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Relationship between Agro-climatic parameters and Sugarcane Yield in Adamawa State, Nigeria

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Abstract: *The study examined the relationship between the major climatic parameters and the yield of sugarcane in Southern parts of Adamawa state, Nigeria. The parameters considered include rainfall, temperature, relative humidity and solar energy. To achieve the aim of the study, Pearson's Product Moment Correlation Coefficient (PPMCC) tool was used to examine the relationship between each climatic condition and the yield of sugarcane. Climatic data were obtained from Nigerian Meteorological Agency (NiMet), Global Weather Data for SWAT (GWDS) and NASA Prediction of Worldwide Energy Resources (POWER). The data were from 1979 to 2014 (35 years). The result indicated that, there is weak positive correlation between the yield of sugarcane and Minimum temperature, rainfall and relative humidity (RH) which had PPMCC values of 0.1, 0.2 and 0.1 respectively. While weak negative correlation was observed between the yield of sugarcane and Maximum temperature, and solar energy with PPMCC values of -0.3 and -0.1 respectively. This shows that as the values of Minimum temperature, rainfall and RH increase, the yield of sugarcane increases gradually too. On the other hand, as the values of Maximum temperature and solar energy increase the yield of sugarcane declines gradually in response. Therefore, the trend of these climatic conditions should be considered when investing in sugarcane production. Advice on the expected prevailing weather by authorities such as Nigerian Meteorological Agency should be taken serious by stakeholders for maximum yields.*

Keywords: *Agro-climatic, correlations, dataset, sugarcane, yield.*

INTRODUCTION

Agro-climatic conditions are indisputably very important in crop production, especially for large scale farming in Nigeria where irrigational farming is a costly venture. Nevertheless, the peasant subsistent farmers always depend on the natural source of all the agro-climatic conditions needed for crop production. Therefore, the outcome of a study on the relationship between these conditions and crop yield will be good information to the stakeholders.

According to Republic South Africa (2014), the scientific name for sugarcane is *Saccharum officinarum*. That the crop composed of six species of perennial grasses of the genus *Saccharum* L., in tribe Andropogoneae of the Poaceae. There are however, two wild species (*S. spontaneum* L. and *S. robustum*) and four cultivated species, *S.officinarum* L., *S. barberi*, *S. sinense* and *S. edul*e. The four cultivated species are complicated hybrids, and all intercross readily. All commercial canes grown today are inter-specific hybrids. Looking at some of the characteristics of sugarcane Samui*et al.* (2003) pointed that, the crop is a highly versatile one which is successfully grown on diverse types of soils and climatic conditions. Because it is a tropical crop, it grows well in hot, sunny and humid environments.

Every plant has specific climatic condition in which it strives well, same as sugarcane. Srivastava & Rai (2012) noted that climate plays an important role in all the phases of sugarcane crop (and of course any other crop). That, since sugarcane stands in the field for 12-24 months, hence it passes through all possible limits of weather parameters such as rainfall, temperature, sunshine, and humidity. Consequently, all climatic conditions have significant role in the crop's growth, sugar yield, quality and sucrose. For optimum growth of the crop and high production, specific amount of weather conditions is required. Directorate of Sugarcane Development (2013), reported that temperature from 32° to 38°C is the best for stem cutting sprouting. Temperature below 25°C usually slows down growth and reaches its apex between 30°-34°C. Temperatures more than 38°C reduce the rate

of photosynthesis and speed up the rate of respiration. In terms of ripening, the ideal value is put at relatively low (12°C to 14°C).

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In terms of the uses of sugarcane, the crop has some significant impact to our lives all over the world. Yamane (n.d.) & Magness *et al.* (1998) identified some uses of this crop. For instance, sugarcane by-products that is, bagasse (cane fibers) and straw is used to produce one of the Second-Generation biofuels—cellulosic ethanol. In addition, some other products of sugarcane are rum, molasses, and Brazilian alcohol called cachaça, the cane itself is used as thatch and as well as fodder for livestock. Sugarcane is broadly considered amongst the most efficient sources of biomass in the production of bio-fuel (NETAFIM, 2014). The crop is grown solely for production of sugar and bio-fuel, to make molasses, soda, cachaca, rum. The by-products of sugarcane known as bagasse is used as a source of fuel for heat and in the generation of electricity (Grant, 2018; Asiafarming.com, 2018; Nasir, 2001).

This study is an effort put to look at how the major climatic parameters in the southern parts of Adamawa state relate with the yield of sugarcane. This will help the farmers in their plans for the cultivation of sugarcane in the southern parts of Adamawa state. There are two major sugar factories one located at Numan in Adamawa state and the other at Bacita in Kwara state; were both established in 1977 and 1961 respectively. These two factories originally have combined capacity, estimated at 105,000tonnes of sugar annually, which was meant to meet 10% of Nigerian total sugar demand. However, sugar output has been hovering around 50,000 tonnes yearly which is below 5% of the nation's total demand (Daniel *et al.,* 2013).

METHODOLOGY

Study Area

Adamawa state in located in the north-eastern part of Nigeria within latitudes 7°N and 11°N and longitudes 11°E and 14°E with total area coverage of about 36,917m². It shares boundaries with Taraba state in the south-west,

Gombe state in the north-west and in the north with Borno state. In the eastern part, the state shares an international boundary with the Republic of Cameroon (Adebayo & Tukur, 1999). However, the study area, that is the southern parts of the Adamawa state consists of only eleven (11) Local Government Areas and lies between latitude 7°N and 10°N (Field work, 2019).

According to Adebayo & Tukur (1999), Adamawa state is characterised with varied rainfall ranging from 700mm in the north-western part to 1600mm in the southern part. By and large, the mean annual rainfall is less than 1000mm in the central part of the state. This region includes, Song, Gombi, Shelleng, Guyuk, Numan, Demsa, Yola and part of Fufore Local Government Areas (LGAs). Northern strip and southern part have over 1000mm in the other hand. This variation of the annual rainfall amount is as the result of the altitudes of the stations. The landforms can be divided into valleys/troughs, low lands, upland plains and hills/mountains ranges. It is pertinent to note that, Benue valley—the largest valley in the state—divides the state into two relatively equal parts, with landform of similarity in outlook and area coverage (Adebayo & Tukur, 1999).

The major vegetation formation of the state is divided into three zones: The southern Guinea savannah, the northern Guinea savannah and the Sudan savannah. However, each formation is characterised by interspersion of thickets trees Savannah, open grass Savannah and fringing forest in the river valleys (Adebayo & Tukur, 1999).

Data Collection

The climatic and yield of sugarcane in the study area data which are secondary data were used for the study. The climatic data used include: Rainfall, Maximum Temperature, Minimum Temperature, Solar energy, and Relative Humidity (RH). These datasets were obtained from Nigerian Meteorological Agency (NiMet), Global Weather Data for SWAT (GWDS) and NASA Prediction of Worldwide Energy Resources (POWER). The data covered a period of 35 years, which is from 1982 to 2017. The computation was carried as follows:

The yield of sugarcane data for the study area from 1980 was obtained from Dangote Sugar Company, Numan.

Data Analysis

The daily amount and mean values of all the climatic data of the study area were computed in the Excel environment to come up with annual amount and mean used in achieving the aim of this study. This was done to prepare the data for correlation analysis and examination of their relationship with the yield of sugarcane in the southern parts of Adamawa state.

For the rainfall, simple arithmetic of addition was used. The daily values were summed up to come up with the monthly amounts, which were further added to get the total annual value for a given year. This computation was carried out using the *summation* tool in Microsoft Excel 2010. The computation was carried out as follows:

1. ***Monthly Total Amount*** = *Day 1 (Value) + Day 2(Value) + Day 3 (Value)……..Last Day of the Month (Value)*

2. ***Annual Total Amount*** = *January (Value) + February (Value) +March (Value)……..December*

For the other climatic datasets that is temperature, relative humidity and solar energy, their annual means were computed and used in the analysis. This was done by first, computing the monthly means from the daily values, which in turn were used to get the annual means used for the study. Here too, Microsoft Excel 2010 *Average* tool played a great role. The arithmetic mean formula used is as follows:

$$\bar{X} = \frac{X1+X2+X3...XN}{N}$$

Where: $\bar{X}$ = the mean
X1 = the first value
X2 = the second value
X3 = the third value
XN = the last value
N = the number of value

1. ***Monthly Means*** =

$$\frac{\textit{Sum of Daily Values for the Month}}{\textit{Number of Days in the Month}}$$

2. ***Annual Means =***

$$\frac{\textit{Sum of Monthly Mean Values}}{12}$$

Pearson's Product Moment Correlation Analysis

Pearson *r* correlation is used to measure the degree of relationship between two variables. The point-biserial correlation is conducted with the Pearson correlation formula except that one of the variables is dichotomous. The following formula is used to calculate the Pearson *r* correlation:

$$r = \frac{N\sum xy - \sum(x)(y)}{\sqrt{[N\sum x^2 - \sum(x^2)][\sqrt{N[\sum y^2 - \sum(y^2)]}}}$$

Where : r = Pearson r correlation coefficient
N = number of observations
∑xy = sum of the products of paired scores
∑x = sum of x scores
∑y = sum of y scores
∑x2= sum of squared x scores
∑y2= sum of squared y scores

If the value of *r* is close to +1, it indicates a strong positive correlation, and if *r* is close to -1, it denotes a strong negative correlation.

RESULTS AND DISCUSSION

Results

Relationship between Maximum Temperature and Yield of Sugarcane

From Figure 2 and Table 1 the correlation test carried out for maximum temperature and yield of sugarcane indicates that, there is weak negative correlation between the yield of sugarcane and maximum temperature.

Table 1 Results of Pearson's Product Moment Correlation Coefficient at a Significance level alpha 0.05 and p-value 0.032

Variable	Value
Maximum Temperature and Yield	-0.26137
Minimum Temperature and Yield	0.139888
Rainfall and Yield	0.210854
RH and Yield	0.083491
Solar Energy and Yield	-0.09106

Source: Author

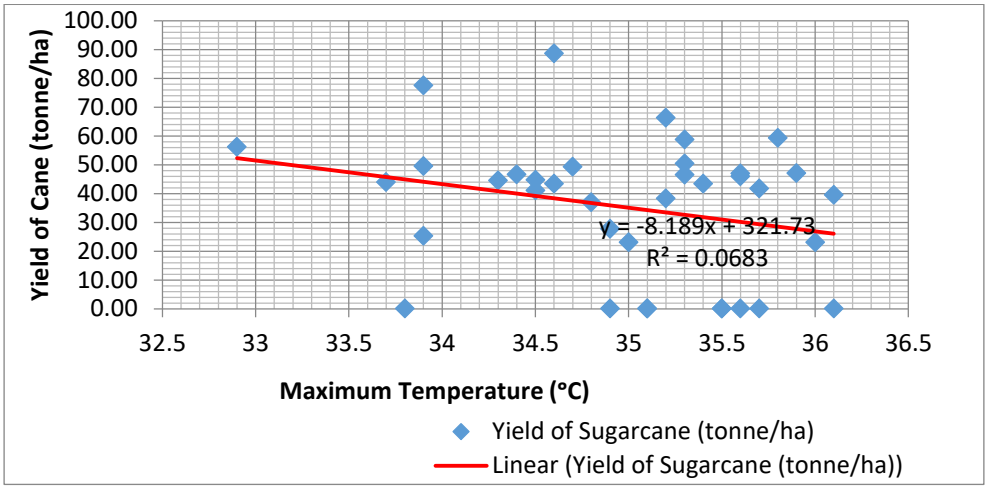

Figure 2 Relationship between Maximum Temperature and Yield of Sugarcane
Source: Author

Relationship between Minimum Temperature and Yield of Cane

From figure 3 and table 1 the relationship between minimum temperatue and yield of cane indicates a positive correlations.

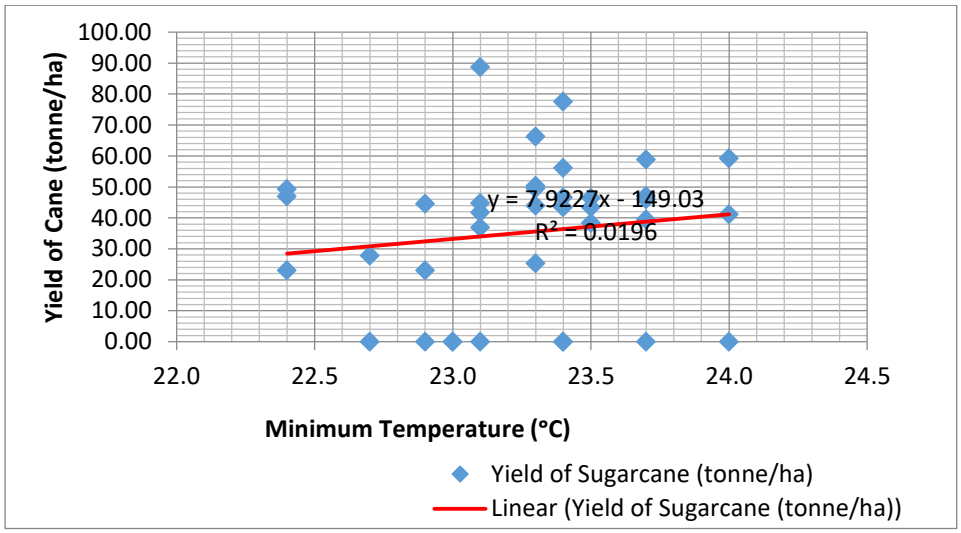

Figure 3 Relationship between Minimum Temperature and Yield of Sugarcane
Source: Author

Relationship between Rainfall and Yield of Cane

Rainfall is one of the most important climatic elements a crop requires for growth and yield. The correlation test result in figure 4 and table 1 shows that, there is a positive correlation between the total annual rainfall and the yield of cane.

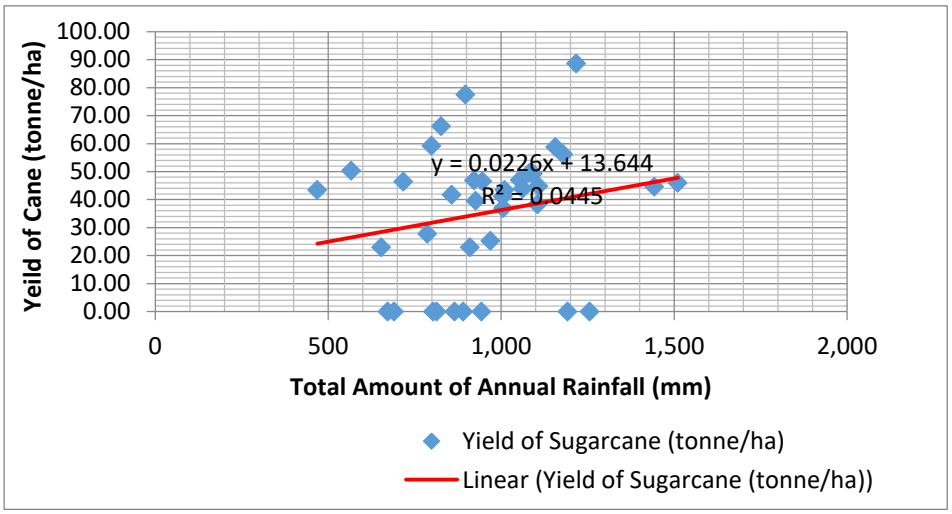

Figure 4 Relationship between Rainfall and Yield of Sugarcane
Source: Author

Relationship between Relative Humidity (RH) and Yield of Cane

Relative Humidity plays an important role in the cultivation of sugarcane also. The correlation test carried out in this study on yield of cane and RH is shown in figure 5 and table 1.

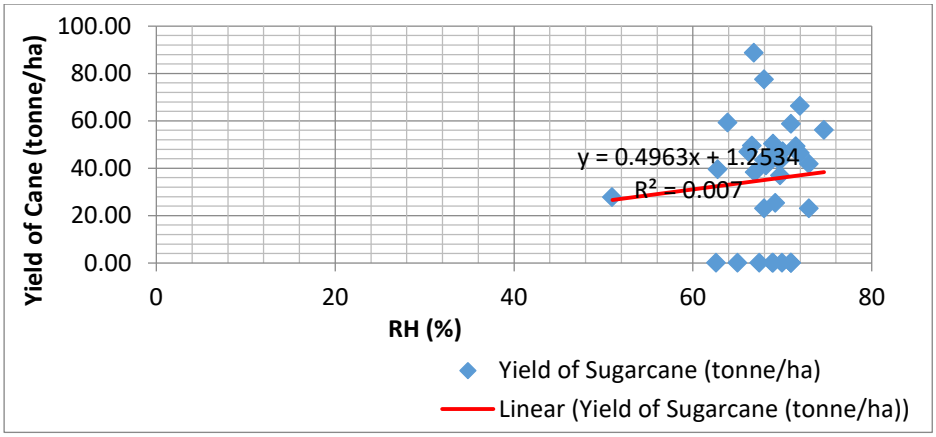

Figure 5 Relationship between Relative Humidity and Yield of Sugarcane
Source: Author

Relationship between Solar Energy and Yield of Cane

Solar energy is also one of the requirements for any crop growth and yield. Sugarcane also requires certain intensity of solar radiation to undergo the process of photosynthesis like any other crop. Therefore, to examine the relationship between solar energy and sugarcane, correlations test was carried out. The results are shown in figure 6 and table 1.

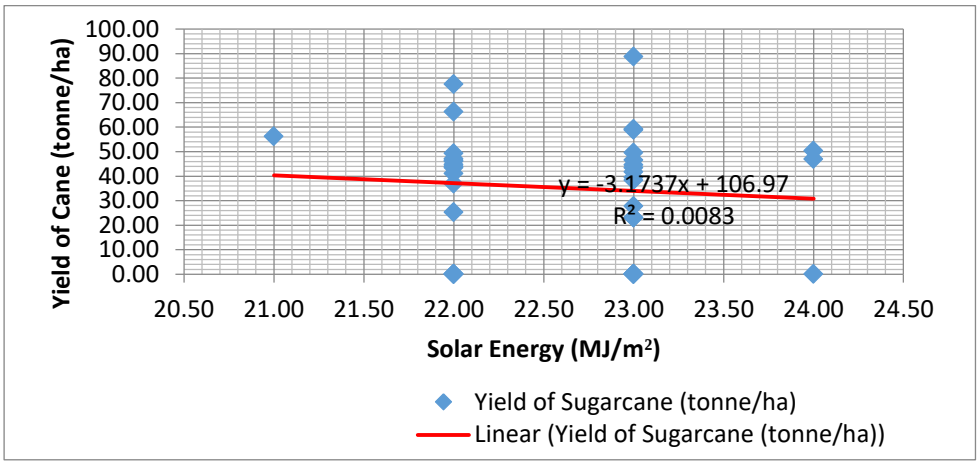

Figure 6 Relationship between Solar Energy and Yield of Sugarcane
Source: Author

Discussion

The Pearson's Product Moment Correlation Coefficient (PPMCC) computation was used to examine the relationship between each agro-climatic condition and the yield of sugarcane in the study area. The result of each test is explained in the following sections in topical order.

Rainfall and Sugarcane Yield

Rainfall is one of the most important climatic elements a crop requires for growth, development and yield. The correlation test result shows that, the PPMCC value is 0.21 (table 1). This is an indication that, there is a weak positive correlation between the two variables. Therefore, it is not out of place to conclude that, over the period covered in this study, yield of sugarcane showed a gradual increase as the amount of annual rainfall increased too (figure 4).

Maximum Temperature and Sugarcane Yield

The result of the relationship test is shown in table 2 and figure 1. From the result, the PPMCC value for the relationship is -0.26. This is an indication that there is a weak negative correlation between the yield of cane and the maximum temperature in the study area. This

means that, as the temperature increases the yield of cane decreases gradually over the time.

Minimum Temperature Sugarcane Yield

In examining the relationship between the yield of cane and minimum temperature, table 1 and figure 3 are the result of the analysis. From the result, the PPMCC is 0.14, which indicates a weak positive correlation. This in other words means that as the minimum temperature increases over time the yield of sugarcane also increases gradually through the period of the study.

Relative Humidity (RH) and Sugarcane Yield

From the result of the test shown in table 1 and figure 5, it is indicated that there is a correlation between the two variables. However, from the value of PPMCC (0.08), one could deduct that; the correlation is a weak positive one. This means that, over the period covered by this analysis, the yield of sugarcane increased gradually as the RH value increased.

Solar Energy and Sugarcane Yield

Solar energy is also one of the requirements for any crop's growth and yield. Sugarcane also requires certain intensity and duration of solar radiation to undergo the process of photosynthesis like any other crop. Therefore, to examine the relationship between the solar energy and yield of cane, correlation test was carried out. The result shows that there is a weak negative correlation between the two variables (table 1). Therefore, increase in the amount of solar radiation induces a gradual decrease in the yield of sugarcane (figure 6).

CONCLUSION AND RECOMMENDATIONS

This study indicates that, there is weak relationship between the yield of sugarcane and the agro-climatic conditions. Nevertheless, it is noteworthy that, all these climatic factors have impact in the production of sugarcane in the study area.

In as much as all the climatic factors are essential in the production of sugarcane, there is also a required amount needed as ideal. The study therefore, shows that, increase in some of these factors result in increase in the yield of sugarcane, increase in others leads to decrease in the yield of the crop. From the study, it is clear that, even though maximum temperature and solar energy are needed for the crop to grow, yield and product sugar, increase in their amount will always lead to decrease in the yield of the crop. In the other hand rainfall, relative humidity and minimum temperature show a positive influence on sugarcane production. This means that, increase in the amount or quantity of these factors will always induce increase in the yield of sugarcane.

To many peasant farmers this fact may not be clear to them, but if ministry of Agriculture in the state could take the pain of enlightening them on this fact, their approach to sugarcane cultivation would be improve for good yield. Agency such as NiMet usually gives seasonal rainfall prediction and early warning on the expected prevailing seasons. Therefore, stakeholders in the business of sugarcane cultivation should always adhere to their pieces of advice when planning to cultivate the crop. Since, increase in the amount of rainfall will lead to increase in the yield of sugarcane; irrigation should be encouraged and incentive provided by the government to the prospective farmers to enable them supplement shortage of rainfall should it occur in a given year.

REFERENCES

Adebayo A. A. & Tukur A. L. (1999). *Adamawa state in maps*. First edition. Yola. Paraclete Publishers.

AsiaFarming.com (2018). Sugarcane cultivation guide. Retrieved from: www.asiafarming.com/sugarcane-cultivation.

Daniel, J. D., Adebayo, E. F., Shehu, J. F., & Tashikalma, A. K. (2013). Technical efficiency of resource-use among sugarcane farmers in the Northeast of Adamawa state, Nigeria. *International Journal of Management and Social Sciences Research (IJMSSR),* 2 (6), 13—18, ISSN: 2319-4421.

Directorate of Sugarcane Development (2013). Government of India, Ministry of Agriculture, 1-16.

Duli, Z. & Yang-Rui, L. (2015). Change and sugarcane production: potential impact and mitigation strategies. *International Journal of Agronomy*. Volume 2015. http://dx.doi.org/10.1155/2015/547386

GAMERS (2019). Map of Adamawa State, Nigeria.Retrieved from: https://www.gamers.com.ng/map-of-adamawa-state-nigeria/

Grant, A. (2018). Sugarcane care – sugarcane plant info and growing tips. Gardening Know How. Retrieved from https://www.gardeningknowhow.com/edible/herbs/sugarcane/sugarcane-plant-information.htm.

Letstalkagric (2017). Sugarcane farming guide. Retrieved from http://www.letstalkagric.com/crops/sugarcane-farming-information-guide.

Magness, J. R., Markle, G. M. & Compton, C. C. (1998). Food and feed crops of the United States. *Interregional Research Project IR-4, IR Bul. 1*. Bul 828. New Jersey Agri. Expt. Sta. Retrieved from https://www.hort.purdue.edu/newcrop/Crops/Sugar_cane.html.

Mondale, P. (2017). Sugarcane Cultivation in India: conditions, production and distribution. Retrieved from http://www.yourarticlelibrary.com/cultivation/sugarcane-cultivation-in-india-conditions-production-and-distribution/20945.

Nasir, A. (2001). Sugar production in Nigeria: A case study of Savannah Sugar Company limited, Numan, Adamawa State, Nigeria. Unpublished MSc. Thesis, University of Ibadan.1–27.

NETAFIM, (2014). Sugarcane cultivation with drip irrigation. Retrieved from www.netafim.com.

Obi, J. N. & Zemba, A. A. (2016). Impact of local climate on sugarcane water footprint: a case study of Dangote Sugar Company Numan, Nigeria. FUTY *Journal of the Environment*. 10 (1). 95-106.

Republic of South Africa (2014). Sugarcane production guidelines. Department of Agriculture, Forestry and Fisheries. 1-24.

Srivatava, A. K. & Rai, M. K. (2012). Sugarcane production: impact of climate change and its mitigation. *Bio Diversit AS*. 12 (4) 214-227 doi: 10.13057/biodiv/d130408.

Yamane, T. (n.d).Sugarcane.Encyclopaedia Britannica. Retrieved from https://www.britannica.com/plant/sugarcane.

