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Effect of Rainfall Variability on the Yield of Yams in Apa Local Government Area of Benue State, Nigeria

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Abstract

This study examined the effect of rainfall variability on the yield of yams in Apa Local Government Area of Benue State, Nigeria. Rainfall data was sourced from the archives of the Nigerian Meteorological station, Oshodi, Lagos; the yam yield data was collected from the archives of Benue State Agricultural and Rural Development Agency (BNARDA). The rainfall and yam yield data for 33 years (1988-2021) were used to characterise the yam yield response to rainfall pattern (increase or decrease). Trend line equation was used to show the trend of rainfall, while Pearson's Correlation Coefficient (r) showed the degree of relationship between rainfall and yam yield. The result in the trend line equation showed increase in the total annual rainfall ($y = 7.1873x + 1106.4$). The result in the yield pattern of yams also showed that yam yield is on the increase ($y = 3.3328x + 284.52$). The result of the correlation showed that there is a significant correlation between annual rainfall and yam yield ($r=0.65$), which implies that yam yields increase as rainfall amount increases. The result corroborated the findings of previous researchers which confirmed that rainfall influence yam yield in Benue State. This increase in yields was also attributed to increase in knowledge and adoption of viable adaptation strategies/improved production practices by the farmers. Based on these findings, the study therefore recommend the adoption of viable adaptation strategies for the continuous production of yams towards food security in the area; farmers should be encouraged to adapt measures such as improved seed varieties; use of organic or inorganic fertilizer; use of early maturing varieties among others.

Keywords: Crop Production; Pearson's Correlation, Rainfall; Relationship; Variability and Yield

Introduction

Rainfall variability is arguably one of the most important challenges facing African countries, largely due to their geographic exposure, low income, greater reliance on climate-sensitive sectors such as agriculture, and weak capacity to adapt to the changing climate (Belloumi, 2014). Nigerian agriculture depends profoundly on climate since rainfall is a principal driver of crop yield and growth (Webber, 2017). Rainfall variability and pattern has significantly affected global agriculture in several ways, ranging from direct effects on crop production. The Intergovernmental Panel on Climate Change (IPCC, 2007) assessment report indicates that most countries will experience an increase in average temperature, more stressed water

resources, and periods of heavy precipitation.

Rainfall variability is the fluctuations of rainfall occurrence annually or seasonally above or below a long-term normal value. Every year, the rainfall of a location can be different in a specific period, either above or below normal (IPCC, 2012). Rainfall values in last decade reduced drastically and affected crop yields across Nigeria (Iornongo, 2021).

Yams (Dioscorea sp.) are annual or perennial tuber-bearing and climbing plants. The genus Dioscorea has over 600 species but only a few are cultivated for food and others for medical uses. The major edible species of African origin are white guinea yam (Dioscorea rotundata Poir), yellow guinea yam (Dioscorea cayenesis Lam) and trifoliate or bitter yam (Dioscorea dumetorum Kunth) (Akissoe et al., 2003). In Nigeria the common species grown are white yam (Dioscorea rutundata) and water yam (Dioscorea alata) (Brand-Miller et al., 2003 & Osunde, 2008).

Nigeria is the world's largest producer of yams, accounting for 71% (26 million ton) of the total world production of yam harvested from 2,760.00 hectares (Central Bank of Nigeria [CBN], 2003; Food and Agricultural Organisation (FAO, 2002). Statistically in 2004, the global yam production was about 47 million metric tons, which about 95% of the metric tons was produced in Africa. With growing demand, yam has assumed great importance in Nigeria. The nation produces about 31.5 million metric tons of yams annually.

Based on quantity of root and tuber crops produced in Nigeria, yam ranks second only after cassava (National Bureau of Statistics (NBS, 2007). Although, there has been a decline in yam production relative to cassava and rice in Africa. Yam is such a preferred staple food that, bearing in mind that as population increases, demand will remain, and the absolute production will rather increase. Despite the importance of yam to Nigeria's economy, the production and yield of these crops are being threatened by rainfall variability (Srivastava & Gaiser, 2008).

Benue State is proudly referred to as the 'food basket of the nation' since the rich nutrients deposits of alluvial soils that support bumper harvest have helped farmers in producing crops on large scale. However, with the climate change and rainfall pattern, rainfall has become a critical issue in recent years. Therefore, rainfall variability and its attendant weather events have become what farmers will have to cope with, since it is fast becoming

unpredictable to give accurate account of crop yields on farms (Akinkunmi, 2020).

Irrespective of the yam's culinary, health, and economic benefits for Nigeria, research shows a decline in yam production in the country's north-central regions, such as Benue State, where most yams are grown (Aighewi et al., 2021 & Apu et al., 2020). The decline in production is mostly owing to its sensitivity to climatic conditions, particularly moisture, as a result of variations in rainfall, rather than other environmental or edaphic factors. (Atedhor, 2020; Eruola, *et al.* 2012 & Okongor, *et al.*, 2021). This is because an optimal yield requires a balanced water supply during the critical and active growth periods of vine and leaf development, tuber initiation, and bulking, but this is not always the case as yam is grown under a rain-fed system, which cannot guarantee consistent moisture availability throughout the growing season (Eruola et al., 2012).

Despite its contribution to the economy, Benue's agricultural sector faces many challenges which affect its productivity. Previous studies (Tyubeel, *et al.*, 2020; Adamgbe & Ujoh, 2013; Shaibu, *et al.*, (2022) all confirmed rainfall variability in Benue State and that the variability impact greatly on crop yield, including yams. Crop yield, apart from being a source of boost to the economy of the nation, improves the quality of life and aids in the sustenance of human existence. The objective of the study is to assess the impact of rainfall on yam yield and to show the relationship between rainfall and yield in the area. It is on this premise that this study investigated the effects of rainfall variability on the yield of yams in Apa Local Government Area (LGA) of Benue State, Nigeria.

Study Area and Methodology

Study Area

Apa LGA is in North-Western part of Benue State. The LGA is located on Latitude 7°20′ North to 7° 50′ North and Longitude 7° 40′ East to 8° 10′. It is bounded to the North by Agatu LGA, Otukpo LGA to the south, Gwer-West LGA to the East and Olamaboro LGA of Kogi State to the West (Jande & Amonjenu, 2018). The LGA has its headquarters at Ugbokpo and it consists of 11 council wards. The LGA has a population of about 146,138 people (projected to 2023) and a land area of about 995 Km^2 (National Population Commission, 2006).

Climatically, the State belongs to the Koppen's Aw climate group and experiences seasonal wet and dry seasons. The rain falls for seven months from April to October with total annual amount ranging between 12,000-20,000mm while

dry season sets in November and ends in March (Ologunorisa & Tersoo, 2006). Temperatures are constantly high averaging between 28-32°C and sometimes rising to 37°C. The vegetation still possesses relics of the guinea savanna with coarse grasses and numerous species of scattered trees. Dense forests are very few and far apart in the State and exist either as gallery forest, village forest or forest reserves (Terwase & Terese, 2013). Agriculture forms the backbone of the State economy, engaging more than 70% of the population. The State has an advantage of being located across both the forest zone where tree crops are grown and the savanna where mainly grains are cultivated.

Apa LGA is called "the green land" of Benue State because of its huge agricultural potential. The area is endowed with rich fertile lands, which encourage variety of arable crops such as yam, rice, cassava guinea corn, maize, groundnuts, beniseed, pepper, cowpea, e.tc. Crops such as vegetables are produced on smaller scale during the dry season (Jande & Amonjenu, 2018).

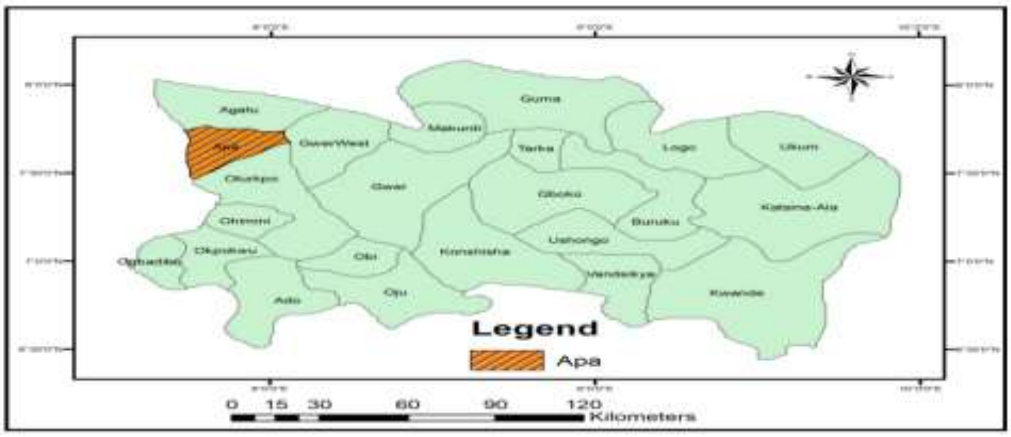

Figure 1: The study Area in Benue State
Source: Nigeria shape file

Data required

Rainfall and yam yield data for 33 years (1988 - 2021) were obtained and used for the study. The choice of using thirty-three (33) years data was because of the unavailability of yam yield data for the area before 1988.

Sources of data

Rainfall data was sourced from the archives of the Nigerian Meteorological station, Oshodi, Lagos, while the yam yield data was collected from the archives of Benue State Agricultural and Rural Development Agency (BNARDA).

Analytical techniques

The rainfall and yam yield data for 33 years (1988-2021) were used to characterise the

yam yield response to rainfall pattern (increase or decrease). Trend line equation was used to show the trend of rainfall, while Pearson's Correlation Coefficient (r) showed the degree of relationship between rainfall and yam yield. The analysed results were presented using charts and tables.

Results and Discussion

Trend in the Total Annual Rainfall (TAR) of the study area for the period of study is presented in Figure 2.

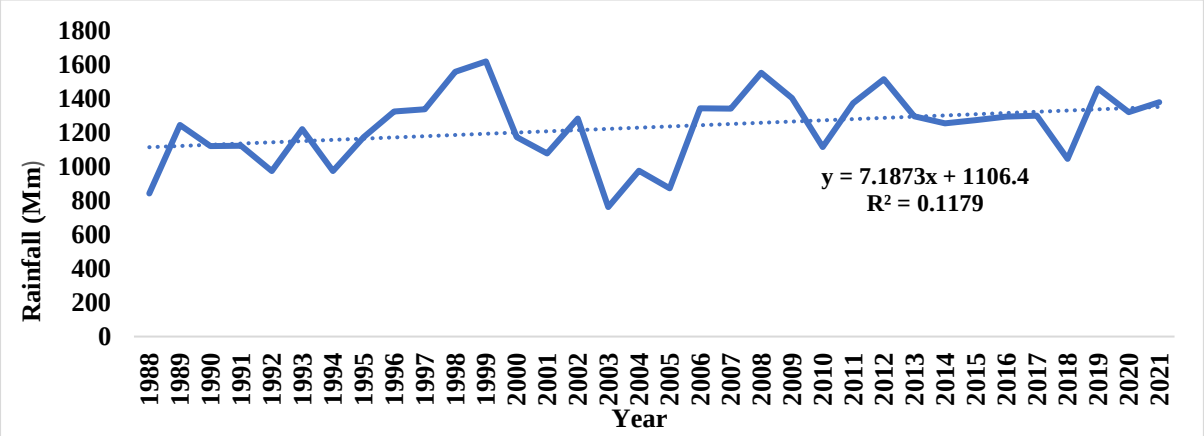

Figure 2: Trend in Total Annual Rainfall (1988 – 2021)

The trends show a fluctuating pattern in the TAR for the 33 years reviewed. Although, the best fit trend line shows a positive equation (y = 7.1873x + 1106.4) which implies that TAR is on the increase. This result agrees with the findings of Adamgbe & Ujoh (2013), which reported that rainfall amount is on the increase in Gboko LGA of Benue State. According to Akinola, *et al., (2019),* farmers' in Benue State perceived an increasing trend in annual rainfall, while the observed variability showed increasing trend in all the rainfall variables.

According to Ayoade (2004), rainfall has more significant effect on inter-annual changes in crop yield in a tropical environment as it determines the supplies of water to plants. Moreover, rainfall is the most variable of all climatic elements and determines the growing season in developing countries like Nigeria where agriculture is predominantly rain-fed. Almost every farmer is interested in what the expected rainfall would be, more than any other climatic elements as it determines the success or failure of crops. Timely and accurate weather forecasting is crucial to improving farming activities. This would require developing human capacity and appropriate infrastructure for weather forecasting and information sharing (Ikpe *et al.*, 2016).

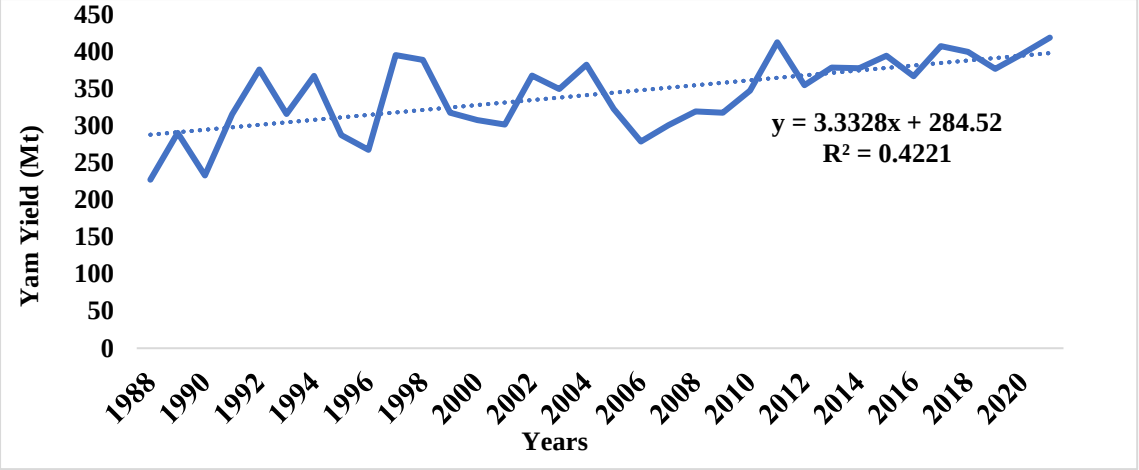

Figure 3: Yield Data for Yam for 1988 – 2021

Figure 3 indicate that yam yield in the study area is characterized by marked variability, although the trend line equation y = 3.3328x + 284.52 shows an increasing trend in the yield of yam between 1988 - 2021. The highest yield was recorded in 2021 (418.69 tons/ha).

Figure 4 showed the correlational trend chart for rainfall and yam yield for Apa LGA. The result indicated that rainfall plays a significant role in yam yields as yields were above rainfall amount. The results showed a positive interaction between rainfall and yield. This implies that beyond rainfall, there are other factors that could contribute to the yield of yams in the area. These factors could be related to the farmers' farming experience and possible adoption of climate smart agricultural practices towards food security in the area. The results of the analysis and the maps produced further eshowd that inter-annual rainfall brings about the differences in water availability, which consequently affect the rate of yam (high) yield in the study area.

According to Akinkunmi (2020), rainfall determines the yield of crops in Benue State, including yam. He reported that the yield data from 1980 to 2018 recorded more often a decreasing trend and less increasing trend on the various crops analyzed. This is due to the amount of rainfall (mm) that Benue State accessed and whether such rainfall is in adequate supply or excess (which leads to flooding).

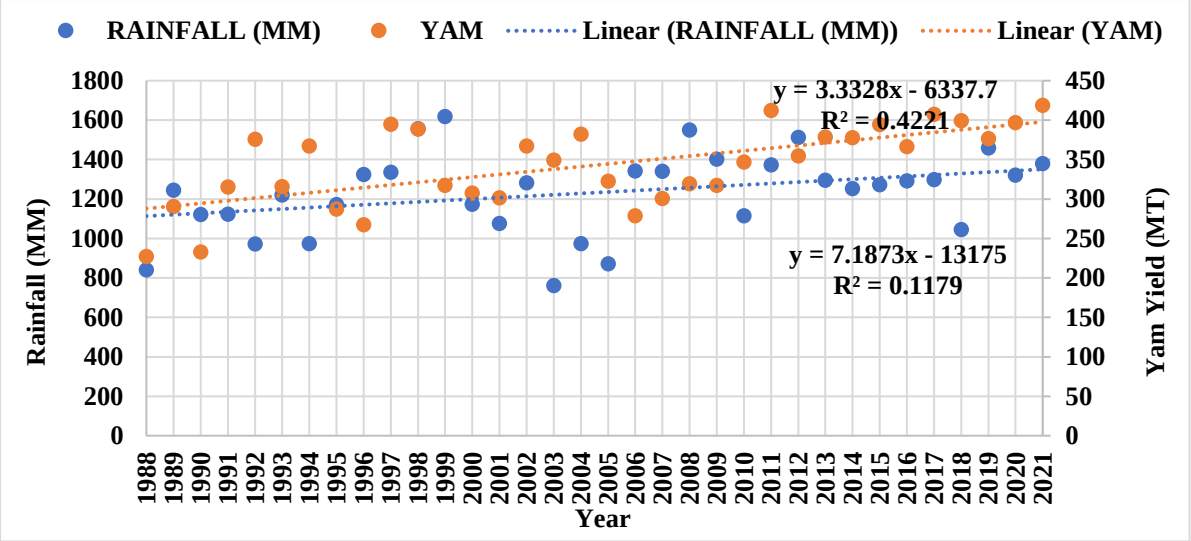

Figure 4: Correlational Trend Chart for Rainfall(mm) and Yam Yield(mt)

The relationship between rainfall and yield of yam in Benue State is presented in Table 1. Rainfall shows a significant low relationship with years with a coefficient of 0.34 at P<0.05. Yield of yam had a positive significant relationship with years with a coefficient of 0.65 implying a strong positive correlation. This indicates that yield of yam increases at a high rate with advance in years of yield. The results corroborated with the findings of Samuel, et al., (2018) which reported that the yield of yam had a positive significant relationship with TAR. Their result also showed that rainfall variability and yam yield is statistically significant at P<0.05 in Cross River State, Nigeria. This increase may be attributed to increase in knowledge and adoption of viable adaptation strategies/improved production practices. However, yield of yam and rainfall amount showed a significant relationship (Table 1).

To deal with the effects of rainfall variability, there are several adaptation strategies that can be adopted in different situations. In general, the more adaptation there is, the less will be the impacts to which we will have to adjust, and the less the risk for which we will have to try and prepare. Adaptation has three possible objectives: to reduce exposure to the risk of damage; to develop the capacity to cope with unavoidable damages; and to take advantage of new opportunities (IPCC, 2014). One important issue in agricultural adaptation to rainfall variability is the way farmers update their expectations of the climate in response to unusual weather patterns. Our reactions to the effect of climate change are measured in terms of adaptation strategies (Ikpe, 2014).

Table 1: Rainfall and Yield Data for Yam in the study area (1988-2021)

Variables	Years	Rainfall (MM)	Yam yield (MT)
Years	1.00		
Rainfall (MM)	0.34*	1.00	
Yam yield (MT)	0.65**	0.20^{NS}	1.00

Source: Author's computation (2023)
*: Correlation is significant at the 0.05 level (5 %).
**: Correlation is significant at the 0.01 level (1 %).
NS: Not significant correlation at 0.05 level

The results (Table 1) showed that there is a significant relationship between rainfall and yield data for yam in the study area. This result agrees with the findings of Maforikan (2021) which reported that rainfall significantly affects outputs of yam and rice. Moreover, the results agree with Patrick *et al.,* (2019) and Adamgbe & Ujoh (2012) which found a positive correlation between climatic factors and yam production in Benue State. According to Akinkunmi (2020), the trends of the climatic variables (especially rainfall) were significant on the yields of Yam.

Conclusion

In this study, the relationship between the rainfall variability and yam yield was studied. The analysis revealed an increase in the TAR amount and increase in the yield of yam. The result further showed that there is a significant correlation between annual rainfall and yam yield, which implies that yield increases as rainfall amount increases. Increase in yield was also attributed to increase in knowledge and adoption of viable adaptation strategies/improved production practices.

Recommendation

Based on the findings of the study which showed increase in the yields of yams with years and significant relationship between rainfall and yam yields is a pointer to the preponderance of viable adaptation strategies in the production of yams towards food security in the study area. Considering the sensitivity of agricultural activities to these variables, farmers should be encouraged to adapt measures such as improved seed varieties; use of organic or inorganic fertilizer; use of early maturing varieties among others. Government and non-governmental farm agents/extension workers can help to provide farm inputs and educate the farmers on suitable adaptation strategies in the study area.

References

Adamgbe, E. M. & Ujoh, F. (2013). Effect of variability in rainfall characteristics on maize yield in Gboko, Nigeria. Journal of Environmental Protection, 4(9), 7-15. doi:10.4236/jep.2013.49103

Aighewi, B., Maroya, N., Kumar, P. L., Balogun, M., Aihebhoria, D., Mignouna, D., & Asiedu, R. (2021). Seed yam production using high-quality minitubers derived from plants established with vine cuttings. Agronomy, 11(5), 1–13. https://doi.org/10.3390/agronomy11050978

Akinkunmi, A. B. (2020). Determinants of climatic variability and adaptation strategies of farming in Benue State Nigeria, Sumerianz Journal of Economics and Finance, 3(6), 47-84: 2617-7641 Website: https://www.sumerianz.com

Akinola A. A., Oke J. T. O., Adesiyan A. T., and Famuyini C. A (2019). Climate Change and Economic Efficiency of Yam Farmers in Ekiti State, Nigeria, AgEcon Search Research in Agricultural and Applied Economics, 1-6.

Akissoe, N., Hounhonigan, J., Mestres, C. & Nago, M. (2003). How blanching and drying affect the colour and functional characteristics of yam (Dioscorea cayenensis-rotundata) flour. Food Chemistry, 82, 257 - 264. http://dx.doi.org/10.1016/S0308-8146(02)00546-0

Apu, U., Ani, N., Agbarevo, M. N. B., Ugboaja, C. I., & Obinna, L. O. (2020). Determinants of sustainable use of improved yam production practices among farmers in Ebonyi State, Nigeria. Nigerian Agricultural Journal, 51(3), 279–284.

Atedhor, G. O. (2020). Rainfall variability during onset and cessation of the growing season in the Sudano Sahelian region of Nigeria. JGME Journal of Geography, Meteorology and Environment, 3(1), 1–14.

Ayoade, J. O. (2004). *Introduction to climatology for the Tropics*. Ibadan. Published by Spectrum Books Ltd.

Belloumi, M. (2014). Investigating the impact of climate change on agricultural production in Eastern and Southern African Countries. AGRODEP Working Paper 0003, African Growth and Development Policy Modeling Consortium.

Brand-Miller, J.C., Thomas, M., Swan, V., Ahmad, Z.I., Petocz, P. & Colagiuri, S. (2003). Physiological validation of the concept of glycaemic load in lean young adults. Journal of Nutrition, 133, 2728-2732

Central Bank Nigeria (2003). Statistical bulletin. Abuja: Central Bank of Nigeria.

Eruola, A., Bello, J., Ufogbune, G., & Makinde, A. (2012). An assessment of rain water supply on yam production in Southwestern Nigeria. Journal of Meteorology & Climate Science, 10(1), 34–41

Food and Agriculture Organization (FAO) (2002) Statistics of the Food and Agriculture Organization of the United Nations.

Ikpe, E. (2014). Adaptation strategies to climate change among grain

farmers in Goronyo Local Government Area of Sokoto State, Nigeria. An unpublished M.Sc Thesis, Department of Geography, Ahmadu Bello University, Zaria, Nigeria.

Ikpe, E., Sawa, B. A., Idoma K., Ejeh, L. & Meshubi, A. O. (2016). Shift in crop production as an adaptation strategy to climate change by grain farmers in Goronyo LGA of Sokoto State, Nigeria. *International Journal of Science for Global Sustainability*, 2(1), 106-113. doi: 10.13140/RG.2.2.10444.26249

Intergovernmental Panel on Climate Change (IPCC) (2007). *Climate Change 2007: Impacts, Adaptation, and Vulnerability.* Contribution of working Group II to the fourth Assessment report of the Intergovernmental Panel on Climate Change (Parry, Martin L., Canziani, Osvaldo F., Palutikof, Jean P., Vander Linden, Paul J., and Hanson, Clair E.) (eds.) Cambridge University Press, Cambridge, U.K.

Intergovernmental Panel on Climate Change (IPCC) (2014). AR5 Climate Change 2014: Impacts, adaptation and vulnerability. Cambridge University Press, Cambridge, United Kingdom.

Iornongo, T. (2021). Effect of rainfall variability on yield of selected crops in Benue State, Nigeria. http://repository.futminna.edu.ng:8080/jspui/handle/123456789/14588

Jande, J. A. & Amonjenu, I. O. (2018). Land use/landcover change detection mapping of Apa Local Government Area, Benue State, Nigeria, Journal of Research in Forestry, Wildlife & Environment,10(3). http://www.ajol.info/index.php/jrfwejfewr.

1.1.1

1.1.2 Maforikan, (2021). Impact of climate change on major staple food crops and farmers' adaptation strategies in Atacora. https://anyl4psd.org/wp-content/uploads /2021/10/ MAFORIKAN-Ella-S-3.pdf

National Bureau of Statistics [NBS] (2007). National ureau of statistics annual agricultural survey report: 1994/95-2005/06.

National Population Commission (2006). Population census, official gazatte (FGP 71/52007/2, 500 (OL24, also available on www.nigerianstat.gov.ng

Okongor, G., Njoku, C., Essoka, P., & Efiong, J. (2021). Climate variability and yam production: nexus and projections. Sarhad Journal of Agriculture, 37(2), 406–418. https://doi.org/10.17582

Ologunorisa, T. E. & Tersoo, T. (2006). The changing rainfall pattern and its implication for flood frequency in Makurdi, Northern Nigeria. Journal of Applied Sciences and Environmental Management, 10 (3), 26. doi: 10.4314/jasem.v10i3.17327

Osunde Z.D. (2008). Effects of storage conditions and storage period on nutritional and other qualities of stored yam (Dioscorea spp.) tubers, African Journal of Food, Agriculture, Nutrition and Development 9(2), 678-690

Patrick, O. A., Emmanuel, N., & Obadiah, A. A. (2019). An analysis of the impact of rainfall onset, cessation and length of growing season variability on crop yields in Benue State, Nigeria. East African Scholars

Journal of Agricultural Life Science, 2(9), 439–442. https://doi.org/10.36349/EASJALS.2019.v02i09.002

Samuel, E. T., Ogonna, O. O. & Samuel, A. E. (2018). Effects of climate change on yam production in Cross River State, Nigeria. International Journal of Agriculture and Forestry, 8(2), 104-111, doi: 10.5923/j.ijaf.20180802.09

Shaibu, J. I., Fanen & Yusuf, B. (2022). Variability in some selected rainfall characteristics and yam production in Makurdi and Gboko, Benue State, Nigeria. Fudma Journal of Agriculture and Agricultural Technology, 8(1), 13-322, https://doi.org/10.33003/jaat.2022.0801.099.

Srivastava, A.K., Gaiser, T., 2008. Biomass production and partitioning pattern of yam (Dioscorea rotundata). Agricultural Journal, 3, 334–337.

Terwase S. & Terese E. T. (2013). Residents coping measures in flood prone areas of Makurdi Town, Benue State. *Applied Ecology and Environmental Sciences*; 1(6), 120-125. doi: 10.12691/aees-1-6-4.

Tyubeel, B.T., Tsavhemba, L. & Iwan, M. T. (2020). Assessment of perceived trend, impact and adaptation strategy of rainfall variability by crop farmers in Yandev district, Benue State, Nigeria. Journal of Agriculture and Environmental Sciences, 9(2), 19-31 https://doi.org/10.15640/jaes.v9n2a4

Webber, S. (2017). Circulating climate services: commercializing science for climate change adaptation in Pacific Islands. Geoforum 85:82–91

