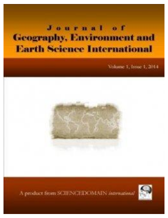

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Crop-Specific Response to Climatic Variability and Agricultural Planning Implications in North West Cameroon

Jude Ndzifon Kimengsi[1*] and Andin Quinter Botanga[2]

[1]Department of Geography and Environmental Studies, Catholic University of Cameroon (CATUC), P.O.Box 782, Bamenda, Cameroon.
[2]Department of Geography and Planning, University of Bamenda, P.O.Box 39 Bambili, Cameroon.

Authors' contributions

This work was carried out in collaboration between both authors. Author JNK designed the study, wrote the first draft of the manuscript and made final corrections for the paper. Author AQB coordinated field data collection, managed the literature searches and data analysis. Both authors read and approved the final manuscript.

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ABSTRACT

The discourse on climate variability has gained prominence over the years, considering the crucial role climate plays in the development of the human society. This perhaps led to the proposition of the United Nations Sustainable Development Goal 13 which stresses on the need to take urgent action to combat climate change and its impacts. Unarguably, one of the most affected sectors in this dispensation is the agricultural sector. Crop production in Sub Saharan Africa is predominantly rain-fed and climate variability through fluctuations in rainfall and temperature pose a significant threat to the sustainability of this sector. Although a climatic regime is broadly established for the Western Highland agro-ecological system of Cameroon, specific local peculiarities are necessary to be understood especially in Bali which fairly lies within a transitional zone between the grassfield

**Corresponding author: E-mail: jude.kimengsi@catuc.org;*

and the coastal forest zones of Cameroon. In the context of Bali, knowledge gaps exist with respect to crop-specific response to climate variability. An understanding of the crops-specific responses and their agricultural planning implications is necessary. In this paper, we employed an exploratory approach to examine crop-specific responses to climate variability and their implications for agricultural planning. We used the Pearson's correlation analysis to correlate climatic records (temperature and rainfall) for 25 years (1991-2015) with the output of specific food crops (maize, beans, cassava and cocoyam). We equally underscore the climatic thresholds for the target crops in a bid to understand the deviations thereof. Our analysis led to the conclusion that with a 1% margin of error, both positive and negative correlations exist between crops and the varying climatic elements. By implication, farmers could invest more in the production of more climate tolerant crops in the face of projected increase in temperature.

Keywords: Climate variability; crop response; Bali; agricultural planning.

1. INTRODUCTION

Concerns about long and short term climatic variations are not new in geo-environmental literature. Changes in climatic characteristics over time and space are often associated with climatic extremes such as drought and floods which have varying seasonal and annual patterns [1,2]. Half of the world's population is engaged in agriculture which is highly susceptible to the impacts of climate variability, associated with seasonal, short and long term fluctuations. Natural variations are said to be influenced by drivers such as the El Nino, La Nina, solar output, volcanic eruption and sunspots [3]. Apart from natural occurrences, human activities through deforestation and agricultural intensification practices are on the rise and they equally contribute to fluctuations in climatic elements [3,4,5,6]. Increasing temperatures and inter-annual fluctuations in rainfall amounts in Sub-saharan Africa are indicators of climate variability and change. This is often associated with a high dependence of agriculture on climate variability indicators such as irrigation and the intensification of fertilizer intake [7,8]. Farming systems in general and crop production particularly in Sub Saharan Africa including Cameroon are exposed to droughts and floods [9,10]. Irrigation is therefore an important factor which enhances crop yield and growth [11] thereby reducing the rate of crop exposure to the caprices of weather which are evident through varying temperatures and rainfall.

The effects of climate variability are felt both in developed and developing countries at uneven frequencies and magnitudes, making it a global concern. Current temperatures may serve as an indicator for the sensitivity of agriculture to climate variability, given the fact that additional and prolonged warming has negative effects on all economic sectors. This situation has been noticed particularly in the aspects of rain-fed agriculture which accounts for about 95% of total agricultural production [3]. Climate directly influences the spatial distribution of crop types and agricultural systems. Different crops require different amounts of water, warmth, humidity and sunshine which becomes detrimental to cultivate specific crops under certain climatic limits [11,12]. For instance, cropping and crop yields require specific temperature and rainfall thresholds for high yields to be attained. Threshold temperatures vary with crops and higher temperatures during grain-filling becomes detrimental [11,12]. Cameroon has a huge potential for agricultural activities enhanced by distinct climatic regions which are the tropical (Sahel and Sudan/humid climates) and equatorial (the Cameroon and Guinea type) climates. The availability of arable land suitable for ploughing and agro-ecological conditions favour the production of diverse species of crops. Despite all these, the country still imports at least a quarter of its cereal requirements to meet the growing food demands of its population. Natural adversities of climate variability associated with conditions of prolonged droughts and floods combined with the invasion of pest and crop diseases render crops vulnerable. These glaring adversities of climate variability are real in the country in general and with particular cases in the Savanna zone, associated with the Cameroon type climate (Western Highlands) and the Sahel zone/climate [9,10,13]. Bali, just like any other rural area in the Western Highlands has a greater proportion of its population engaged in agricultural activities. Apart from the natural/traditional cash crops (coffee and palm) systems which have been explored in Bali, other crops which are commercialized and also serves as a source of livelihood have not been sufficiently studied especially in the context of crop-specific response to climate variability. It is imperative to understand such micro-level peculiarities. The objective of this paper is to employ an exploratory approach to examine crop-specific responses to climate variability and their implications for agricultural planning. In this regard, the paper makes use of the Pearson's correlation analysis to correlate climatic records (temperature and rainfall) for 25 years (1991-2015) with the output of specific food crops (maize, beans, cassava and cocoyam).

2. THE PROBLEM

Long and short term climatic variations has the potential to exacerbate existing threats to crop production, food security and impose constrains to rural development particularly amongst farmers whose livelihood depends on rain-fed agriculture [3,9,14]. Agriculture forms the base of economic progress in Sub Saharan Africa. Yet, the issue of hunger, malnutrition and food insecurity still prevails within regions and countries. Some of the Sustainable Development Goals focus on tackling the effects of climate variability on crop production. For these to be achieved, research efforts are needed to provide information at all levels. Climate variability has raised much scientific attention especially in the agricultural sector. For instance, the works of [15] in Cameroon, [13] in North Cameron, [9] in the Western Highlands of Cameroon, [16] on the CDC crops, [17] on cocoa production, [4] on market gardening and [18] in the North District of Ashanti region are eloquent examples. Although a climatic regime is broadly established for the Western Highland agro-ecological system, specific local peculiarities are necessary to be understood especially in Bali which lies within a transitional zone between the grassland and the forest region of the country. In the context of Bali, knowledge gaps exist with respect to crop-specific response to climate variability. An understanding of the crops-specific responses and their agricultural planning implications is necessary.

3. LITERATURE REVIEW

Climate variability, crops and cropping systems do relate. This can assume a positive or a negative relationship depending on the crop types [4,15,18]. Climate variability in terms of magnitude and frequency varies within and between places. For instance, [4] established the role of seasonal, annual temperature and rainfall variability on tomatoes, lettuce and green beans in Santa. The role of these climatic elements is evident as it determines germination, early growth, fruiting and maturity of these crops. High temperatures however speed up phenological development of crops and allow limited time for grain and seed formation [15]. Empirical literature shows crop-specific responses to climate variations. For instance, it has been observed that temperature demonstrates a strong negative relationship with tomatoes and cabbage yields, as yields reduce with increasing temperatures in Santa sub division. A strong positive relationship is maintained with carrot and leeks. In another dimension, fluctuations in rainfall show a weak negative relationship with cabbage (-0.225), a strong positive relationship with carrot (0.439), and a weak positive relationship with leaks (+0.270) [4]. In contrast to this, [19] noted that no significant relationship exists between recent climate variability effects and cassava yields in Osun state. To [12], the yields of some staple crops were diversely influenced by extreme weather. It was found that there exist a robust correlation between crops and heat; cocoyam (-3.744), cassava (-4.051), maize (-4.527), and between crops and rainfall; cocoyam (-3.150), cassava (-3.362) and maize (-3.815). It was then revealed that root and tuber crops had an edge over other staple crops in Nigeria. The determinants of change in crop production have been noted [20,21,22]. [20] notes that inter-annual variability in rainfall is the main cause of the year to year variations of crops (sorghum) in terms of area cultivated and yields in the Amhara region, Ethiopia. The influence of the actions of weather cause the yields per unit area of cultivated land to be lower than average. Highlighting that, a non-linear relationship exists between crop production and rainfall amount whose temporal distribution affects crop yields. [23] points out that rising temperatures on crop productivity depends on crop characteristics, the timing of heat stress in relation to crop development and the conditions under which the crop is grown.

The outcome of climate variability tends to be huge on crop production at the level of extremes. Evident in the fluctuations is the amount and timing of rains and increasing temperatures [18,24]. For instance, [18] in a study carried out in the Offinso North District on the effects of climate variability on tomato production ascertains that, temperature has a significant impact on tomato yield, while higher temperatures above its threshold can be detrimental to crops. The results equally maintain a similar relationship with rainfall. [24] notes the same experience as climate led to a reduction in crop yields in Bangladesh. Defang et al. (2014) asserted that climate change impacts on crop production are felt by farmers in Muyuka subdivision, Cameroon. The yields of crops such as plantain, cassava, cocoyam, egusi and maize are witnessing a decline in the subdivision as a result of increasing temperature and sunshine, low rainfall and increase in the prevalence of pest and diseases [cited in 4]. [15] highlights a reduction in maize yields in all the agricultural regions in Cameroon under future climatic conditions with exceptions in soybeans yields as it will register an increase. [15,23] asserts that climate variability could have many effects evident in the occurrence of fluctuations in climate, prolonged variations and crop diseases. These phenomena lead to a reduction in agricultural yields and food shortages; this has constrained food production, distribution, consumption and contributes to food insecurity in south Western Cameroon.

4. STUDY AREA AND RESEARCH METHODOLOGY

Bali subdivision (Fig. 1) is located in Mezam Division in the North West Region of Cameroon. It is found at the transition between the grasslands and the forest to the south and west. Bali Nyonga makes up one of the 32 subdivisions of the North West Region. It is situated some 20 km from Bamenda, which is the regional headquarters of the North West Region. Bali is located between latitude 5°54' north of the Equator and longitude 10° east of the Greenwich Meridian. It has a basin shape and covers a surface area of about 277.77 km^2 with a population density of about 27 persons per kilometer square [25]. Bali is bordered to the North East by Bamenda, to the South East by Santa Sub division, to the North West by Mbengwi and to the South by Batibo Subdivision.

The population of Bali Subdivision is noted to be on an increasing trend. It stood at 12,763 people in 1976, moved to 17,612 in 1987 and by 2005, the population was estimated at 30,375 people [26] with a greater proportion of females than males. Presently, the population is estimated to have increased to 85,058 inhabitants and has a density of about 188 persons per square kilometer, having an annual growth rate of 4.2%. Bali had 7582 homes within 17 villages in 2005 which are estimated to have increased presently [25]. Agriculture is the dominant economic activity and climatic variations tend to affect crops not to thrive well and even animals thereby, injuring the health of the economy.

The study is exploratory in nature since it investigates crop-specific responses to climatic variability using time-series data. Crop specific correlational values were derived to give a clear picture of relationships with temperature and rainfall, their significance and implications. Pearson's product moment correlation was used to test and show whether a significant relationship exist between maize, beans, cassava, cocoyam, temperature and rainfall variables. Pearson's correlation measures the strength and direction of the relationship between 2 or more variables on an interval scale. The study provides the conditions to perform a correlational test as information are recorded in a table form, requires data of the interval measure from at least 2 or more variables showing trends and relationships. The main purpose of this statistical tool is to determine relationships that exist between variables which are normally distributed thereby, enhancing predictions. It is calculated by using the formula;

$$\text{Correlation (X, Y)} = \frac{\Sigma(X-\bar{X})(Y-\bar{Y})}{\sqrt{\Sigma(X-\bar{X})^2\,\Sigma(Y-\bar{Y})^2}}$$

where;

X and Y = variables

$$\bar{X} = \frac{\Sigma x}{nx} \tag{1}$$

$$\bar{Y} = \frac{\Sigma y}{ny} \tag{2}$$

(which give the mean of each variable found in X and Y).

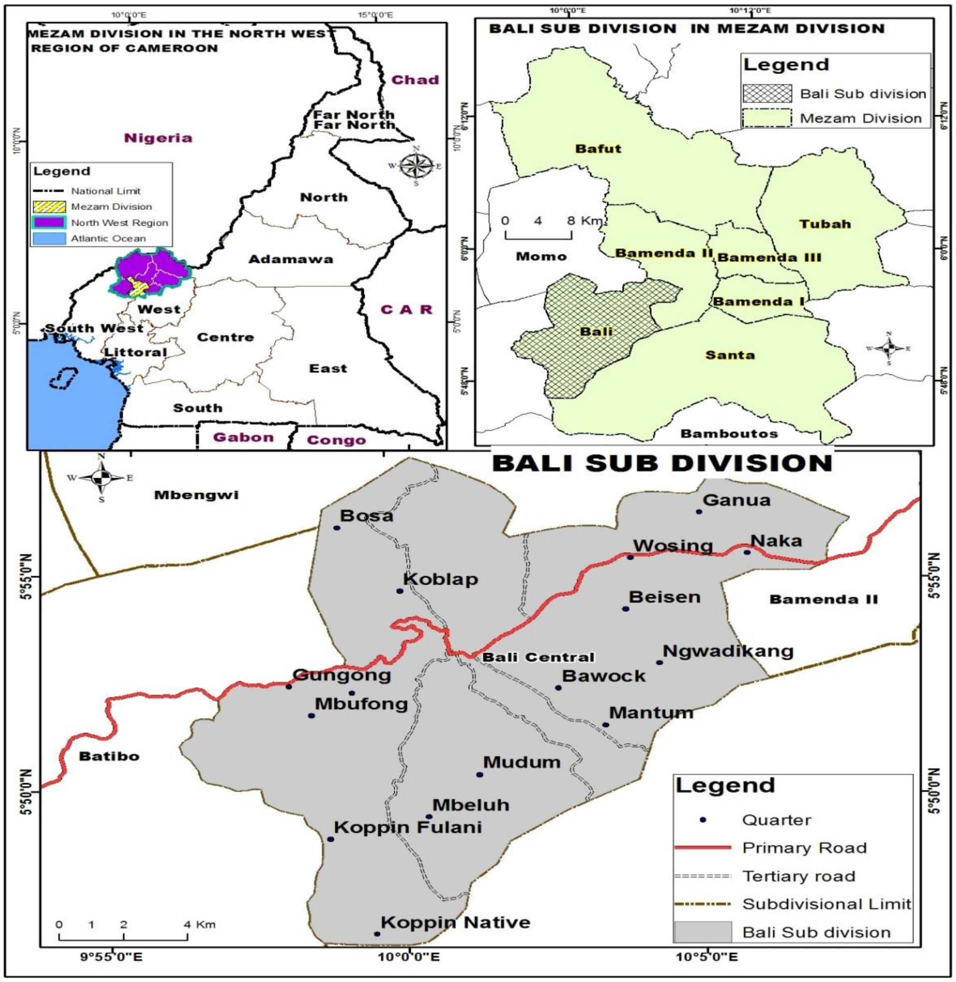

Fig. 1. Location of Bali Sub Division. (Source; Geo Spatial data, NIS, Yaounde 2013)

5. RESULTS AND DISCUSSION

Cropping and crop yields require specific temperature and rainfall thresholds for high yields to be attained. Threshold temperatures vary with crops and higher temperatures during grain-filling becomes detrimental [12,27]. Variations in the elements of climate affect crop production in all its stages of growth. Table 1 shows crop specific temperature and rainfall requirements. Deviations from these crop necessities have been noted for the early periods of 1991-1995 and later periods of 2011-2015. Comparatively, temperatures had been fluctuating around the mean requirements (20.57°C-20.92°C) of the target crops (maize and beans) except for cassava and cocoyam that it had been far below 27°C. Temperature and beans production in the year 2012 was evident to be favourable as the required temperature for the crop to thrive well was met (21.33°C) but coincided with rainfall amounts (182.15 mm) lesser than the mean (400 mm).

Table 1. Average temperature and rainfall requirement of crops

Crops	Mean temperatures (°c)	Mean rainfall (mm)
Maize	25°C	650mm
Beans	21°C	400mm
Cassava	27.5°C	1000mm
Cocoyam	27.5°C	1725mm

Source; Obtained from temperature and rainfall thresholds [12]

Rainfall amounts for both periods had not always been up to the target crop requirement but could provide at least a quarter of water needed for beans and maize. Generally, temperatures from

1991-2015 had been on an increasing trend while rainfall had been decreasing. This implies that a continues increase in temperature will enable crop requirements to be met but becomes detrimental in a rain-fed agricultural community associated with declining rainfall amounts. Specific crops are however subjected to impacts of variations in temperature and rainfall. Higher coefficients of variation in the output of maize (21%), Beans (21%), cassava (21%) and cocoyam (-22%) signifies greater fluctuations. This coincides with periods of high variability and less reliability on temperature and rainfall by crops. The output of maize, beans and cassava is seen to be on an increasing trend (Fig. 2), not necessarily because they maintain a significant positive relation with climate variables. This could be attributed to other factors such as the extension of farm sizes (area of land under cultivation), increasing use and reliance on chemical fertilizers which increases total production/yields.

Results on crop production trends are linked to deviations from crop-specific threshold requirements in which a negative trend line in output is observed. A reversed situation is evident as portrayed on the trend lines of all the other crops except cocoyam due to the dependence of these crops on farm adjustments. Maize, cassava and beans are skewed towards a positive direction with an increasing trend from 1991-2015, while *colocasia* is falling negatively with a decrease in output (Fig. 3). However, respondents (farmers') affirmed that although yields of *colocasia* had been on a decrease, the periods between 2001-1991 were the most preferred years. Reasons being that they invested less in the production of cocoyam when compared with the other crops and realised reasonable output. Then a sharp fall from 2002-2015 is as a result of diseases attack and the declining interest in *colocasia* cultivation.

Fluctuation rates vary between individual crops within cropping seasons and from one year to another (Fig. 4). These variations coincide with yearly deviations from their threshold and the maximum levels of fluctuations in output were obtained for maize (6.3%), beans (6.1%), cassava (6.2%) and cocoyam (-6.8%). This implies that despite increasing temperatures and decreasing rainfall amounts, the yields of the 3 other crops excluding cocoyam are found to be positive although not having an outstanding increase with percentages below the mean (10%). [28] noted that the effect of increasing temperature is exhibited more on the yields of grain and tuber crops than on their vegetative growth. However, there is improvement and introduction of new varieties of beans and maize species while cassava is found to be heat tolerant, has high soil acidity and has been noted as a food security crop [15]. The Pearson's correlation coefficient had been used to determine whether there is a significant relationship between climate variability and crop production in Bali Subdivision. This was done based on temperature and rainfall data for 25 years and the production trend of maize, beans, cassava and cocoyam for the same period (Table 2).

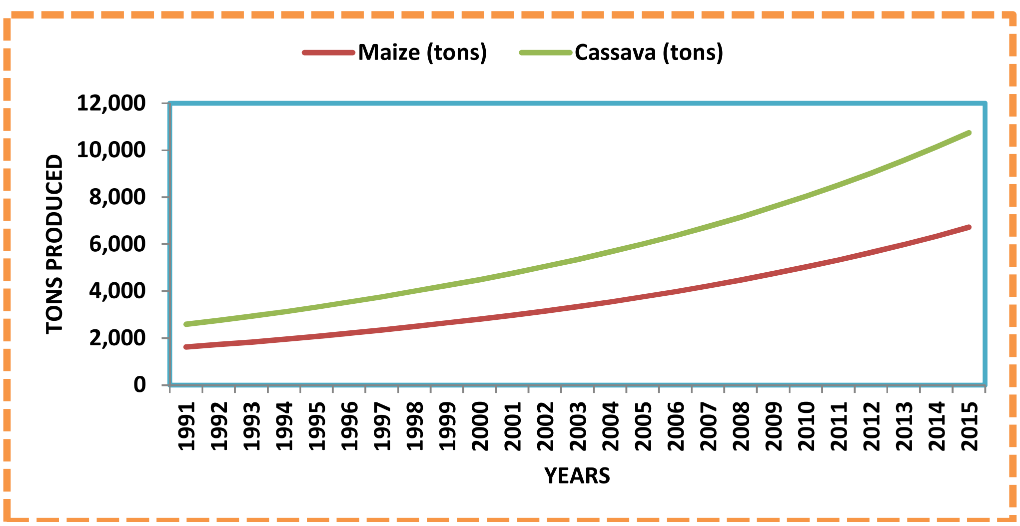

Fig. 2. Production trend for maize and cassava

Table 2. Pearson' Correlations between temperature and rainfall amounts and crop production (maize, beans, cassava and cocoyam)

		Rainfall (mm)	Temperature (°c)	Maize (tons)	Beans (tons)	Cassava (tons)	Cocoyam (tons)
Rainfall (mm)	Pearson Correlation	1	-.215	.158	.156	.158	-.149
	Sig. (2-tailed)	.	.302	.451	.455	.451	.477
	N	25	25	25	25	25	25
Temperature (0c)	Pearson Correlation	-.215	1	.326	.329	.325	-.185
	Sig. (2-tailed)	.302		.112	.109	.113	.376
	N	25	25	25	25	25	25
Maize (tons)	Pearson Correlation	.158	.326	1	1.000**	1.000**	-.940**
	Sig. (2-tailed)	.451	.112		.000	.000	.000
	N	25	25	25	25	25	25
Beans (tons)	Pearson Correlation	.156	.329	1.000**	1	1.000**	-.937**
	Sig. (2-tailed)	.455	.109	.000		.000	.000
	N	25	25	25	25	25	25
Cassava (tons)	Pearson Correlation	.158	.325	1.000**	1.000**	1	-.940**
	Sig. (2-tailed)	.451	.113	.000	.000		.000
	N	25	25	25	25	25	25
Cocoyam (tons)	Pearson Correlation	-.149	-.185	-.940**	-.937**	-.940**	1
	Sig. (2-tailed)	.477	.376	.000	.000	.000	
	N	25	25	25	25	25	25

***. Correlation is significant at the 0.01 level (2-tailed).*

Source; Derived from quantitative data of climate variables and output of crops, 2017

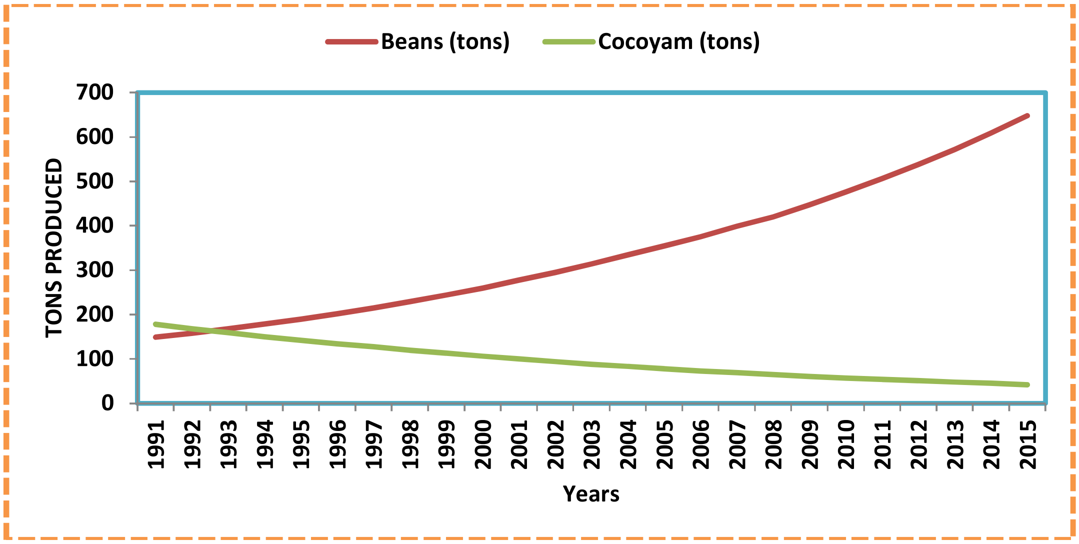

Fig. 3. Production trend for beans and cocoyam (derived from field estimates, 2017)

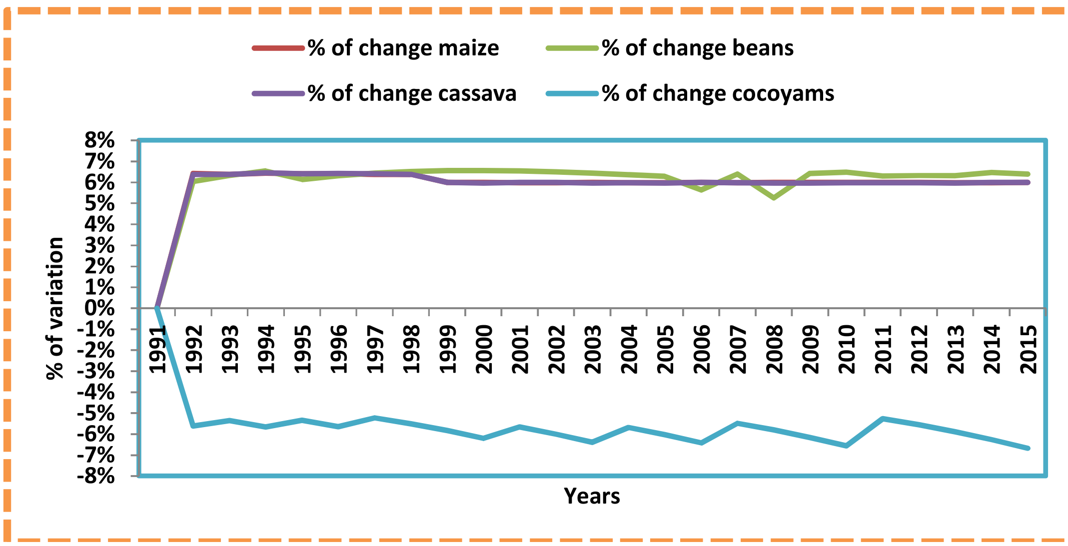

Fig. 4. Yearly fluctuation rates in crop output in Bali subdivision

The results show a strong positive relation (1) at the level of individual variables (temperature, rainfall, maize, beans, cassava and cocoyam). While temperature and rainfall have a negative relationship (-0.215) with a P-value of (0.302) which is significant at 0.01 level of significance. This implies that temperature and rainfall fluctuations are not of the same trend and has great repercussions on crop yields during prolonged increase and decrease in amounts. There exist a strong positive relationship with maize (0.158), beans (0.156), cassava (0.158) and rainfall. This implies that as rainfall increases, the yields of these crops also increase. Rainfall equally demonstrates a weak-negative relationship with cocoyam (-0.149) which signifies that as rainfall increases above a threshold of 2200 mm per growing season, the yield of cocoyam decreases. In another dimension, temperature shows a weak-positive relationship with maize (0.326), beans (0.329) and cassava (0.325). This suggests that temperature increase will be of trivial importance to bring about increase in the yields of maize, beans and cassava production. Cocoyam presents a weak-negative relationship with temperature (-0.185) which implies that its production and yields are not encouraged by temperature increase. The implications of these results show that maize, beans, cassava and cocoyam requires much water which greatly varies from one growth stage of each crop to another. These results were all found to be significant at 0.01 level (2 tailed) for the target crops (maize, beans, cassava and cocoyam). This result agrees with the results of [17] in a similar investigation carried out in Meme division on climate variability and crop production. It equally agrees with the findings of [4] on the implications of climate variability on market garden crops in Santa subdivision. [12] in analyzing the sensitivity of crop yield to extreme weather in Nigeria noted that a 1% increase in extreme temperature increase yield variability of cassava, cocoyam and maize; while a decline in maize yield results from a 1% increase in extreme temperature. Conversely, the results of this study disagree with the works of [29] who highlighted that non-climate factors determine the success and failure of smallholder agriculture at both regional (neglect of investment in agriculture, increasing land degradation) and local levels (widespread poverty among small holder, low agricultural intensification and adoption of technologies). In addition, [19] contend that no significant relationship exists between recent effects of climate variability and cassava yield in Osun State which implies that, the quantity of cassava yields does not vary with current effects of climate change. The role of other factors such as cassava varieties, pests and diseases and socio-economic characteristic were evident to be having a negative impact on cassava productivity. It equally disagrees with the work of [12] who noted that crop yields are sensitive to extreme weather and that there exists robust (strong) correlations between cocoyam, maize, cassava and heat and rain with emphasis on the fact that, root and tuber crops have an edge over all other staple crops in Nigeria.

6. CONCLUSION AND RECOMMENDATIONS

Crop production is solely dependent on rainfall from when it is planted till when it gets mature. A continuous increase in temperature and a reduction in rainfall amounts which most often do not meet the threshold requirements calls for the need of specific crops monitoring. There is therefore a need for the Regional and Sub divisional Delegations of agriculture to introduce more adaptive species of beans, maize, cocoyam and cassava whose yields can be significant even in the phase of increasing temperatures. Cassava is found to be heat-tolerant and should be cultivated more in environments void of shelter and often exposed to sunlight most (slopes) than the other crops. Valleys should be targeted most for the production of cocoyam especially during the first cycle cropping season; while shaded environments and inter-cropping with tree crops will help to regulate surrounding temperatures and enhance annual average rainfall requirements (1725 mm) to be obtained. The most common dwarf species of beans produced have varied lengths of growth and reacts differently to different climatic conditions. The pink-dotted white and yellow-dotted white species, larger in size, are short term and should be highly cultivated during the first cropping season (crops cultivated and harvested during the rainy season) than the other species. Priority should be given to the yellow-dotted white specie (during first cycle cropping). This explains why the small grain red and black species should be cultivated partly during the rainy season and harvested under dry conditions; since they are made up of pods which cannot withstand excess rain and have a growing period (medium) which is often longer than the other species. Also, farmers should integrate the cultivation of both dwarf and climbing species of beans in crop production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Padgham J. Agricultural development under a changing climate: Opportunities and challenges for adaptation. Agriculture and Rural Development (ARD), World Bank. Washington, D.C. 2009;1.
2. Recha J, Kinyangi J, Omondi H. Climate related risk and opportunities for agricultural adaptation and mitigation in Semi-arid Kenya-CCDFS; 2012.
3. IPCC. Climate change. Mitigation of Climate Change. Technical Support Unit IPCC Working Group III, Netherlands Environmental Assessment Agency; 2007.

   Available:https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf (Accessed on 15/09/2016)

4. Amawa SG, Kimengsi JN, Tata ES, Awambeng EA. The implications of climate variability on market gardening in Santa Sub-division, North West Region of Cameroon. Environmental and Natural Resources Research. 20155(2).
DOI: 10.5539/enrr.v5n2p14
Available:http://dx.doi.org
5. Balgah RA, Forti AK. Farmers' perception and knowledge on climate variability in the Western Highlands of Cameroon. Science, Technology and Development Discussion Paper No.003; 2015.
6. Balgah RA, Kimengsi JN, Bime MJW, Forti AK. Farmers' knowledge and perceptions on climate variability in North West Cameroon. World Journal of Social Science Research. 2016;3(3).
Available:www.scholink.org/ojs/index..php/wjss
(Accessed on 24/12/2016)
7. El-Maayar M, Lange MA. A methodology to infer crop yield response to climate variability and change using long-term observations. Atmosphere Energy, Environment and Water Research Centre, Cyprus; 2013.
Available:www.mdpi.com/journal/atmosphere
(Accessed on 11/06/2017)
8. Mngumi J. Perceptions of climate change, environmental variability and the role of agricultural adaptation strategies by small-scale farmers in Africa: The case of Mwanga district in Northern Tanzania; 2016.
Available:http://theses.gla.ac.uk/7441/1/2016 MngumiPhd %20%281% 29.pdf
(Accessed on 11/06/2017)
9. Tsalefac M. Variabilité climatique, insécurité alimentaire et adaptation des populations sur les Hautes Terres de l'Ouest du Cameroun, in Publications de l'Association Internationale de Climatologie, Rennes, France; 2012.
10. Manetsa V, Tsalefac M. Variabilité pluviométrique dans le Bassin forestier du Congo (1951-2002) in Gestion des forêts du Bassin du Congo et adaptation aux changements climatiques, éd. Karthala. 2013;21-36.
11. Molua EL, Lambi CM. The economic impact of climate change on agriculture in Cameroon. Policy Research Working Paper 4364; 2007.
12. Ajetombi JO. Sensitivity of crop yield to extreme weather in Nigeria. African Journal of Food, Agriculture, Nutrition and Development; 2012.
Available:https://www.ajol.info/index.php/ajfand/article/view/149175
(Accessed on 25/03/2017)
13. Tsalefac M, Boukar C. Changements climatiques et adaptations des populations paysannes autour du parc national de Waza dans la plaine du Logone (Nord-Cameroun) in Natures Tropicales: Enjeux actuels et perspectives, ADES, Maison des Suds Guy Lasserre, 12, Esplanade des Antilles, PESSAC; 2011.
14. Kimengsi JN, Amawa SG, Fondufe LS. Building a strategy to overcome the psychological barriers to climate change management in rural communities of Fako Division, Cameroon. Journal of Sustainable Development. Canadian Centre of Science And Education 2016;9(1).
Available:http://dx.doi.org/10.5539/jsd.v9n14
(Accessed on 30/12/2016)
15. Molua EL. Climate variability, vulnerability and effectiveness of farm-level adaptation options: The challenges and implications for food security in South West Cameroon. Environment and Development Economics. 2002;7:529–545.
DOI: 10.1017/SI 355770x02000311
16. Kimengsi JN, Muluh GN. A comparative assessment of the effects of climate variations on the crops of the Cameroon Development Corporation (CDC): Adaptation options. Environment and Natural Resources Research. 2013;3(1).
Available:http://dx.doi.org/10.5539/enrr.v3n 1p144
17. Kimengsi JN, Tosam JN. Climate variability and crop production in Meme Division of Cameroon: Agricultural development policy options. Greener Journal of Agricultural Sciences. 2013;3(8):606-617.
18. Guodaar L. Effects of climate variability on tomato crop production in the Offinso North District of Ashanti Region; 2015.
19. Ezekiel AA, Olawuyi SO, Ganiyu MO, Ojedokun IK, Adeyemo SA. Effects of climate change on cassava productivity in Ilesa – East local government area, Osun State, Nigeria. British Journal of Arts and Social Sciences; 2012.
Available:http.//www.bjournal.co.uk/BJASS.aspx
(Accessed on 27/03/2016)

20. Bewket W. Rainfall variability and crop production in Ethiopia. Case Study in the Amhara Region; 2009.
21. Stanturf JA, Warren ML, Charnley S, Sophia C, Polasky SC, Scott LG, Armah F, Yaw AN. Ghana climate change vulnerability and adaptation assessment; 2011.
22. Asante FA, Mensah FA. Climate change and variability in Ghana: Stocktaking climate; 2014. ISSN: 2225-1154 DOI: 103390/cli3010078
23. Molua EL, Lambi CM. The economic impact of climate change on agriculture in Cameroon. Policy Research Working Paper, WPS4364; 2007,
24. Selvaraju R, Subbiah AR, Baas S, Juergens I. Livelihood adaptation to climate variability and change in drought-prone areas of Bangladesh. Institutions for rural development-ADPC (Asian Disaster Preparedness Centre-DFID, Rome; 2006. ISBN: 978-92-5-105602-8.
25. Bali rural council monographic study; 2005.
26. Bureau Central des Recensements et des Etudes de Population (BUCREP); 2010.
27. Perry M, Will L, Stu B. Using growing degree days (GDDs) to predict plant stages. MONTANA State University Extension Service; 2010.
28. Hatfield JL, Prueger JH. Temperature extremes: Effects on plant growth and development. Weather and Climate Extremes. 2015;10(part A):4-10. Available:https://doi.org/10.1016/j.wace.2015.08.001 (Accessed on 29/07/2017)
29. Chinwe IS. Resilient adaptation to climate change in African agriculture. Deutches Institute fur Entwicklungspolitik; 2010. ISSN: 1860-0468 Bonn.

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