global surface temperature is estimated to have increased by 0.6°C since the late 19th Century, with the 1990s being the warmest decade on the instrumental record. Climate change and its associated disasters such as insect pest and disease occurrence are likely to make life even harder for smallholder farmers, who are responsible for the production of the majority of food for subsistence as they provide up to 80 percent of food in Sub Saharan Africa and parts of Asia, manage vast areas of land and makeup the largest share of the developing world's undernourished people.

Agriculture remains indispensable to both men and women and its importance cannot be overemphasized. Molua and Lambi (2006) warned that changes in climate especially those related to seasonal and yearly changes in temperature and precipitation (climate variability) could seriously damage the economy of Cameroon. Agricultural products are considered an absolute necessity of life, with virtually no substitutes. The overall effect of climate change on

agriculture could be positive or negative; the magnitude of impact can also vary from very low to very high, depending on regional or geographical location and status of socio-economic development. Despite the several indigenous adaptation strategies put in place by horticultural and other food crop producers, climate variability has been seen to hit hard on farmers in Buea Urban Area, Cameroon (Sounders *et al*., 2017). There is therefore the need to investigate climate variability related impacts on market gardening crop production and propose policy implications. Attempts to ensure sustainable agricultural production and combat urban food insecurity have often failed because information on climate variability related impact on market gardening crop production is sparse. Existing studies on the subject has mostly dwelled on trying to build a strategy to overcome the psychological barriers to climate change management (Kimengsi *et al*, 2016). The effects of rainfall and temperature oscillations on maize yields in the area have also been examined (Sounders *et al*., 2017). Furthermore, small scale farmers' indigenous agricultural adaptation options in the face of declining or stagnant yields have equally been investigated (Epule and Bryant, 2016).

The main problem of our study stems from the fact that climatic variability have greater potential of adverse impact on agricultural crops in general and market gardening crop production such as tomatoes, pepper and leafy vegetables in particular through the creation of favourable conditions for the growth of insect pest and diseases which attack these crops and reduce the amount of yield received. Climatic variability is therefore epitomised as a limiting factor in market gardening crop production in the Buea Urban Area through the prevalence and increased incidence of insect pests and diseases as a result of increased temperatures and rainfall. For instance, it has been observed that increasing temperatures create favourable conditions for insect pests and diseases to multiply thereby reducing crop yields (Garrett *et al.*, 2013). This is exactly the case with market gardening crop production in the study area due to climatic variability.

This study aimed at investigating climate variability related impacts on market gardening crop production and proposes policy implications in order to ensure sustainability of market gardening crop production and long term urban food security. It sets out to answer the following research questions: (1) What is the extent of rainfall and temperature variability in Buea Urban Area? (2) To what extent does rainfall and temperature variability occasion a decline in tomatoes, pepper and leafy vegetables production? (3) What is the nature of the relationship existing between quantities of tomatoes, pepper and leafy vegetables crop loss and variations in rainfall and temperature between 2004-2015? (4) What policy implications need to be proposed to policy makers in order to ensure sustainability of market gardening crop production and long term urban food security?

2. Materials and Methods

2.1 Study area

This study was conducted in the Buea Uran Area in the South West Region of Cameroon (Fig. 1). Buea is situated at the foot of Mount Fako. It is located between latitude 4°14 north of the Equator and longitude 9°20 east of the Greenwich Meridian (Wanie, 2017). There are two main seasons; the rainy season which runs from Mid-March to Mid-October and dry season from Mid-October to Mid-March. March is the warmest month of the year. The temperature in March averages 19.7°C. In July, the average temperature is 17.3°C. It is the lowest average temperature of the whole year. The average temperatures vary during the year by 2.4 °C. There is a difference of 459mm of precipitation between the driest and wettest months. The driest month is December, with 29mm of rain. Most precipitation falls in August, with an average of 488mm (Climate-data.org, 2019). This climatic situation of Buea greatly favours the cultivation of market gardening crops such as tomatoes, pepper and leafy vegetables in the Buea Urban Area.

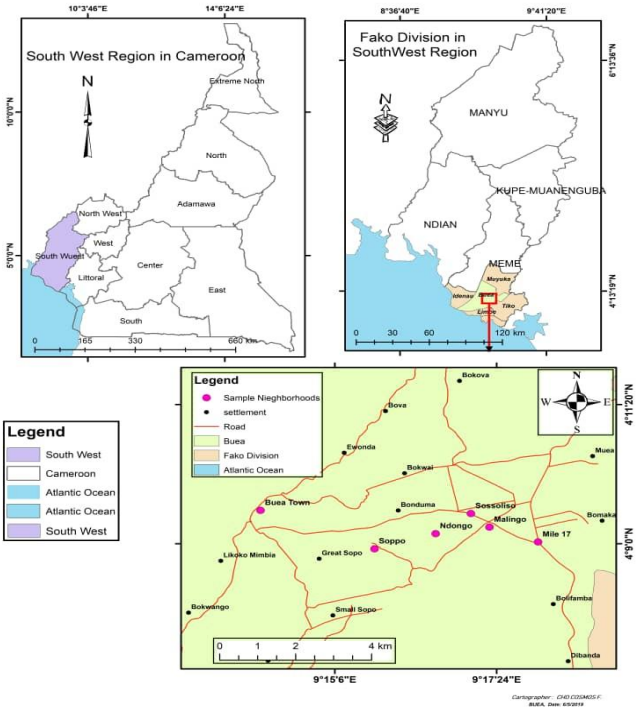


Figure 1: Location of the study area showing the sampled neighbourhoods
Source: Modified from the Administrative Map of Cameroon (1997)

2.2 Data Collection

This study made use of the social science methodology which involves both data collection and analysis. A 12 years (2004-2015) record of climatic data on rainfall and temperature of Buea was collected from the head office of the Cameroon Development Cooperation (CDC) Meteorological Service in Tiko. Alongside, a 12 years (2004-2015) annual estimated quantities or yields of three (3) market gardening crops (tomato, pepper and leafy vegetables in tons) highly affected by pest and diseases were gotten from the Sub Divisional delegation of Agriculture and Rural Development (Buea).

2.3 Data Analysis and presentation

The data collected were analysed using both descriptive and inferential statistics. Descriptive statistics of mean, maximum and minimum were all calculated to represent and express climate situation of Buea. Linear regression analysis was also applied to identify the extent of variability in the climatic elements of rainfall and temperature. We equally employed the Pearson's Correlation coefficient to test for association between variability in the climatic elements of rainfall and temperature and estimated quantities of market gardening crops (tomatoes, pepper and leafy vegetables) affected by pest and diseases and verified at a 0.05 level of significance.

Data was analysed via Microsoft Excel 2016 and Statistical Package for the Social Sciences, (SPSS) version 21. Analysed data on climatic elements and those on market gardening crops affected by insect pest and diseases were presented in the form of graphs and a table.

3. Results

The variability in temperature and rainfall (Figs 2 and 3) are precursors to the prevalence of insect pest and diseases affecting market gardening crops which lead to market gardening crop production loss or decline in Buea Urban Area (Fig. 4).

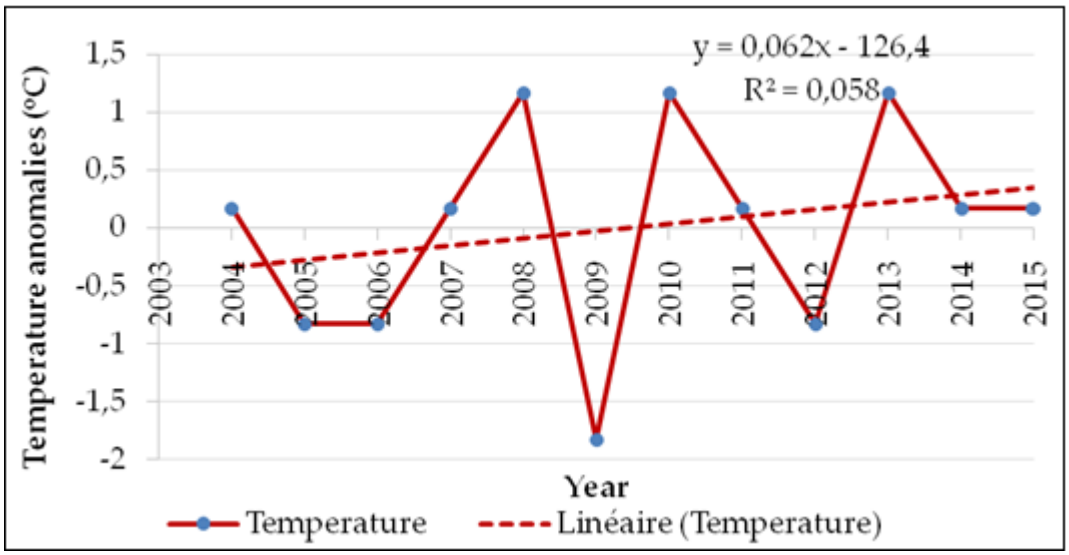


Figure 2: Temperature variability and Trend in Buea (2004-2015)
Source: Analysis based on CDC Meteorological Data, 2019

Figure 2 depicts that annual temperatures over the considered period vary and trend analysis reveals an increasing trend in temperature of 0.0062°C per year in the area.

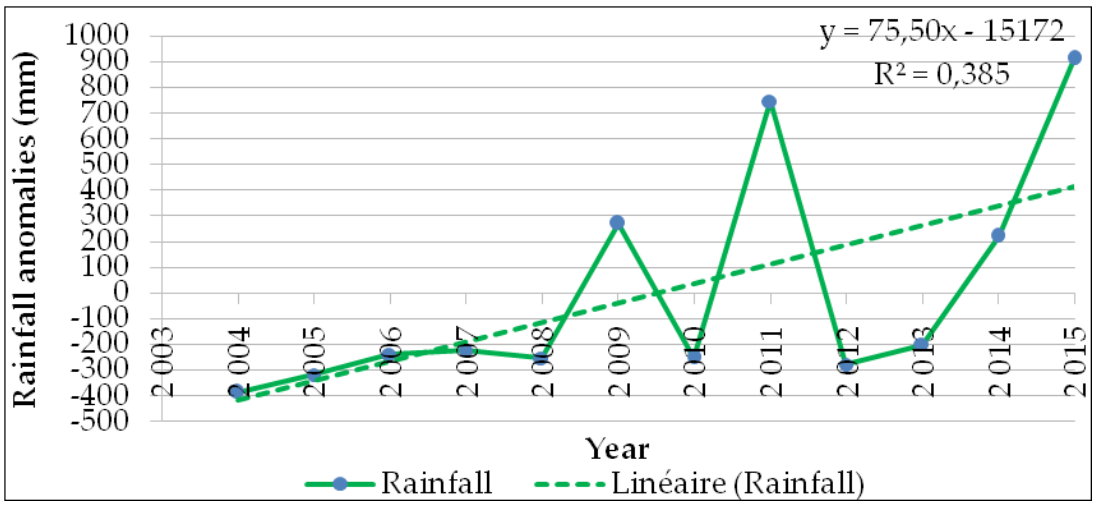
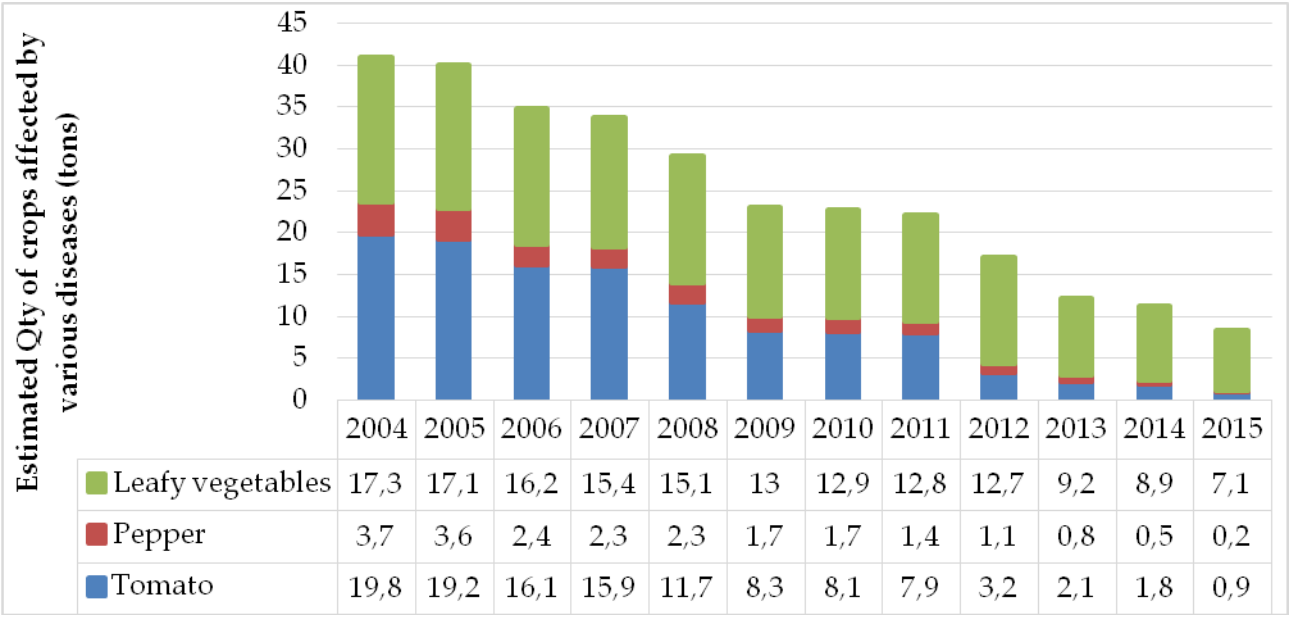


Figure 3: Rainfall variability and Trend in Buea (2004-2015)
Source: Analysis based on CDC Meteorological Data, 2019

Figure 3 reveals that rainfall variability is evident over the years with both negative and positive deviations from the actual mean rainfall of 2302.76mm. This variability is confirmed by the standard deviation value of 438.55mm and a CV value of 19.04%. This indicates fairly high variability in annual rainfall in Buea during the considered period. Trend analysis further reveals an annual rainfall of approximately 75.502mm per year.

The annual quantities of tomatoes, pepper and leafy vegetables (in tons) loss by pest and diseases in Buea Urban Area (2004-2015) is depicted in Table 4.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Leafy vegetables	17,3	17,1	16,2	15,4	15,1	13	12,9	12,8	12,7	9,2	8,9	7,1
Pepper	3,7	3,6	2,4	2,3	2,3	1,7	1,7	1,4	1,1	0,8	0,5	0,2
Tomato	19,8	19,2	16,1	15,9	11,7	8,3	8,1	7,9	3,2	2,1	1,8	0,9

Figure 4: Annual quantities of tomatoes, pepper and leafy vegetables (in tons) loss by pest and diseases in Buea urban Area (2004-2015)
Source: Analysed based on data from Sub Divisional Delegation of Agriculture and Rural Development Buea, 2019

Figure 4 depicts the huge quantities of market gardening crop loss due to related variability in rainfall and temperatures, with higher losses registered in tomatoes and leafy vegetable unlike pepper.

In addition, the Pearson's Correlation Coefficient detected a negative relationship between mean annual temperature and insect pest and disease effect on all three market gardening crops, though not to the same extent (Table 1). For rainfall, results equally indicate significant negative associations with two of the market gardening crops (pepper and leafy vegetables), while that of tomato was found to be negative but not statistically significant (Table 1).

Table 1: Pearson's Correlation Coefficient to estimates the relationship between quantity of market gardening crop loss and variations in climatic elements (2004-2015)

Parameters		Tons of tomato yields affected by pest and diseases	Tons of Pepper yields affected	Tons of leafy vegetable yields affected
Annual mean temperatures (^{o}C)	Pearson Correlation	-.197	-.182	-.248
	Sig. (2-tailed)	.539	.572	.436
	Number of years	12	12	12
Annual rainfall (mm)	Pearson Correlation	-.544	-.622*	-.646*
	Sig. (2-tailed)	.068	.031	.023
	Number of years	12	12	12

*. Correlation is significant at the 0.05 level (2-tailed).
Source: Analysed based on Data from, 2019

Results of Table 1 reveal a negative relationship between annual mean temperatures and quantity of tomatoes, pepper and leafy vegetables loss due to insect pest and diseases for all the three market gardening crops (that is, -0.197, -0.182 and -0.248) respectively. These indicate that as temperatures increase over the years, the quantity or yields of tomato, pepper, and leafy vegetables affected by insect pest and diseases reduces also though not by the same extend.

With respect to annual rainfall and estimated quantities of market gardening crop yield loss due to insect pest and diseases, results reveal significant negative associations between rainfall and two of the market gardening crops of pepper (r = -0.622) and leafy vegetables (r = -0.646) while that of tomato (r = -0.544) was found to be negative but not statistically significant.

4. Discussion

The variability in rainfall and temperature being precursors to the prevalence of insect pest and diseases that leads to the decline in market gardening crop production (tomatoes, pepper and leafy vegetables) observed in our study has been reported previously for food production in Cameroon and beyond the Central African sub-region (Molua and Lambi, 2007). The authors warned that "current climate variation is already altering the types, frequencies, and intensities of crop and livestock pests and diseases". This scenario threatens long term urban food security as natural adversities of climate variability is associated with the invasion of insect pest and crop diseases together with prolonged droughts and floods which all combine to render crops vulnerable (Kimensi and Botanga, 2017; Aryal *et al*., 2019). In Cameroon, insect pests and diseases have been identified as major constraints to vegetable (market gardening) production as they cause both economic and health problems for vegetable farmers (Ellis-Jones *et al*., 2008 cited in Abang *et al*., 2014). Rosenzweig *et al*., (2001) equally hold that with the rising temperature, a range of crop pests and diseases are projected to expand to higher latitudes thereby

worsening the global food security situation. Guodaar (2015) found that pests and diseases influence low tomato yield in the Offinso North District of Ashanti Region (Ghana). More so, Reti's (2007) study reveals that intense rainfall during planting seasons could promote plant pests and diseases. The author further noted that changes in rainfall and temperature could result in the proliferation of new or dormant pest and diseases that could cause considerable damage to agriculture crops and hence food security for the people of Vanuatu, with the study area not left out.

The result indicating a reduction in the quantity or yields of tomato, pepper, and leafy vegetables affected by insect pest and diseases as temperatures increase over the years is consistent with finding by Bindoumou and Edimo (2013) cited in Bate *et al*., (2019) that a 1^{o}C increase in temperature leads to a decrease in net farm income of 2200.20FCFA per hectare. Amawa *et al*., (2015) equally observed a similar trend of a strong negative relationship (-0.730) between temperature increase and tomatoes production and other leafy vegetables like cabbage yields in Santa Subdivision of Cameroon.

Since agriculture in the tropics is largely rain fed, there is the tendency that increased precipitation reduces losses from insect pest and diseases originating from climatic variability. This hypothesis is further supported by our results. Bindoumou and Edimo (2013) cited in Bate *et al*., (2019) have highlighted that a 1mm increase in rainfall leads to an increase in net farm income of 2,322FCFA per hectare. This could hardly occur without a decline in the prevalence of insect pest and diseases. In a similar fashion, Molua and Lambi (2007) highlighted that years of good performance in agriculture in Cameroon are preceded by years of adequate rainfall (e.g. 1969, 1976 and 1995) and the reverse was true for 1973, 1979 and in most of the 1990s.

5. Conclusion and Policy Implications (Recommendations)

This study highlights that climatic variability is a significant environmental factor influencing insect pests and diseases prevalence which adversely affects tropical agriculture, particularly market gardening crop production such as tomatoes, pepper and leafy vegetables by decreasing their productivity or output. From time immemorial, insect pests and diseases have existed but were suited to existing climates before the industrial revolution. After the industrial revolution, increase global temperatures and rainfall patterns have been the order of the day, marked by increased prevalence and new incidence of insect pests and diseases affecting agricultural production. This situation decreases yields or quantities of crops produced and threaten urban food security for the world's bourgeoning urban population. Our study has indicated a negative relationship between mean annual temperature and insect pests and disease impact on three market gardening crops, while a significant negative associations between rainfall and two of the market gardening crops (pepper and leafy vegetables) was observed while that of tomato was found to be negative but not statistically significant.

Based on the above results highlighting the decline in market gardening crop production due to climatic variability related impact on insect pest and diseases, the following policy implications aimed to ensure sustainability of market gardening crop production and long term urban food security are proposed:

1) The promotion of adaptive strategies such as crop diversification and multi-cropping system which are likely to increase the resilience of the market gardening crops to climatic variability and prevent the spread of insect pest and diseases that is often associated with increased temperatures and high rainfall. Crop diversification for instance, improves resilience to climate variability and change by promoting the ability to suppress insect pest and diseases outbreaks.
2) Also, the adoption of technological innovation by all the market gardeners through the use of certified seed varieties that are more resistant to climatic variability and insect pests and diseases that are likely to become prevalent due to more favourable breeding conditions is strongly recommended.
3) Finally, a study of this sort on other subsistence food crop production in the other agro-ecological production basins in Cameroon to determine if climatic variability favours insect pest and diseases prevalence and incidence thereby leading to losses in crop productivity is also encouraged. This is important because for us to benefit from our predominantly rain-fed agriculture widely practiced in the tropics, we must understand and take into account the influence of natural factors such as climatic variability.

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