International Journal of Innovation Scientific Research and Review
Vol. 05, Issue, 07, pp.4901-4907, July 2023
Available online at http://www.journalijisr.com
SJIF Impact Factor 2023: 6.599

ISSN: 2582-6131

Research Article

EVOLVING FARM-LEVEL ADAPTATIONS OF SMALLHOLDER MARKET GARDENING FARMERS TO TEMPERATURE AND RAINFALL VARIABILITY IN BUEA, SOUTH WEST REGION, CAMEROON

[1,*] NKEMASONG Nicasius ANUMVEH, [2]AMINKENG Lucienne FUANYI, [3]INOKOH Biliet ANYIKWO

[1]Lecturer of Geography, Department of Geography, Faculty of Social and Management sciences, University of Buea, Cameroon.
[2]Graduate Teaching Assistant of Geography and PhD Geography Research Fellow, Department of Geography, Faculty of Social and Management sciences, University of Buea, Cameroon.
[3]PhD Geography Research Fellow, Department of Geography, Faculty of Social and Management sciences, University of Buea, Cameroon.

Received 26th May 2023; Accepted 27th June 2023; Published online 30th July 2023

ABSTRACT

Farmer's adaptation either spontaneous or planned, ultimately aims at adjusting and moderating environmental risks such as temperature and rainfall variability. The study sought to explore the evolving farm-level adaptations of smallholder market gardening farmers to temperature and rainfall variability in Buea. Using a mixed research design, the study obtained primary data from 200 sampled farm household heads across four communities (Bomaka, Bokova, Molyko and Lower Farms) in Buea Municipality to supplement direct field observations and measurements. The survey results revealed that market gardening farmers have observed significant debilitating impacts of temperature and rainfall variability on their activity with implications being food insecurity risks, reduction in farm incomes and general livelihood disruptions. The survey revealed that market gardening farmers' adaptation strategies are evolving through an integration of modern and local knowledge such as the use of irrigation, organic manure, agro-chemical application and planting of resilient varieties. Findings highlight some constrains to adaptations being poor farm to market roads, financial constraints, inadequate knowledge/information about occurrences of extreme climate conditions, inadequate water for irrigation during the dry season and inflexible land tenure systems. The study suggested subsidisation of farm inputs and provision of timely information to farmers as per the climate conditions via extension services or other accessible means of communication.

Keywords: Smallholder Farmers, Market gardening, Adaptations, Temperature and Rainfall Variability, Buea.

INTRODUCTION

This gives the context of the study by bringing out a brief survey of related empirical literature and the location of the study area.

Survey of Literature

Globally, smallholder farmers is recognised as being highly vulnerable to climate variability (temperature and rainfall) and change, particularly sub-Saharan Africa where adaptations are handicapped by inadequate adaptation options or means (Serdeczny *et al.,* 2017; Stuch *et al*., 2021; Intergovernmental Panel on Climate Change-IPCC, 2014 and 2022). Climate is a dynamic phenomenon that has been changing continually since the evolution of the earth's history. However, recent rapid and extensive changes are too extreme to be dismissed as "normal", and have been shown to be closely correlated to changes in atmospheric carbon as a result of human activities (IPCC, 2014). Hence, one of the biggest environmental challenges that is bedevilling mankind in this 21st Century is the changing climate across the globe. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has given a strong indication to the impact that, the changing climate is unequivocal and unprecedented since the mid- 20th Century (IPCC, 2014). Rainfall and temperature variability is affecting all dimensions of food security with market gardening not excluded (availability, accessibility, utilisation and stability) among households (Food and Agriculture Organisation-FAO, 2016). As a result of year-to year variability of climatic variables, crop yield of small-holder farmers are questionable with implications being food insecurity and poverty (Ogundari and Onyeaghal, 2021). Variations in climate parameters noticeably rising temperatures, and declining rainfall (amounts and intensity) have intensified in recent years leading to increased pre and post-harvest yield losses, disruption of small holders livelihoods and general food insufficiency (Wood *et al.,* 2021). Given the impacts of climate variability (temperatures and rainfall on market gardening productions of small holders farmers, adaptation strategies are becoming increasingly important remedy the caprices and improve their livelihoods options (IPCC, 2022; Moser and Ekstrom, 2010).

This situation is acute in Sub-saharan Africa which over the years has on continuous bases be exposed to climate variability and deleterious consequences such as some small holder farmers been unable to have sufficient means of livelihoods especially those who sorely depends on market gardening farming for subsistence (Kotir, 2011). Molua and Lambi, (2006); Kimengsi and Muluh, (2013) showed that, the climate of Cameroon has become more variable over the years and that their impacts are astronomical. According to Sofoluwe *et al.,* (2013) cited in Owombo *et al*., (2014), climate variability is the most important limiting factor to agricultural production that can cause serious threat to the sustainability of food production. The ultimate aim of adaptations either autonomous or planned (changing planning dates, mulching, planting drought resistant varieties, crop diversification, changing farm locations and mixed cropping and irrigations) is to adjust to prevailing environmental conditions and or take advantage of it (IPCC, 2014, Baloch *et al.,* 2022; Thornton and Herrero, 2015). With the passage of time and considering the impact of temperatures and rainfall variability, smallholders market gardening farmers are beginning to change or modify their adaptation measures to suit the prevailing environmental conditions or to take advantage of certain conditions for their benefits such as irrigation methods during the dry seasons, use of organic manure in farms and agro forestry and creation of cooperatives to solicit more loan facilities. These

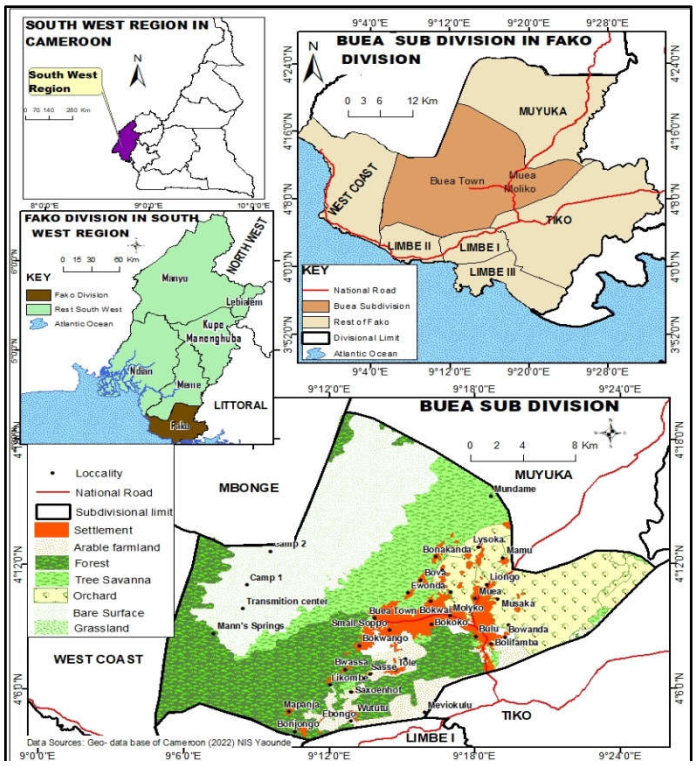
***Corresponding Author: NKEMASONG Nicasius ANUMVEH,**
1Lecturer of Geography, Department of Geography, Faculty of Social and Management sciences, University of Buea, Cameroon.

adaptations are important but can be inhibited by factors such as age, income barriers to purchase farm inputs and credit barriers, individual perceptions, land tenure, inadequate technological knowledge, inadequate/lack of water resources and implications of extreme climatic occurrences (Guodaar and Asante, 2018; Ndamani and Watanabe, 2015) thus, exposing small market gardening holders. Even though myriad of studies exist on the impact of climate variability of market gardening (Mary and Majule (2009), Bryan *et al;* (2010), Hassan and Nchemachea (2008), Tshiala and Olwoch (2010), Mccarthy *et al.,* (2011), Ambang *et al.,* (2014), Bagamba *et al.,* (2012), Fontem *et al.,* (2004); Landston and Faker (2009); Aniah *et al.,* 2019; AntwiAgyei *et al.,* 2018; Armah *et al.,* 2013; Codjoe *et al.,* 2014; Codjoe and Owusu, 2011; Etwire *et al.,* 2013; Owusu *et al.,* 2019; Williams *et al.,* 2017; Wossen and Berger, 2015) studied climate variability and adaptation as well as the determinant but did not take into consideration other farm management strategies such as proper farm sanitation (uproot infected plants and destroy by burning or deep burying in the soil, respect planting distances, stake tomato, use scale crew, timely spray of fungicides and insecticides and preserved cuttings of cassava in a shade especially in the wet season). To this end, this study is framed to update the literature on climate change adaptations especially in Cameroon. The study first highlights trends in temperatures and rainfall variability over Buea, smallholder farmers' observations of temperature and rainfall variability over Buea, adaptations and constrains and then proffer recommendations.

Study Area

Buea Municipality is located between Latitude 4° 2'40"N and Latitude 4° 18'0" North of the Equator and between Longitude 9° 12'21" E and Longitude 9° 19'42" East of the Greenwich Meridian as shown in Figure 1. It is bounded to the west by Mount Cameroon with height of 4095m above sea level, to the east by Tiko Sub-division, to the north by Muyuka Sub-Division and to the south by Limbe. Buea has a surface area of 870km^2 and it is about 896m above sea level. Map 1 shows the location of the study area.

Map 1: Location of Buea Municipality



Source: NIS Yaounde data base 2022

The climate of Buea Subdivision is of the tropical monsoon type and characterized by two main seasons; the wet season with heavy rains (mid-March-October) and the dry season (November to mid- March). The rainy season is characterized by changeable weather with storms and high rainfall variability from mid- March to June and steady rains from mid- June to September. The changing weather with storms and squalls from October to November marks the transition period between the rainy and dry season. Buea Sub Division records high rainfall amount with an annual total of over 3500 mm, distributed evenly almost throughout the year (Balgah, 2005).

MATERIAL AND METHODS

This study adopted the mixed research design as it combined both qualitative and qualitative research approached. Primary data were gotten from the field via observations, and research instruments as questionnaires, interview and focus group discussions guides while secondary data were climatic information obtained from NASA websites and other published works from libraries and online journals and articles which aided review of literature and discussions. To ensure validity and reliability of conclusions from the sample, the study area was stratified into four key market gardening zones of Bokwango, Great Soppo, Molyko and Muea. Their choice as study matrix was motivated by the fact that market gardening is extensively practice within these communities. The target population considered in the study was the total population of each zone since all residents are impacted by market gardening activities either directly as farmers or indirectly as consumers. These are shown on Table 1.

Table 1: Sample Population from Communities

	Questionnaires Distribution			Interviewed Farmers	
Communities	Target Population	% of total population	Sampled Population	% of sampled population	Total
Bokwango	7,635	11.2	35	10	2
Great Soppo	19,355	28.4	100	28.6	8
Molyko	13,831	20.3	65	18.6	5
Muea	27,329	40.1	150	42.9	15
Total	68,150	100	350	100	30

Source: Extracted from population Statistic (2005) and updated from Buea Council Database

From these strata, a total of 350 market gardeners were randomly selected in a proportionate manner as the sampled population for the study, so as to avoid representation bias. The Muea Area was given more respondents because of the intensity of the activity in the area while Molyko and Bokwango were given less as they are more of consuming zones than gardeners. The research therefore employed the stratified random sampling technique.

The structured questionnaires designed on a four point Likert Scale assessed the perception of the market gardeners on climate variability trends and the impacts on their farming activities. Through focused group discussions climate variability adaptation (coping) strategies were analysed. A total of 30 market gardeners were purposively selected as Interviewees. 12 of them were interviewed individually because of their longstanding experience in market gardening for more than 10 years and while others were engaged in focused group discussions. These sources gave more in-depth information the market gardening activities and also direct farm experience accounting. Field visits for direct observations and measurements for change detection in market gardening activities were made during the wet and dry season to ascertain seasonal

disparities market gardening adaptation measures. These were captured by use of the digital cameras. Climate data from NASA data were analysed to establish the trends in rainfall and temperature as well as their anomalies over the study area.

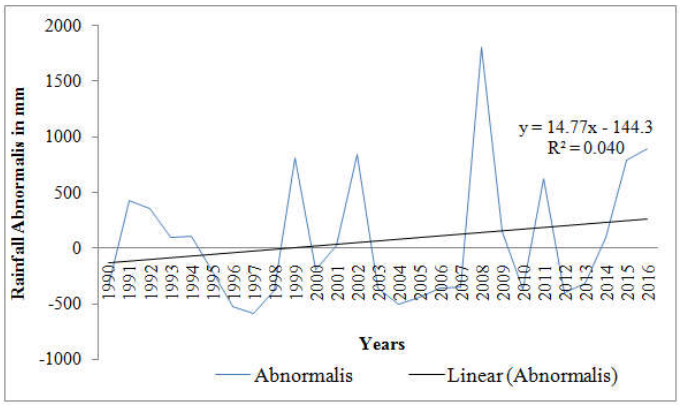
The collected data were analysed quantitatively using SPSS software package and Microsoft excels for trend analysis and anomalies. The analysed data were presented in the form of tables and figures.

RESULTS AND DISCUSSION

Analysis of rainfall and temperature Variability over Buea Sub-Division

Generally, the larger the value of the standard deviation in relation to the mean, the greater the degree of variations. As such, it expresses the relationship between standard deviation and the mean value of climatic elements. Given an annual assumed threshold value of 25% and the calculated CV of 6.38% with annual mean rainfall of 2425.68mm rainfall is highly reliable for market gardening cultivation in Buea but with little variations. Figure 1 shows the rainfall trends and anomalies over Buea Subdivision between the year 1990 and 2016.

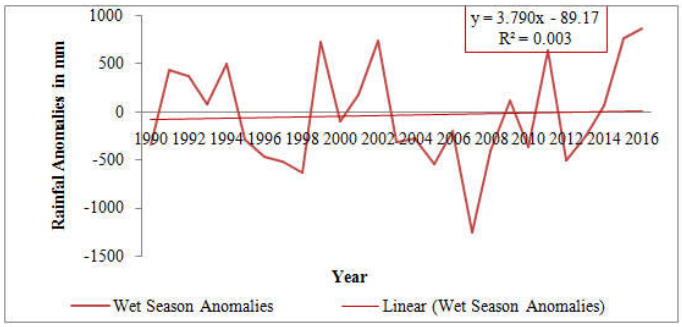
Figure.1: Rainfall Anomaly in Buea Sub -Division

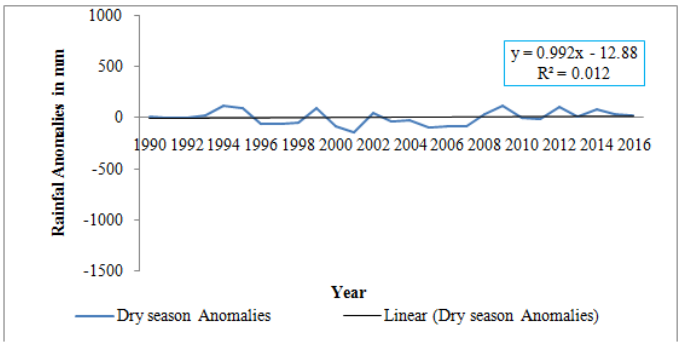


Source: Plotted with rainfall data extracted from NASA Database (2022)

It was observed that between the year 1990 and 1999, rainfall was below the mean (2425.68mm) while from the year 2000 till 2016, rainfall is above the mean. From the linear regression equation, it shows that rainfall is increasing by 14.771mm per annum. Despite fluctuation in rainfall over the years, rainfall trend indicates and increasing trend. From the data obtained, variability of rainfall was compared between seasons in Buea Sub Division and the standard deviation expressed as a percentage of the mean. Variability above 25% violates the assumption of wet and dry season variability in Buea. The standard deviation is 442.85 and the Coefficient of Variation (CV%) is 20.46 with a mean value of 2164.98. The wet season CV is (20.46%) showing a high value of reliability of rainfall for food crop cultivation in Buea Sub-division, given that it is below the threshold limit of 25% with a wet season mean of 2164.98mm. For dry season rainfall variability for Buea Sub-division between1990 - 2016, the mean was 251.63mm with a mean deviation (σ^2) of 5251.05, and a standard deviation (σ) of 72.46, with a coefficient of variation (CV %) of 28.79 respectively. It shows that rainfall cannot solely be relied upon during the dry season for food crop cultivation as the CV (28.79) is above the threshold value of 25%. This suggests that supplementary measures have to be put in place to augment rainfall during the dry season for food crop production in Buea Sub-division. This explains why some tomato and maize farmers resort in irrigation especially along stream valleys for their tomato production. Figure 2 shows seasonal rainfall trend and abnormally in Buea.

Figure 2: Seasonal rainfall anomaly in Buea Sub-Division
Left➔ Wet, Right ➔Dry

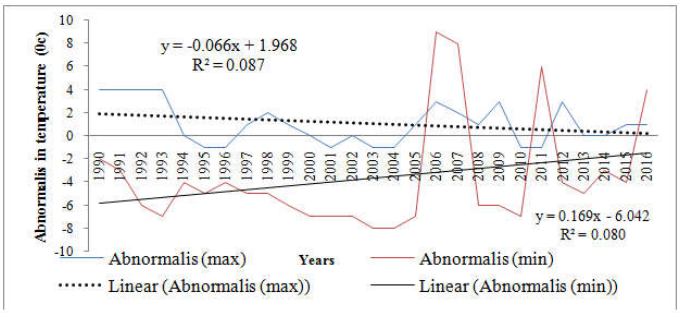




Source: Plotted with rainfall data extracted from NASA Database (2022))

As seen on Figure 2, the trend in wet season rainfall is increasing though with a lot of fluctuation. The year 2016 witnessed wet season rainfall surplus of 869.8mm above the mean while the year 2007 witnessed a deficit of -1255.9mm of rainfall below the mean in the wet season. Wet season rainfall is increasing by 3.709mm per year and 0.9927mm per year for dry season rainfall. For dry season rainfall, the year 2009 witnessed a surplus of 118.2mm while the year 2001 witnessed a deficit of -149mm of rainfall above and below the mean rainfall respectively. However, observations shows that there is a gradual shift of the conventional wet season period into the dry season making the dry season more wetter than before and the rainy season less wetter. Figure 3 presents temperature trends over Buea.

Figure 3: Temperature Variability in Buea Subdivision

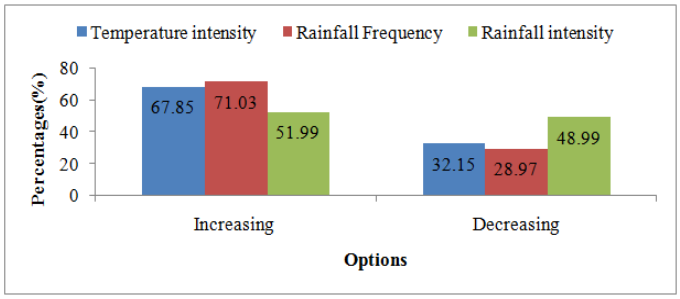


Source: Plotted with temperature data extracted from NASA Database (2022)

Maximum temperature increases by 0.1^{0}C and 0.2^{0}C for minimum temperature per year with sharp decrease in the minimum temperature from 1990 -1993 and thereafter, increases in 1994 and 1995 and falls again in 1996 and keeps fluctuating till 2016 when it became stable in an increasing rate till date. The trend equation and the trend line of the mean minimum temperature generally show an increasing trend which means that the average minimum temperature over the years (1990-2016) has been raising. A plethora of studies have been undertaken concerning the climatic conditions over Buea Sub-Division and amongst these litanies of literature is (Nkemasong,

2014; Balgah *et al.,* 2017). Farmer's perception of rainfall and temperature Variability is presented on Figure 4.

Figure 4: Respondents Observations of Climate Variability



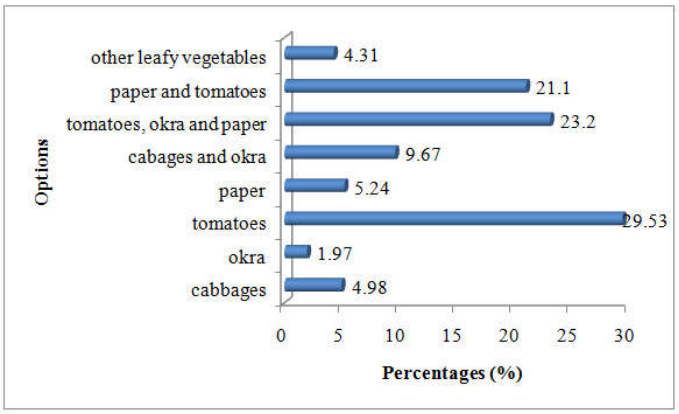
Source: Fieldwork, 2023

As indicated on the column graph, an overwhelming majority of respondents (67.85%) opined that temperature intensity over Buea are increasing. Also, 71.03% of respondents indicated in the affirmative that rainfall frequencies have increase and 51.99% equally indicated an increase in rainfall intensity over Buea.

Small Holders Market Gardening Farmers Adaptations and Constrains

Small holders cultivate varieties of market gardening crops in Buea ranging from the principal crop which is tomatoes, to cabbages (Figure 5).

Figure 4: Types of Market Gardening Crops Cultivated by Small Holders in Buea



Source: Field Observations and Analysis of questionnaires (2023)

As indicated on Figure 4, the major market gardening crop cultivated by small holders in Buea is tomato with an overwhelming affirmation of 29.53%. Also, most small holders cultivate tomatoes, okra and paper as indicated by 32.2% of the population, paper and tomatoes was affirmed by 21.1% while the least market gardening crop cultivated without mix cropping was okra accounted for by 1.97% of the respondents. The practice of mixed cropping method of adaptation is in line with the study of May and Majule (2009) in their study of climate variability and adaptation strategies in semi-arid areas of Tanzania revealed that crop diversification through mixed cropping could better reduce the impact of climate variability on food crop production. The practice of mixed cropping according to some farmers was aimed at spreading risk and to increase farmer's income. The need for adaptation measures is because the crops are impacted by temperature and rainfall variability. Some of the impact identified on the field included early and late blight, wilting for tomatoes, decaying stems for cabbages, stem borer for okra and the destruction of paper by rodents. Plate 1 shows a market gardening farm and climate variability impact in a key market gardening crop (tomatoes) Buea.

Plate 1: Market Gardening Farm
Mix-cropping (A), Fruit rots, early and late blight (B and C)

Source: Fieldwork, 2023

As indicated on Plate 1, market gardening farmers are faced with several challenges which prompted adaptation measures to remedy these issues. To understand the adaptive decisions of small scale farmers in Buea, we assessed the effects of rainfall and temperature variations on their livelihood as presented on Table2.

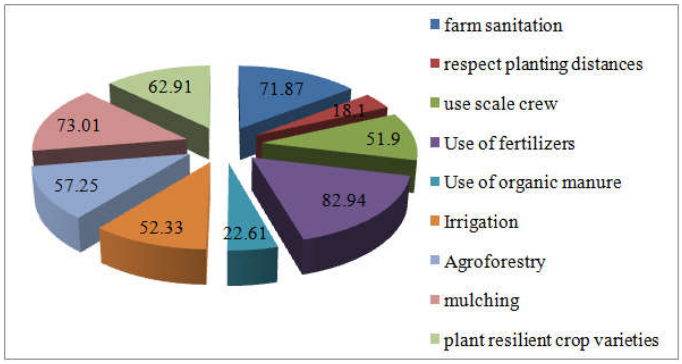
Table 2: Effects of Rainfall and Temperature Variability on Farmer's Livelihood

Effects	Mean	Standard Deviation
Increase farm expenditure to purchase inputs	3.01	1.314
Reduce yields (food insecurity)	3.03	1.250
Disrupting of cropping Calendar	2.61	1.134
Reduce income	2.71	1.127

Source: Analysis of questionnaires (2023)

From Table 2, using a four point likert scale, an overwhelming majority of farmers with a mean score of 3.03 on the scale of 4, strongly agreed that rainfall and temperature variability leads to food insecurity, followed by increased expenditures to purchase farm inputs with a mean score of 3.01. Temperature and rainfall variability also affect farmers' incomes and disrupt cropping calendar wit mean values of 2.71 and 2061 respectively. These effects provided an opportunity for small scale market gardening farmers to unlock their adaptation actions in order to minimize yield loss and improve their livelihoods as was indicated by Michetti and Ghinoi, (2020). Figure 5 presents small scale farmers adaptation measures in Buea.

Figure 5: Adaptations to Temperature and Rainfall Variability



Source: Field Observations and Analysis of questionnaires (2023)

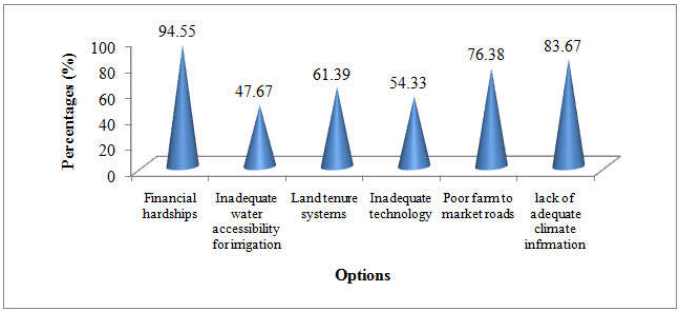
Small holders furnished diverse opinions as to their adaptation strategies as seen on the pie-chart. An overwhelming majority (82.94%) opined that in the wake of variability of rainfall intensity and frequency, they apply fertilizers aimed at augmenting soil fertility and enhancing higher yields of their market gardening crops such as tomatoes, okra, and leafy vegetables. Equally, 73.01% and 71.87% indicated that they have integrated mulching and agro-forestry into their farming practices so conserve soil water, enhance soil fertility, reduce soil erosion and equally serves as modifier of local climates (Armah *et al.,* 2013). With regards to irrigation as an adaptation measure, 52.33% indicated in the affirmative that they use irrigation methods especially in the dry season so as to augment water availability for crops and enhance higher yields for seasonal crops like tomatoes and maize. However, a meager 22.61% equally affirmed that considering the benefit of organic products to human health and the implications of consuming fertilizer rich food, they have resorted to using organic products like caw and poultry dung in their farms (Baloch *et al.,* 2022; Guodaar *et al.,* 2021b). Plate 2, shows the application of chemicals as an adaptation measure in the study area.

Plate 2: Use of Fertilizer on Farms as an adaptation measure

Source: Field Observations and recordings, 2023

The most used mineral fertilizers were NPK 20,10,10, NPK 12,14,19, Yara active 23:10:5 and Yara complex 12:14:18 and most farmers applied approximately a beer cork per plant or use the fertilizer to nurse the seeds on beds. Fertilizer application was highly influenced by seasons as much of it was applied during the rainy season due to frequent leaching of the fertilizer by rains. Farmers reported an increased damage during the rainy season when pest populations are higher coupled with increasing rainfall intensity that warrants that multiple spraying or application of fertilizers be done. Farmers' perceived that, the insect pests had economic implications, given that the insects caused significant damage that warranted the implementation of control measures which some time are beyond the reach of farmers. These small holders' adaptations were however constraint due to certain factors as presented on the cone diagram (Figure 6).

Figure 6: Constraints to Small Holders Market Gardening Farmers Adaptations



Source: Analysis of questionnaires (2023)

From Figure 6, the principal inhibiting factor for adaptations to rainfall and temperature variability by small holder's market gardening farmers in Buea is the issue of finance as indicated by an overwhelming 94.55%. Financial hardship hindered farm management practices such as purchasing farm input such as fertilizers, manure, irrigation facilities amongst others (Calzadilla *et al.,* 2013). This was seconded by lack of adequate climate information (83.67%). Adequate climate information are a prerequisite to ensuring proper and sustainable adaptation options by farmers and equally by poor farm to market roads (76.38%) and land tenure systems (61.39%). The fragmentation of farms due to the land tenure systems operating in Buea was a significant hindrance to adaptation to rainfall and temperature variability in Buea. Many small holders had fragmented farms which constrained the use of farm machineries to further improved production. Land tenure systems was equally observed via the rent age of farms by small holders on seasonal and annual bases which in situation of poor yield resulting from climate variations further constraint their adaptations (Antwi-Agyei *et al.,* 2015). A 57 year old farmer with 14 years experienced in tomato production indicated that and we quote;

> "Previously, I use to cultivate tomatoes on this my piece of land but for some years now, my yield has not been as I used to generate one of the reasons being that predicting when to plant or not is becoming so difficult for me. I often use indigenous means to predict planting calendar but it is no longer effective. So I decided to plant cassava, cocoyam alongside with maize and tomatoes so that if one fails I will recover my expenditure from the other and also get enough to feed my family"

CONCLUSION

Small holders market gardening farmers in Buea implements myriad of adaptation interventions and strategies are implemented by to mitigate the impacts of temperature and rainfall variability but are equally handicapped by several constrains which reduces the effectiveness of their adaptation measures. This study found out that temperatures and rainfall variability are increasing at a fluctuating rate posing severe impacts to market gardening production by small holder farmers in Buea. And in order to revamp their outputs and increase livelihoods, farmers apply fertilizers, mulch crop, practice agro forestry and irrigation measure. However these adaptations are handicapped due to financial hardships, lack of timely information of temperature and rainfall variability and land tenure systems. Based on these conclusions of the major findings of the study, we

recommend the provision of subsidization of farm inputs by the competent stakeholders, continuous sensitization of farmers by the agricultural extension officers to develop a better understanding of the implications of the intensities/frequencies of climatic events such extensive education can also help build farmers adaptive capacity.

CONCLUSION

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ACKNOWLEDGEMENTS

I wish to thank the co-authors of this article for their collaboration in accompanying me in sourcing data from the field and also the market gardening farmers who voluntarily gave information either as questionnaire respondents, interviewees or as panellists in the focused group discussions. The authors are collectively grateful to the authors of source materials they consulted and cited in several parts of this article.

COMPETING INTERESTS

I, NKEMASONG Nicasius ANUMVEH, the lead and corresponding author declare on our collective honour that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Authors 1 and 2 conceptualised the work and designed the research instruments and drilled author 3 on how to proceed with the administering of the questionnaires. Author 3 drafted the first manuscripts into a long essay which was restructured into article format by author 2. Author 1 then finalised the article by editing, proof-reading it and more importantly streamlining it with the template of International journal of innovation scientific research and review (IJISR).

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