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A COMPARATIVE ANALYSIS OF CLIMATIC & NON-CLIMATIC FACTORS AND IMPLICATIONS ON FOOD CROP PRODUCTION IN NDU SUB-DIVISION, NORTH WEST REGION OF CAMEROON

BY

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ABTRACT

Climatic and non-climatic factors play a significant role in food crop production. Research has proven that given our limited ability to predict climate-change-induced actions, coupled with our inadequate understanding of how climatic and non-climatic factors contribute to determining food crop production is the main reason for variations in food crop especially in the developing countries. This paper attempts a comparative analysis between climatic and non-climatic factors and their influence on agricultural production in Ndu Sub-Division. Field observations, focused group discussions and interviews were the major sources of data collection. A total of 200 questionnaires were distributed during the study to food crop cultivators. This provided information on how climatic factors of rainfall have influenced food crop production in the area. On the other hand, the non-climatic factors were carefully observed in the field. Data gotten from the archives of the Nkambe Urban Council especially the map of the study area and the Ministry of Agriculture and MINEPIA constitute secondary sources of data collection. The data were analysed in both qualitative and quantitative terms. Inferential statistics were used to show the correlation between climatic and non-climatic factors and their influence on crop production in the region. The relationship between crop and cattle production with rainfall, temperatures and relative humidity in Ndu was established using the regression analysis technique. From this study, non-climatic factors require careful attention when attempting to predict the biotic consequences of climate variability and change. The study concluded that in as much as climate variability is affecting food crop production, the non-climatic factors should be given a careful thought as they also impact negatively on food crop production.

Key Words: Comparative analysis, Climatic and Non-climatic factors, Implications, Food Crop Production.

INTRODUCTION

Agricultural activities constitute the backbone of most rural economies of the world and a source of food security to the growing population. According to Barrios, et al., (2008:287), agriculture is the main engine of the economic growth for Sub-Saharan African countries. However, feeding the increasing population of Sub-Saharan Africa is becoming a critical challenge for most of the countries in this area (Owusu, 2010: 108). In line with this, Diao and Hazell, (2010:2) underscore the existence of two schools of thought or debates in African agriculture. These debates focus on the potential roles of agriculture and industry in improving African development and the ability of the agricultural sector to ensure pro-poor growth. Hence, the argument that agriculture is a large sector and that upgrading it leads to a better aggregate growth, justifies the public investment in the sector (de Janvry, & Sadoulet, 2010:12).

Many arable areas in Sub-Saharan Africa are under severe pressure to increase food productivity in order to feed the rapidly growing human population (Tchabi *et al*., 2008 ;). Most of the agricultural production is carried out by small-scale farmers of the rural areas who make up about 90% of the farming population (FAO, 2002). The impact of climate variation on crop yield has recently gained prominence, given the significant trend towards global warming and imminent climate variation and change. The high dependence of tropical agriculture on rainfall, coupled with the use of low inputs and degraded soils increases farmers vulnerability to the vagaries of weather (Feddema & Freire, 2001; Nicholson, 2001). Furthermore, climate variability and change is also said to modify evaporation, runoff and soil moisture storage. The occurrence of moisture stress during flowering, pollination and grain filling is harmful to crops, particularly to maize, beans and Irish potatoes.

Agronomists and soil scientists are interested in precipitation and rainfall in particular as a source of soil moisture to crops. Water supply is usually the most critical factor in determining yields (Lambi & Molua, 2006). The effects of water shortages on production may vary according to the particular crop, the soil characteristics, the root system, and the severity and timing of shortages during the growth cycle (Ahn, 1993) quoted in Molua and Lambi (2006). Rainfall reliability particularly at critical phases of plant development accounts for much of the variation in agriculture's potential. Ayonghe, (2001) in a study on climate change in Cameroon ascertained that the evaluation of the magnitude of global warming based on temperatures and rainfall data recorded in localities covering the entire surface of Cameroon from the 1930s to the 1995 shows drastic increases in temperatures at a rate of about 0.41^{o}C per decade giving a net increase of 0.91^{0}C over this period. And a corresponding decrease in the total amount of annual rainfall at a rate of 43mm per decade giving a total decrease of 282mm over this period was also noted. These variations in climatic conditions affect food crop productivity in the region.

Rosenzweig et al., (1993), in a research to find evidence for important threshold effects on crop production indicated a positive crop yield response to temperatures increases of 2^{o}C but yield reductions were observed at a 4^{o}C increase of temperatures. They also asserted that crop impacts in lower latitudes tend to be more negative than crop impacts in higher latitudes, particularly with respect to wheat and maize yields. Rice yields are less variable than wheat and maize yield impacts. This is similar with what obtains in the study area whereby, maize is less vulnerable to variations in the climatic parameters of rainfall and temperatures in the lowland areas of Ntamru, Ntaye, Luh and the Mbaw plains as opposed to the highlands areas of Njimkang, Wowo, Ntissoh and Kakar. But on the whole, since temperatures have been observed to vary minimally, it could account for a significant positive relationship with crops as postulated by Rosenzweig et al. (1993).

Non-climatic factors comprise a wide range of environmental, economic, social and technological factors. The neutral term 'non-climatic factors' is preferred over 'non-climatic stressors' or 'non-climatic risk factors' because these factors may have beneficial as well as adverse effects on agricultural production. Non-climatic factors can affect the sensitivity of a system to climatic stimuli as well as its exposure. The distinction between changes in sensitivity and changes in exposure is not always straightforward. Non-climatic factors such as farm preparation methods, educational level and awareness, farm weeds, crop density, frequency of fertilizer application in relation to the hecterage of land cultivated, and the level of awareness on climate variability have rendered the agricultural sector vulnerable through its negative impacts.

Several researchers have questioned whether the importance of climatic drivers relative to non-climatic forces is really significant. Others have highlighted the greater importance of non-climatic drivers compared to climatic stressors where local adaptation to changing circumstances is concerned. This study sets out to address this knowledge gap on climate resilient agriculture and the influence of climatic and non-climatic factors on food crop production in Ndu, Cameroon. As the interaction between climatic and non-climatic factors in agriculture is immensely complex, the focus was not to measure the relative weight of these factors on changing farm-related practices and food sufficiency but it was simply aimed at assessing the general significance of these factors in contributing to local adaptation by farmers in Ndu. Hence, the aim of this study is to investigate the factors affecting agricultural production in Ndu Sub-Division.

THE PROBLEM

Agriculture remains the key sector in many developing African countries as its contribution to economic growth stimulates other sectors by providing them with inputs. Cameroon is one of the countries that allocate at least 10 % of its total public expenditure on agriculture. Despite the enormous government effort to boost the agricultural sector, the rural communities are still unable to produce enough food to feed themselves. This is a result of the fact that a number of problems plagued this sector. These range from climatic to non-climatic factors affecting food crop production. The climatic factors involve the variations in rainfall and temperatures that do not only alter the agricultural calendar but reduces crop yields considerably. The non-climatic factors can be attributed to human activities. Land preparation for crop cultivation is done either by burning the crop fields or through the use of the Ankara system of farming which is the most dominant practise in the area. The Fulani community also resorts to the burning of the vegetation and nearby crop fields as a method of clearing the land for regeneration or regrowth grass needed by the cattle for grazing. The burnt soil becomes lighter. Hence, there is an acceleration of erosion. Soil decomposing bacterial are equally destroyed as well as Nitrogen fixing bacteria in the soil. This is a common practice in the whole sub-division. Crop density and geometry is a visible problem that is observed in the study area. Weeds also contribute significantly to agricultural vulnerability since they are highly competitive and are highly adaptable under varied adverse situations as opposed to crops that are sensitive to minimal climate variations. The educational level of the farmers as well as market prices have had much to do with regards to food crop production in Ndu.

LOCATION OF STUDY AREA

The study area is Ndu Sub-division in Donga- Mantung Division. This area lays between Latitude 6°20" and 6°40" North and Longitude 6°25" and 11°20" east of the Green Which Meridian. It covers a total surface area of 1350sqkm. Ndu is bounded to the North by Nkambe Central, to the west by Nwa Sub division, to the east by Nkum Sub-division. It is the headquarters of Ndu Sub-division (Ndu Council, 2010). Figure 1 locates Donga-Mantung in the North West Region and Ndu Sub-division in Donga-Mantung Division. Figure 1 is the location map of Ndu Sub-division.

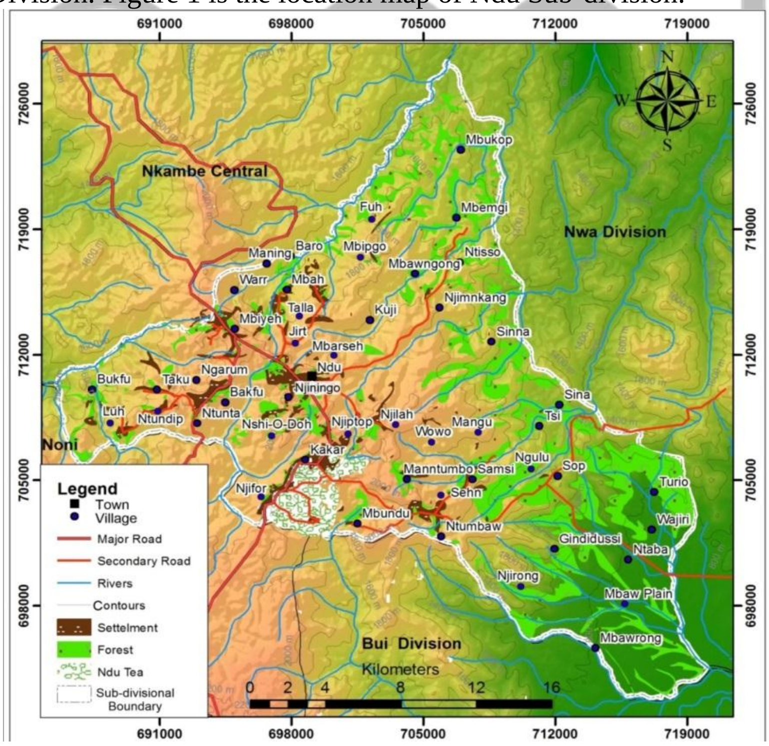

Figure 1: Location of Ndu Sub-Division
Source: Adapted from the map of Nkambe, (2004)

MATERIALS AND METHODS

The study used the standard social scientific methodology which involves the collection of primary and secondary data and analysis of the data using the statistical methods of quantitative and analytical techniques. A total of 200 questionnaires were distributed during the study to food crop cultivators. The questions were directed towards getting information on how climatic factors of rainfall have been impacting on the food crop sector in the area. On the other hand, the non-climatic factors were carefully observed in the field. The data collected were analysed both in qualitative and quantitative terms. Rainfall data were collected and analysed using tables and graphs for the comparative study. Three crops were considered for this study, namely, maize, beans and Irish potatoes. The relationship between crop production and cattle production with rainfall, temperatures and relative humidity in Ndu was established using the regression analysis technique. The rule of thumb for concluding that a relationship exist between an independent variable (rainfall), and a dependent variable (maize) is if the Probability value (P-value) is <0.05. Any P-value >0.05 is an indication that there is no relationship between the variables.

CLIMATIC FACTORS AFFECTING FOOD CROP PRODUCTION

Climatic variables have played significant roles in food crop production. It has been realised that climatic variables vary directly with output. The extent of rainfall is one of the critical factors that influences the agricultural production of farmers. In areas where agricultural activities are predominantly rain-fed as it is the case in Ndu, the percolated rainfall in the roots is the source of moisture and water consumption for the crops (Rockstrom et al., 2009:544).The erratic nature of rainfall makes rain-fed agriculture unreliable for farmers and it is for this reason that the agricultural productivity of rain-fed areas like Ndu varies with the availability of rainfall (Rockstrom et al., 2009:544). Annual rainfall totals for the study area were calculated for each year. From these totals, the mean annual rainfalls were calculated from where deviations from the mean were gotten. A square of these deviations gave the standard deviation. Furthermore, the coefficient of variation was calculated. Figure 2 represents rainfall trends for Ndu from 1981 – 2014. Rainfall shows variations from 1981with sharp increases for the years 1989, 1997 and 1999 with rainfall amounts of close to 400mm. The 2011 and 2013 show falling amounts in precipitation.

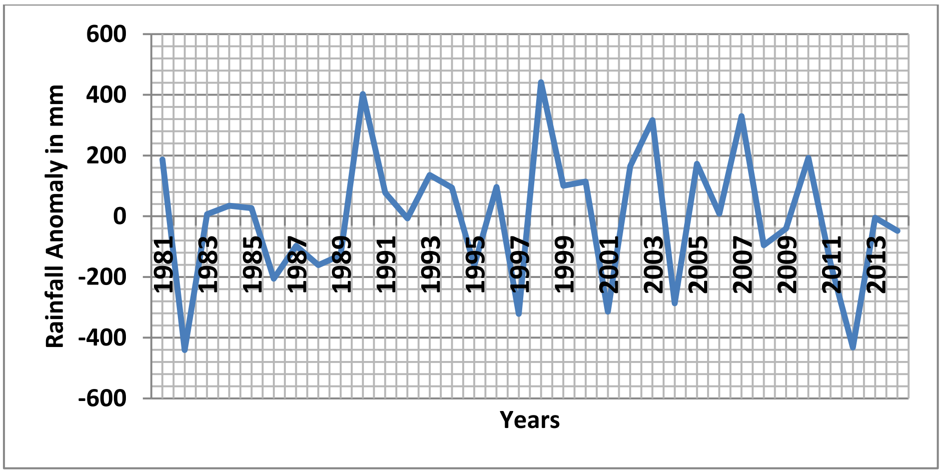

Figure 2: Annual Rainfall Variations for Ndu
Sub-division (1981 – 2014)
Source: Computed from Climate data, 2015

IMPLICATIONS ON FOOD CROP PRODUCTION

Climatic variability especially though the fluctuations in rainfall has a serious impact on food crop production. Field evidence reveals that maize yields dropped drastically during the 1982/83 and the 1997/1998 droughts because rainfall was insufficient for successive growth during its vegetative growth period and so the crops were bound to fail. This was the same with beans where during the pod formation period, there was not sufficient moisture to facilitate growth. Most of the bean plants were affected by the dwarf virus that is associated with high temperature (MINADER, (2015). The potato plants became sunken because of excessive evapotranspiration accompanied by insufficient rainfall. Moreover, potatoes during their tuber enlargement need alternating sunshine and rainfall but these years were characterized by less rainfall such that the tubers could not form properly. These conditions conform to a study carried out in Kogi State, Nigeria, on the effects of rainfall and temperatures on maize yields. This study revealed that 36% of the variations in maize production in this state were accounted for by variations in rainfall. The study used a ten year period, that is, from 2001 to 2010.

NON-CLIMATIC FACTORS AFFECTING FOOD CROP PRODUCTION

Like the climatic factors, the non-climatic factors equally play significant roles in determining the quality and quantity of food crops produced. The non-climatic factors in Ndu are tailored towards the different stages involved in the land preparation process. The farming characteristics consist of many variables that affect the agricultural production of farm operators. Some of these variables are: farm preparation methods, crop density and geometry and the educational level, as well as weed attack.

Land preparation method is one of the most significant non-climatic elements rendering the agricultural sector vulnerable in Ndu. Results from questionnaire analysis revealed that only 1% of farmers are engaged in the appropriate farm preparation method of clearing and burying of the cleared grasses into the soil to decay and add to soil fertility. On the other hand, 99% of the farmers are involved in the Ankara system of farm preparation in which farm residue is being burnt. This affects the soil negatively and renders the crop production sector vulnerable in both quality and quantity of the yields realized at the end of each harvesting season. The burning of crop fields is practised for the rapid clearing of farmland and grazing land. The burnt soil becomes lighter and erosion is accelerated subsequently. Soil decomposing bacteria are destroyed as well as Nitrogen fixing bacteria in the soil. This is a common practice in the whole sub-division. The Sub-divisional Delegate for Agriculture and Rural Development in Ndu was of the opinion that these poor farming methods to which the indigenes seem to have a cultural inertia have contributed to the increasing changes in the chemical compositions of the soil over the years, with the rapid clearance of forest land. Table 1 represents these changes in the chemical composition of the soil from 1982-2013.

Most plant species are adapted to specific soil (edaphic) conditions and are unlikely to be able to move over barriers of unsuitable soils. Factors such as texture, water holding capacity, nutrient status and acidity are likely to be the most important in terms of soil suitability. But given these poor farming practices, most of the suitability factors have been tampered with. For example, the steady reduction in potato can possibly be accounted for by the increase in the soil water pH from 5.5 in the 1980s to 7 in the year 2000. This plant survives under a pH of between 5.5 - 6.

Table 1 Changes in the Chemical Composition of Soils in Ndu Sub-Division 1984-2014

	1982		2013	
Properties	0-30cm dip	30-60cm	0-30cm	30-60cm
Organic carbon %	4.64	2.30	2.52	1.81
Total Nitrogen % C/N ratio	0.3	0.15	0.25	0.10
Available Phosphorous			5.0	3.0
PH of soil water	5.55	6.8	6.0	7.0
PH KCl	7.0	7.0	5.5	4.3
Exchange basis				
Na	0.03	0.03	0.00	0.00
K	0.40	0.42	0.20	0.20
Ca	1.70	0.79	1.87	0.47
Mg	1.80	1.00	0.98	0.98
TEB (total exchangeable basis)				
Al +H	0.10	0.10	0.21	0.25
CEC (cation exchange capacity	20.2	15.3	15.0	12.0

Source: Sub-Divisional Delegation for Agriculture and Rural Development

CROP DENSITY AND GEOMETRY

Crop density is the number of plants per unit area in a crop field or ridge. It indicates the size of the area available for individual plants while crop geometry is the pattern of distribution of plant on the ridge or field. There exists, a standard set aside for crop geometry. Table 2 presents the standards set aside for crop geometry for the study.

Table 2: Standard Densities and Geometry for Sol Cropping and Mixed Cropping in Ndu Sub-division

Crops	Dimension for soil cropping	Dimensions for mixed cropping
Maize	30x80cm	50x80cm (mixed with beans)
Beans	25x80cm	35x80 (mixed with maize)
Potatoes	40x80cm	30x80cm(mixed with maize)

Source: MINADER (year) Nkambe, Phytosanitary Department.

The yield of a crop depends on the final plant density. The establishment of required plant density is essential for getting a maximum yield. For example, when a crop is raised on stored soil moisture under rain-fed conditions, a high density will deplete moisture before crop maturity. On the other hand, a low density will leave moisture unutilized. Hence, optimum density will lead to effective utilization of soil moisture, nutrients and sunlight amongst others. When soil moisture and nutrients are not limited, higher density is necessary to utilize other growth factors (solar radiation) efficiency. Figure 3 presents a farm with crop field with the required density and geometry but which did not receive sufficient sunlight. Notice the unhealthy appearance of the crops as a result of the shade of sunlight from the trees adjacent to the farm plot. The maize plants grew very thin with the leaves becoming yellowish showing deficiency in nutrients. From field evidence, the bean plants in this part of the farm were affected by the dwarf virus and all the bean plants appear stunted with their leaves twisted.

Figure 3: Farm land shaded by trees from sunlight.
Note the stunted nature of the crops due to nutrient deficiency
Source: Field work (2015)

On the contrary, when the density is more than required, individual plants get narrow space leading to competition for growth factors between plants resulting in a reduction of yield per plant. The yield per plant decreases gradually as plant density per unit area is increased as shown in Figure 4

Figure 4: Crop density and geometry of maize, beans, potatoes, soya beans, Chinese cabbage and a pumpkin farm in Kakar. (Field work, 2015)

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Optimum plant density is necessary to obtain maximum yields. Crop fields with high crop densities in the study area from observation did not produce healthy crops. Maize, for example, did not show healthy ears in such fields as opposed to low density crop fields. Figure 5 shows a farm with a good crop density and geometry in the vicinity of Ndu Town.

Figure 5: A Crop Farm Showing the Required
Crop Density and Geometry for Intercropping Maize,
Beans and Irish Potatoes on a Single Ridge
Source: Field work (2015)

THE INTERCROPPING SYSTEM AND ITS IMPLICATION ON CROP YIELDS

Intercropping is the intensification of land and resource use in the space dimension. Table 3 presents investigations on the intercropping system practised by farmers in the sub-division. The average results revealed that the maximum crop density is seven crops per ridge and a minimum of four crops per ridge with a standard deviation of 1.023 that deviates from the mean of 4.64. On a whole, results on crop geometry showed that a maximum distance of 50cm exist between crops and a minimum distance of 10cm and a standard deviation of 11.524cm from the mean of 20.47. This is to confirm the fact that a good number of farmers in the study area do not respect the required crop geometry for mixed cropping.

Table 3: Distribution of crops on a single ridge and the distance from each crop to another

	N	Minimum	Maximum	Mean	Std. Deviation
Number Crops/Ridge	200	4	7	4.64	1.023

	N	Minimum	Maximum	Mean	Std. Deviation
Distance 2 Crops	200	10	50	20.47	11.524

Source: Appendix 1

Well-designed intercropping systems and the use of natural organic resources as sources of plant nutrients would benefit and satisfy both the producers and consumers in the system. This can lead to enhanced efficiency of incident light use with two or more species that can occupy the same land area and have different patterns of foliage display; different rooting patterns can explore a greater soil volume with roots of different depths; competition with weeds from a combination of species occupying two or more niches in the cropping environment can effectively reduce weed germination while a mixture of crops can provide a buffer against losses to plant diseases.

WEEDS AND FOOD CROP PRODUCTION

Weeds from field observation contribute significantly to agricultural vulnerability in Ndu. Any plants in the field other than the crop planted are weeds. Weeds are highly competitive and are highly adaptable under varied adverse situations as opposed to crops that are sensitive to minimal climate variations. Without interference by man, weeds would easily wipe out the crop plants (Harpals et al., 1984). This is so because of their competition for nutrients, moisture, light and space which are the principal factors on which crop survival is based. Generally, an increase in one kilogram of weed growth will decrease one kilogram of crop growth (Roundy, 1996). Figure 6 displays a farm infested by weeds in Mbaw Plains. This shows that the weeds have absorbed all the nutrients and the crops are left with nothing. Weeds germinate earlier and their seedlings grow faster. They also flower earlier and mature ahead of the crop they infest.

Figure 6: A Weed Infested Farm in The Mbaw Plains
Ndu Sub Division (Notice Yellowish Nature of Maize
Leaves and Groundnut Leaves
Source: Field Work (2015)

In situations where weeds infest a crop field, crop growth and yield is affected as the crop suffers from nutritional deficiency. Leaf area development is reduced and yield attributes are lowered. It reduces the water used by the crop and affects the dry matter production. It lowers the input response and causes yield reduction. Pest and disease incidence on crops are a result of the proliferation of weeds in the field. This increased proliferation of weeds on the farms renders many croplands in the Mbaw Plains such as Luh, Ntudip, Senna, Ngulu and Makah villages unproductive. Most often some farmers abandon the farms for the weeds. Field observations have shown that even if the weeds taken care of, the crops can never remain the same as compared to the fields that the weeds were taken care of earlier before their maturity.

WEED COMPETITION FOR NUTRIENTS WITH CROPS:
Weeds usually absorb mineral nutrients faster than many plants and accumulate them in their tissues in relatively larger amounts. *Amaranthus sp*. accumulates over 3% of Nitrogen on dry weight basis and is termed as “nitrophills”. *Achyranthus aspera*, a Phosphorous accumulator with over 1.5% of phosphorous and *Chenopodium* sp. and *Portulaca* sp. are potassium lovers with over 1.3% of potassium in dry matter. The associated weed is responsive to nitrogen and it utilizes more of the applied Nitrogen than the crop. Nutrient removal by weeds leads to a huge loss of nutrients in each crop season, which is often twice that of crop plants. For instance, at the early stages of maize cultivation, the weeds are said to remove 9 times more of Nitrogen, 10 times more of Phosphorous and 7 times more of Potassium than the planted crops.

Competition for moisture:
Weeds transpire more water than do most of our crop plants. It becomes increasingly critical with increasing soil moisture stress, as found in arid and semi-arid areas. As a rule, C_4 weeds utilize water more efficiently resulting in more biomass per unit of water. In weedy fields, soil moisture may be exhausted by the time the crop reaches the fruiting stage, that ism, the peak consumptive use period of the crop, causing a significant loss in crop yields.

Competition for light:
This may commence very early in the crop season if a dense weed growth smothers the crop seedlings. It becomes an important element of crop-weed competition when moisture and nutrients are plentiful. In dry land agriculture, in years of normal rainfall, the crop - weed competition is limited to nitrogen and light. Unlike the competition for nutrients and moisture, once weeds shade a crop plant, increased light intensity cannot benefit it, and consequently there is crop failure.

Competition for space (Carbon dioxide CO_2):

Crop-weed competition for space is the requirement for CO_2 and the competition may occur under extremely crowded plant community condition like the case in the study area where about seven crops are crowded on a single ridge. A more efficient utilization of CO_2 by C_4 type weeds may contribute to their rapid growth over C_3 type of crops.

Education and agricultural production
The level of literacy plays a significant role in improving in food crop production. This is possible through formal education that enhances farmers' engagement in environmental programmes and methods for the sustainability of agriculture (Burton, 2013:22). Education is also believed to stimulate economic growth by enhancing the productive capability of farmers as well as eliminating the customs that are contrary to growth such as traditional word-of-mouth communication methods (Asfaw, & Admassie, 2004:216). If there is inequality in educational endowments, the returns remain low for knowledge deficient farmers, thereby supporting the notion that "knowledge poor will remain income poor" (Hussain, & Hanjra, 2004:8). Table 4 presents the educational status of some of the farmers in Ndu.

Table 4: The educational status of the 200 farmers interviewed in Ndu

Educational Status	Frequency	Percentage
No formal education	111	46.3
Primary	90	37.5
Secondary	39	16.2

Source: Field work, (2017)

Table 4 reveals that there is high level of lack of formal education in the region constituting 46.3% of the sampled population. Over 37.5% of the population have undergone primary education while only 16.2% attained secondary education. The statistics show that there are high levels of illiteracy amongst the farmers. This is reflected in the fall in food crop production since the farmers are redundant to new ideas that could guard against the whims and caprices of climate change impacts.

Poor access to information, the lack of awareness and inadequate knowledge on how to cope with variations in climate are some social constraints that have rendered the agricultural sector vulnerable to an extent in Ndu. Farmers have knowledge of many traditional and rudimentary practices in minimizing stresses, but often have little knowledge of new or alternate methods due to poor access to education, training or extension services. In Ndu, awareness reduces as you move away from villages around Ndu town, like, Ngarum, Kakar, Njiptop, Mbiyeh Njinigo, Njimkang to the hinterland villages, like, Ntayi, Luh, Ntantallah, Njimsar Nguluh, and Majeng.

On an educational scale, the more educated in this context are those who have gone through formal education and are receptive to modern adaptation methods than those who have not had any formal education. The less educated demonstrate a strong tie with their cultural inertias of local practices in farming like the burning of the soil, the refusal to apply fertilizers and fungicides amongst others. This goes to confirm what Mogou et al., (2007) concludes that, due to the lack of education and knowledge, farmers do not want to change from inherited traditional practices to evaluate and implement new methods. Most forecast information although rare, when made available to the population are poorly disseminated and delivered only shortly in advance of the forecast periods and only reach smallholder farmers in forms that they do not readily understand. This was the case in Ndu during the early rains of 2004, where farmers were told not to plant until the agricultural technicians told them to do so. Before this information got to villages like Njijong and Ntantalla, the villagers had planted and the rains went away for a month and they were forced to plant again during the March rains. Benhin (2006) and Enete et al., (2008) also noted further that the level of education of farmers and access to extension services are major determinants of the speed of adoption of the adaptation measures to climate change.

CLIMATIC AND NON-CLIMATIC FACTORS AFFECTING FOOD CROP PRODUCTION USING INFERENTIAL TOOLS

There exist a relationship between climatic and non-climatic factors and food crop production. From Table 5, rainfall shows a P-value of 0.1959 which implies that rainfall statistically accounts for 19.59% variation in maize production for the period under consideration. Therefore, a weak relationship exists between maize productions and rainfall. The remaining 80.41% of the variations in maize production could be accounted for by other factors, namely, farm inputs, soil structure and quality, and the seed varieties cultivated.

Table 5: Regression Results for Maize Production in Ndu Sub-division

Dependent Variable: MAIZE				
Method: Least Squares				
Date: 09/17/15 Time: 13:46				
Sample: 2000 2014				
Included observations: 15				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Rainfall	19.51966	14.17721	1.376834	0.1959
Temp	10222.48	3086.655	3.311832	0.0069
Humidity	-262.2858	947.2113	-0.276903	0.7870
C	-172583.8	76363.27	-2.260036	0.0451
R-squared	0.593187	Mean dependent var		38583.27
Adjusted R-squared	0.482238	S.D. dependent var		16304.81
S.E. of regression	11732.23	Akaike info criterion		21.80125
Sum squared resid	1.51E+09	Schwarz criterion		21.99006
Log likelihood	-159.5093	F-statistic		5.346486
Durbin-Watson stat	2.910389	Prob(F-statistic)		0.016228

Source: Computed from Data Gotten from the Meteorological Station for Ndu Tea Plantation (2014)

The p-value registered by relative humidity in Table 5 shows that there exist a non-significantly weak relationship between relative humidity and maize production. The relative humidity registered a P-value of 0.7870 which implies that 87.7% variations in maize productions are accounted for by relative humidity. The table also shows a P-value for external factors or non-climatic factors that account for variations in maize production. This P-value is 0.0451. A 1mm increase in these external factors which could possibly be the poor farming methods, poor planting seeds and the low level of awareness will reduce maize production by -172583.8 Tons per annum.

Table 6 shows a P-value of 0.5087 for rainfall. This means that rainfall accounts for 50.87% of variations in beans production. The P-value shows that there is no significant relationship between rainfall and beans production because the P-value is >0.05 threshold for a significant relationship to exist. Temperatures on the other hand, show a positive relationship with beans production. A P-value of 0.0525 on Table 6 indicates that there is a significant positive relationship between beans and variations in temperatures. This value implies that temperatures account for only 5.25% of variations in bean production in Ndu for the period under consideration. These results are realistic because the bean plant needs little rain and more of sunshine for flower formation and ripening of the bean pods. Furthermore, Table 6 reveals that relative humidity with a P-value of 0.8447 shows a weak relationship with beans production.

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Table 6: Regression results for beans production in Ndu Sub-Division

Dependent Variable: Beans
Method: Least Squares
Date: 09/17/15 Time: 13:47
Sample: 2000 2014
Included observations: 15

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Rainfall	2.493478	3.650065	0.683133	0.5087
Temp	1727.209	794.6902	2.173437	0.0525
Humty	-48.92349	243.8690	-0.200614	0.8447
C	-24692.03	19660.49	-1.255922	0.2352
R-squared	0.363975	Mean dependent var		9078.893
Adjusted R-squared	0.190513	S.D. dependent var		3357.265
S.E. of regression	3020.581	Akaike info criterion		19.08746
Sum squared resid	1.00E+08	Schwarz criterion		19.27628
Log likelihood	-139.1560	F-statistic		2.098304
Durbin-Watson stat	2.843539	Prob(F-statistic)		0.158586

Source: Computed from Data Gotten from the Meteorological Station for Ndu Tea Plantation (2014)

Non-climatic or external factors account for 23.52% in variations in bean production annually. Furthermore, these statistical results imply that an increase in these factors accounts for -24692.03 tons reduction in the quantity of beans produced. These factors are poor seeds, soil texture and structure, soil quality and poor knowledge on what to do to reduce variability and consequently the vulnerability of beans production. Table 7 presents the regression for potatoes production in Ndu.

From Table 7, a P-value for rainfall was recorded as 0.3011 meaning that there is no significant relationship between rainfall and potatoes production according to the statistical role. This value also means that 30.11% of the variation in potatoes production is accounted for by rainfall and a 1mm increase in rainfall will reduce potatoes production by 16.117 tons annually. The potatoes plant is very sensitive to heavy rainfall. This can partly be accounted for by the weak relationship that exists between rainfall and potato production. The late blight and early blight diseases that is common in the study area have registered their highest vulnerabilities in years of increased rainfall, namely, 1999, 2004, and 2009. This is because the blight causing bacterium proliferates more in high humidity and rainfall conditions.

Table 7: Regression results for potatoes production in Ndu Sub-Division

Dependent Variable: Potatoes
Method: Least Squares
Date: 09/17/15 Time: 13:48
Sample: 2000 2014
Included observations: 15

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Rainfall	16.11786	14.85318	1.085146	0.3011
Temp	7652.284	3233.826	2.366325	0.0374
Humidity	-312.4157	992.3741	-0.314816	0.7588
C	-139472.4	80004.25	-1.743312	0.1091
R-squared	0.432972	Mean dependent var		13371.73
Adjusted R-squared	0.278328	S.D. dependent var		14469.03
S.E. of regression	12291.62	Akaike info criterion		21.89440
Sum squared resid	1.66E+09	Schwarz criterion		22.08322
Log likelihood	-160.2080	F-statistic		2.799799
Durbin-Watson stat	2.123062	Prob(F-statistic)		0.089626

Source: Computed from Data Gotten From the Meteorological Station for Ndu Tea Plantation

Temperatures show a significant positive relationship with potatoes production. Temperatures have a P-value of 0.0374 which is <0.05. Statistically, this P-value means that temperatures would account for merely 3.74% of the variations in potatoes production. Furthermore, a 1^{o}C increase in temperatures will account for an increase in potatoes production by 7652.284tons annually. A potato plant during its tuber formation needs more of sunshine than heavy rains that may encourage blight attack. Temperatures therefore have a significant positive relationship with potato as it partakes in the growth process. Also, temperatures play a very important role both in the dark and light stages of photosynthesis in plants.

Relative humidity, relates negatively with potato production as shown in Table 7. Relative humidity registered a P-value of 0.7588. This is an indication that 75.88% variations in potato production is statistically accounted for by relative humidity. Again, statistically, a 1mm increase in relative humidity as depicted by Table 7 will reduce potato production by -312.4157tons annually for the period under consideration. The standard relative humidity required for potato production in high altitude areas like Ndu is 65%. Above this standard, the crop is bound to fail, consequently increasing variability.

External factors not considered in the model account for 10.91% in variations in potato production. Furthermore, an increase in any of these factors will account for a reduction of -139472.4 tons in potato production annually for the period under consideration. The study found out that though favourable rainfall, temperatures and humidity are necessary conditions in the growth cycle of food crops, the data sourced and analyzed, revealed that there is a variation in the relationships that exists between crop production and the climatic parameters of rainfall, temperatures and relative humidity in the study area. The regression analysis revealed that there is no significant relationship between maize, beans, potatoes, cattle and rainfall variability in the study area for the time period under consideration. The regression results were further corroborated with the correlation technique which further revealed a weak correlation between maize, beans, potatoes and rainfall variations in Ndu from 1981 to 2014.

Conversely, the regression analysis showed that there exist a significant relationship between maize, beans, potatoes and variations in temperatures. The correlation matrix further revealed that a strong positive relationship exists with crop production and variations in temperatures. However, the regression analysis showed a negative relationship with cattle production and variations in temperatures which is not significant. The correlation results again, further revealed a weak negative relationship with cattle production and temperature variations.

Relative humidity on the other hand, revealed that there exists a negative relationship between maize, beans, potatoes and temperature variations. Correlation analyses revealed that the negative relationship is a weak one with correlation values all <2. Astonishingly, the only variable with which relative humidity did not negatively relate with was cattle but this was a weak positive relationship, with a P-value of >0.9200 and a correlation value of <0.2. All these showed that a weak relationship exists between the cattle production and relative humidity.

CONCLUSIONS

The weak relationships that exist between the climatic parameters of rainfall and relative humidity suggest that variations in agricultural production in the study area may therefore be attributed to other factors which are also critical in agricultural production. These include the non-climatic factors that have been discussed extensively in the study. With respect to the different variables that determine agricultural production, the results of this study show that the different villages studied had much in common and could benefit equally from the same improved technologies and recommendations. Sustainable agricultural intensification in the Western Highlands of Cameroon and Ndu in particular would involve the scaling up of farming practices that maintain the resource base on which smallholders depend, so that it can continue to support food security and rural development into the future. This could be done by addressing land use intensity.

RECCOMENDATIONS

Through the Sub-Divisional Delegation for Agriculture and Rural Development for Ndu Sub-division, emphasis should be laid on more sustainable farming practices. This will go a long way to limit the non-climatic factors that seem to be having a great deal of impact on the crop sector in this area. As a result, agriculture that is truly sustainable will not mean business as usual. It will be a type of agriculture that will provide environmental sustainability. Emphasis should not be placed on maximizing yields and economic returns, but should rather focus on optimizing productivity and conserving the natural resource base. Researchers on the other hand need to address land use intensity, off-farm inputs intensity, household adjustment factors and the mobility of the households since the variations in farming systems and the common characteristics of farms lead to uncertainties about the effectiveness of decisions, from farmer's and from a policy perspective.

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