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Research Article

Impact of climate variability on the yield of staple grain crops in Wudil local government area, Kano State, Nigeria

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ABSTRACT

This study is centered on the impacts of climate variability on some cereals crop yields (sorghum, millet and maize) in Wudil local government area, Kano State. Climatic data were used that covers 1997–2017. Seasonal data were collected from Kano State Agricultural and Rural Development Authority where rainfall and crop yields data was collected. Geography Department, Kano State University of Science and Technology, Wudil, was where rainfall and temperature data were collected. Atmospheric humidity was derived by using 6.11 x 100 (7.5 x TC/ 237.7 +TC), were TC = Temperature in Degree Celsius. And also Evapotranspiration data was derived using 0.0023 (Tavg + 17.8) (Tmax _ Tmin) 0.5 Ra. Where Tavg, Tmax and Tmin are respectively mean, average, maximum and minimum temperature and Ra represents extraterrestrial radiation. Regression analysis was used to determine the impacts of climatic elements (rainfall, temperature, humidity and evapotranspiration) as an independent variables on crop yields (sorghum, millet and maize) as dependent variables; furthermore, standardize coefficient index were determined in order to know which climatic variable has more effects on the crop yields in the study area. The results obtained reveals that all the climatic elements were highly variable as no years with the same annual total except temperature which shows little annual variation over the study period. Climatic elements were found to have moderate impacts on the crop yields based on the regression coefficient of determination. However, rainfall was found to be the most influential variable on crop yields followed by atmospheric humidity, temperature and evapotranspiration based on standardize coefficients indices. In the situation of changing climate and weather variability and changing seasonal rainfall pattern in present and future, it is important to enhance the efficiency of rainfall and soil water use in crop cultivations. Adaptation of water saving/conserving technologies and identification of crops species and species-specific traits that improves crop water use efficiency of crops under rain-fed, irrigated and dry land farming system is recommended.

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1. Introduction

Climate variability represents a significant environmental, social and economic threat which is now recognized by the majority of the world's governments and scientists as an issue of serious concern (Cyprian et. al., 2014). Several studies suggest that Africa is particularly most vulnerable to climate variability (Birkman et al., 2013; Lobell, et al., 2011). This vulnerability has been attributed to the continent's high poverty levels, low adaptive capacity, its dependence on rain-fed agriculture as well as its limited economic and institutional capacity. Food production and related livelihoods will be disproportionately affected by climate variability in Sub-Saharan Africa. Climate variability has been described as a new food security threat for Africa (Adhikari et al., 2015; Jimoh, 2017). Climate variability on crop production is a major force in which the world will have to cope with in the twenty-first century (IPCC, 2014). Climate variability affects agriculture in several ways e.g. reduced growing seasons, including its direct impact on food production. Available evidence show that climate variability is global, likewise its impacts, but the most adverse effects will be felt mainly by developing countries, especially those in Africa, due to their low level of coping capabilities (Mwaura et al., 2014).

In predominantly agricultural system, natural rainfall is the main source of water for agricultural sector in the study area. This rain-fed based agricultural sector is highly sensitive to spatio-temporal variability of rainfall in the area where rainfall is limiting factor for crop production. In addition to amount of rainfall its distribution in a given season is critical in affecting crop growth and its production.

Uneven seasonal distribution of rainfall can expose crops to different degree of dry-spells without significant reduction in total amount of rainfall (Barron et al., 2003). In this area rainfall intensity is very high in the month of July and August. As a result though the environment is generally dry, crops are frequently lost through too much rain, inter-annual variability is very high (Afifi et al., 2014). Due to the large inter-annual variability of rainfall, this area is subject to frequent dry-spells, often resulting in severe and widespread drought capable of large scale destruction of plants which in turn causes low yield (Ati et al., 2002).

A part from rainfall, temperature (maximum and minimum) have also proven to have a significant influence on production of crops (FAO, 2012). Furthermore, as the growing season progresses and canopy cover increases, evaporation from wet soil surface gradually decreases when the transpiration and evaporation from the crop canopy where most of the solar radiation is intercepted (Marine et al., 2015). Prevailing weather condition, available water in the soil, crop species and growth stage influence crop water use. Evapotranspiration rates are affected by solar radiation, temperature, relative humidity and wind speed. It rate is also affected by solar radiation, temperature, relative humidity and wind speed. This means that the crop water use will also be affected by solar radiation, temperature, relative humidity and the wind, more water evaporates from crops and soils in conditions of higher temperature, low humidity, strong solar energy and strong wind speed (Allen et al., 1998). Relative humidity is a measure of the amount of water in the air, its role in plant health is extremely important. The potential water-holding capacity of air greatly increases as the temperature in the air increases. Plants not only contain a large proportion of water, they move large volumes of water through their tissues. Although water is used in photosynthesis, most of the water taken in by a plant is used in transpiration. That is, the water is taken in by the roots and evaporated through the leaves into the air. This process cools the plant. The relative humidity in the air can affect the flow of water through the plant: the higher the relative humidity, the more slowly transpiration occurs. If environmental changes that affect the transpiration rate are rapid enough, plant tissue damage can occur. If the humidity is too low, plant growth is often compromised as crops take much longer to obtain the saleable size. Also, lower leaves often drop off, growth is hard, and overall quality is not very good (Allen, 1998).

Weather is a significant climatic aspect playing a vital role in agricultural production (Ogonma et al., 2015), by the determining rainfall, temperature, humidity and evapotranspiration which directly affects crops. Many studies have been conducted in order to detect and understand the level of climatic variables influence on crop yield across the world. However, these are limited studies coring Kano Dryland Regions characterized with rainfall irregularity and variability. For this reason, this research was carried out to detect and understand the influence of climatic variables on crop yields in Wudil Local Government Area, Kano State.

2. The Study Area

2.1. Location and extent

Wudil local government area is located in the east-central area of Kano state. It's located between latitudes 11° 37″N and 11° 56″N as well as longitudes 8° 45″E and 8° 57″E. It shears its western boundary with Warawa local government to the Northwest and Dawakin Kudu local government area to the Southwest. It is bounded to the South and Southeast by Garko local government area on the East by Albasu local government area (Southeast), Gaya (East) and Ajingi, Northeast and North.

2.2. Climate of the study area

The climate of the study area is within the tropical dry-and-wet type, classified by Koppen as Aw. The seasonal migration of the Inter-tropical Convergence Zone (ITCz), also known as the Inter-Tropical Discontinuity (ITD), gives rise to two seasons, one dry and the other wet. The wet season lasts from June to September although May is sometimes humid. The dry season extends properly from mid-October of the one calendar-year to mid-May of the next. The highlights of the climatic parameters include: the occurrence of peak rainfall, peak runoff and peak discharge from the last decade of August to the first decade of September. The annual mean rainfall in the region is between 800 mm and 900 mm. Olofin (2016) variations about the annual mean value are up to ± 30 percent. More than 300 mm of the rainfall is received in August alone, while the truly wet season lasts from June to September. However, it is usual to regard mid-May to mid-October as the wet season. Rainfall intensity is in the range of 40-60mm hr^{-1} (Olofin 2016) but it is particularly at the beginning and end of the wet season when rainfall is characterized by heavy storms whose average intensity is about 80mm hr^{-1} (Olofin 2016). There is the occurrence of squalls and thunderstorms from April through to August. During the early part of this period (April and May) squall winds at speeds of up to 100 km hr^{-1} usually occur.

2.3. Geology

The Study area located within the Basement Complex area but extends Eastward beyond the Hydro-Geological Divide in some areas transitional to Chad Formation Zone, the outcrops of the ancient rocks are encountered all over the area including the bed of the Hadejia River (Olofin, 2016).

2.4. Relief and landforms

The study area lie on the elevations ranging between 450 m and 650 m, the high plains consist of areas of low relief usually less than 20 m and areas of grouped hills where the hills may rise higher than 100 m above the plains. This plains developed on the rocks of the Basement Complex and outcrops of these rocks constitutes most of the hills both grouped and ungrouped. The landforms found in Wudil is a typical drift plain, which consists of the following morphological units: an upland plain, two river terraces and wide channel beds, all sloping at angles less than 2 degrees. Others are inter-unit scarps sloping at angles steeper than 60 degrees and isolated residual hills ranging in height from 10 m to 50 m above the plains. Consequently, Nedeco (1974) has recognized the following landform units in the area: a storm channel (also called "floodplain") which is flanked by a low terrace which rises steeply from the channel, a high terrace separated from the low terrace by a steep wall, and an upland plain, also separated from the high terrace by a steep wall. Thus from the upland plain to the river channel, there are three steep units. 3 to 4 meters high and up to 60° steep which encourage rapid runoff, in spite of the gentle slopes (1° to 2°) on the terraces and upland plain (Olofin, 2016).

2.5 Soil and vegetation

The soil of the study area was derived from two main geological formation, the Basement Complex and the Chad Formation. The Basement Complex rocks are variable in size and composition and includes schists, shales, and granites among others. The soil is relatively well structured and possess sufficient depth to permit the cultivation of most staple crops. The Sudan savanna vegetation exist which consists of expense of shorter grasses, usually 1.0 to 1.5 meters tall and scattered low trees with wide canopies. The trees hardly rise above ten meters, several species of acacias and baobab dominates the vegetation. A few thorny trees are encountered on an increasing occurrence as one move northwards.

2.5.1 Drainage and hydrology

The area is within the drainage system of the Chad Basin which drain to the Niger and Benue respectively which influenced by the climate, rock and human activities. The area drains essentially northeastwards to the Chad Lake, although the headstreams rise from the foot slopes of the Jos plateau to the south and flows generally north and northwest until about 30 km from its confluence with the Chalawa River where it swings more than 90o to flow northeast. The principal type surface drainage system in this area is the through flow which consists of the Hadejia (known as River Wudil in Wudil) and Jama`are River systems and drains the southeast, south and southwest sections of the region towards the northeast. The important headstreams include the Kano, the Chalawa and the Gaya (headstreams of the Hadejia River).

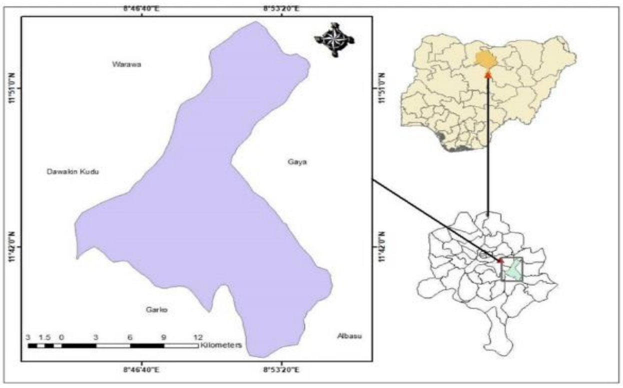

Figure 1. The study area

3. Materials and methods

The data used in this Study include only secondary of data. These are data set that are documented and kept for numerous uses. These data sets were found in sources like existing dissertations and thesis, journals and textbooks among others similarly, they also found in governmental and non-governmental organization that observed and recorded agro-climatic data; these includes Kano State Rural and Agricultural Development Agency (KNARDA), Aminu Kano Meteorological station, International Institutes for Tropical Agriculture (IITA), International Crops Research Institutes for the Semi-arid Tropics (ICRISAT) and Wudil Geography Department weather station. Due to the absent of weather station in some locations temperature data were downloaded from Marksim Weahter Data Generator, fews-net.com. However, for evapotranspiration and Atmospheric humidity a formula were used to determine. That is: 6.11 x 100(7.5 x TC/ 237.7 +TC), Were TC = Temperature in Degree Celsius and ETo as: ETo = 0.0023 (Tavg + 17.8) (Tmax - Tmin)^{05} Ra. Where Tavg, Tmax and Tmin are respectively mean, average, maximum and minimum temperature and Ra represents extraterrestrial radiation, (Allen et al., 1995).

This study apply multiple linear regression analysis to investigate the impact of rainfall, temperature, humidity and evapotranspiration variability which were the independent variables on sorghum, millet and maize yields which were the dependent variables. Regression analysis have been applied in several studies by (Rosenzweig and Parray, 1994, Barrios et al. 2008). This method of analysis allow the quantification of weather parameters changes or variations on crop yields in an actual cropping context. Among the few regression based researches include, Ben Mohamed et al. (2002), and Van Duivenbrodenet al. (2002), consider millet, cowpea and groundnut in Niger, Schlenker and Lobell (2010): estimate the aggregate output production function for sub-Saharan Africa on commonly grown crops in SSA (cassava, maize, millet and sorghum), Tundeet al. (2011) effects of climatic variables on crop production in Patigi L.G.A, Kwara State, Nigeria.

4. Results and discussions

4.1. Rainfall trend from 1997 to 2017

The temporal rainfall variations are more complex than the spatial variations. These findings was in line with (Olofin, 2016) which reported that normal or seasonal variations occur annually at different levels in the amount and durations of rainfall in the area. Such variations are believed to be in the order of ±30% about the normal mean values in the tropical wet and dry climate, tis agreed with the finding of Mortimore et al. (1999) in Umar et al. (2014) that the amount and frequency of rainfall is generally decrease from south to north of the study area with some variation over a short distances as shown that most of the northern local government areas receives low annual amount of rainfall compared to the Southern local government areas within the study area. It also reported that, it is a combination of different factors believed to be responsible for recent climatic anomalies and the seasonal and inter-annual variability of rainfall in this area. They include regional and global sea surface temperature (SST) changes (Lamb, 1978; Folland et al., 1986; Umar et al., 2014), the depth and strength of the seasonal WAM wind (Lamb et al., 1983 in Umar et al., 2014). The propagation of the African Easterly Jet (AEJ) (Fortaine et al., 1995; Cook, 1999), Sahara/Sahel aerosol dust concentration (Nicholson, 2013) and bio-geophysical feedback mechanism (Los et al., 2006; Umar et al., 2014), this finding is almost similar to that of (Yamusa et al., 2015) which reported that there is high inter-annual variability of rainfall over the study area.

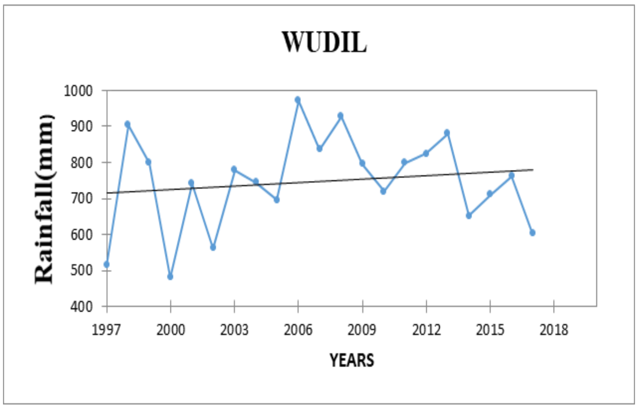

Figure 2. Rainfall variability of Wudil local government area, Kano state.

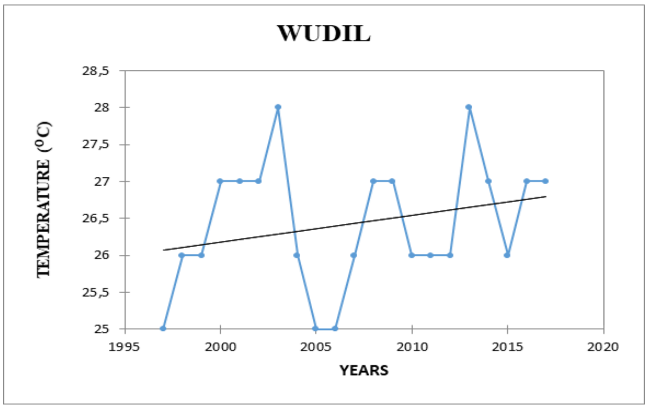

Figure 3. Temperature variability of Wudil local government area, Kano State.

Figure 2; Displayed rainfall trends of Wudil local government area, Kano State. It's indicated that, the area received its highest annual rainfall amount in 1998, 2006, 2008, 2012 and 2013. 1999, 2001, 2003, 2004, 2005, 2007, 2009, 2010, 2011, 2014, 2015 and 2016 are the years with moderate annual average rainfall amount. While the area received its lowest annual average rainfall amount were recorded in 1997, 2000, 2002 and 2017 respectively.

4.2. Temperature trend from 1997 to 2017

Today, there is sufficient evidence of rising global temperature due to increasing emission of greenhouse gases (carbon dioxide, nitrous oxide, methane and chlorofluorocarbons) into the atmosphere. The increasing global warming has the capacity to trigger large-scale climate disturbances, which ultimately may have significant impacts on the rainfall (Biasutti and Giannini, 2006). In spite of this, now an increase in global temperature caused sea level to rise and change the amount and pattern of precipitation, more frequent occurrence of extreme weather events such as heat wave, drought, heavy rainfall, species extinctions due to shifting temperature regimes and change in crop yields.

Changes in temperature pattern have caused dramatic changed in cropping seasons and the effect of these changes has resulted in wide fluctuation in yield and seed quality of most crops (Maureen et al., 2015). Temperature in Nigeria is generally high with annual mean of about 27ºC, while diurnal variations are more pronounced than seasonal differences (Salami and Mathew, 2009). The temperature distribution over the study area closely follows the seasonal migratory pattern of the overhead sun. The main features is that seasonal temperature values range between 21ºC and 33ºC. The annual temperature range is small, however, a weak spatial variability could be observed, seasonal average temperature in the area do not differ markedly, 22º to 30ºC (Buba, 2017). A part from rainfall, temperature (maximum and minimum) have also proven (FAO, 2012), to have a significant influence on production of crops. Maximum temperature refers to the highest daily temperature recorded during the day (normally called a daytime temperature) and minimum temperature refers to the lowest temperature recorded during the day night (called as night time temperature). The trend showed an increasing trend. Similarly, maximum temperature, the minimum temperature also showed increasing trend.

Wudil local government area recorded its highest annual average temperature in 2003 and 2013. 1998, 1999, 2000, 2002,2004, 2007, 2010, 2012, 2014, 2015, 2016 and 2017 are the years with moderate annual average temperature over the study period. With lowest annual average in 1997, 2005 and 2006.

The increasing night temperature had implication on crop yields, as many of the crops could not tolerate the changes in temperatures. Maize is the most sensitive to an increase in temperature at all stages of growth and development because it usually affect the flower viability which in turn affect the ability of producing normal good yield (Issahaku et al., 2017). Generally, temperature determine the length of the growing season of crops by determining the germination, vegetative and reproductive stage (FAO, 2009). Increase in temperature leads to increase evapotranspiration (Holmen, 2003), thus affecting water availability which is very important in the process of photosynthesis (Dowyer et al., 2006). Generally, high temperature affects the chloroplasts where photosynthesis take place through generation of reaction oxygen species (Kreslavski et al., 2007). Low temperature also affect crops by reducing their metabolic reactions (Sage and Kubien, 2007). Maize and Kim (2006) carried out experimental research and found out that leaves of maize under 23ºC, photosynthesis faster than the leaves of 13ºC and 28ºC, sorghum. Bassam (2010) observed that the optimum temperature for sorghum germination and development range from 25ºC and 30ºC. The minimum temperature are 7ºC to 10ºC.

4.3. Evapotranspiration trend from 1997 to 2017

Crops waters use also known as evapotranspiration (ET), represent. Soil evaporation and the water used by a crop for growth and cooling by the root system, which represent transpiration and is no longer available as stored water in the soil consequently ET is used interchangeably with crop water use. The evapotranspiration process is compared of soil evaporation (E) and transpiration (T). transpiration is the water evaporate or transpires through leaf to the atmosphere from the small openings on the leaf surface of plant; evaporation is water evaporated or lost from the wet soil and plant surfaces significant evaporation can take place only when soil surface is moist or saturated and when soil is getting dry, evaporation decreases sharply. Thus, significant evaporation occurs after rain. Furthermore, as the growing season progresses and canopy cover increases, evaporation from wet soil surface gradually decreases when the transpiration and evaporation from the crop canopy where most of the solar radiation is intercepted (Marine et al., 2015).

Prevailing weather condition, available water in the soil, crop species and growth stage influence crop water use. Evaporation rates are affected by solar radiation, temperature, relative humidity and wind speed. ET, which includes evaporation from soil and transpiration from plants is also evaporative, so the ET rate is also affected by solar radiation, temperature, relative humidity and wind speed. This means that the crop water use will also be affected by solar radiation, temperature, relative humidity and the wind, more water evaporates from crops and soils in conditions of higher temperature, low humidity, strong solar energy and strong wind speed (Allen et al., 1998).

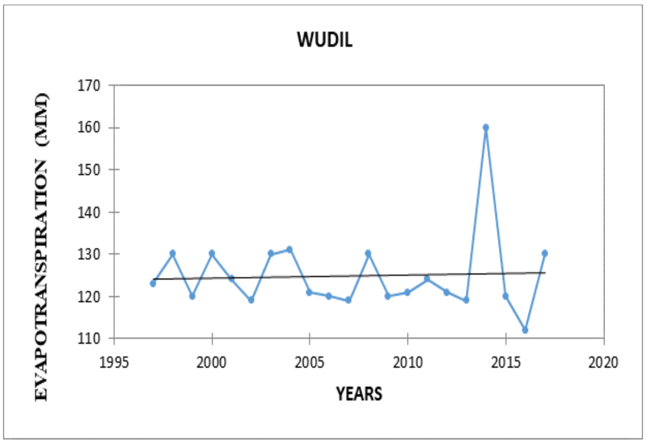

Figure 4. Evapotranspiration variability of Wudil local government area Kano State

Wudil local government area recorded its highest annual average evapotranspiration in 2014 and lowest annual average in 2016.

4.4. Atmospheric humidity trend from 1997 to 2017

Relative humidity is a measure of the amount of water in the air. Relative Humidity is measured on a relative scale rather than a linear scale (like measurements of temperature and distance) for example. Although this may make Relative Humidity a little harder to understand, its role in plant health is extremely important. The potential water-holding capacity of air greatly increases as the temperature in the air increases. Plants not only contain a large proportion of water, they move large volumes of water through their tissues. Although water is used in photosynthesis, most of the water taken in by a plant is used in transpiration. That is, the water is taken in by the roots and evaporated through the leaves into the air. This process cools the plant. The relative humidity in the air can affect the flow of water through the plant: the higher the relative humidity, the more slowly transpiration occurs. If environmental changes that affect the transpiration rate are rapid enough, plant tissue damage can occur. If the humidity is too low, plant growth is often compromised as crops take much longer to obtain the saleable size. Also lower leaves often drop off, growth is hard, and overall quality is not very good (Allen, 1998).

Vapor pressure deficit (VPD) is more accurate when determining water loss from the plant. VPD is simply the difference between the vapor pressure inside the leaf compared to the vapor pressure of the air. If the VDP is high, meaning that the vapor pressure inside the plant is higher than the outside air, then more water vapor escapes out through the stomata's (pores in the bottom of leaves). This process of water loss through the leaves is called "transpiration". If the VPD is low, the stomatal openings close and little water and fertilizer is taken up by the plant from the growing medium. VPD is important to know because it is used to schedule irrigations, to determine if air exchanges are needed and if air temperature needs to be increased in order to hold more moisture. Role of humidity in plant growth: Plants are always adjusting their leaf stomatal openings based on the VPD and the humidity in the air. As seen above, high humidity is a problem because water usage by the plant is too slow and compromises quality, even though the stomata's are constantly open. Likewise, if humidity is very low and subsequent transpiration is too high, the plant closes its stomatal openings to minimize water loss and wilting. Unfortunately this also means photosynthesis is slowed and subsequently, so is plant growth (Marine et al., 2015).

As alluded to above, the two major functions of the plant that tie in closely with the humidity in the air and affect crop performance are transpiration and photosynthesis. Transpiration; this is the process where plants absorb water through the roots and then give off water vapor through pores in their leaves. The drier or the hotter the air temperature, the faster the transpiration rate from the plant. However, the moisture deficit and transpiration rate are not directly related. This means that in very dry air, the increased rate of transpiration can only go so high in the plant and then it begins to wilt. For example, if the air is extremely dry, but the growing medium has enough water, the plant may wilt and, unless the humidity increases, the plant could die (Marine et al., 2015)

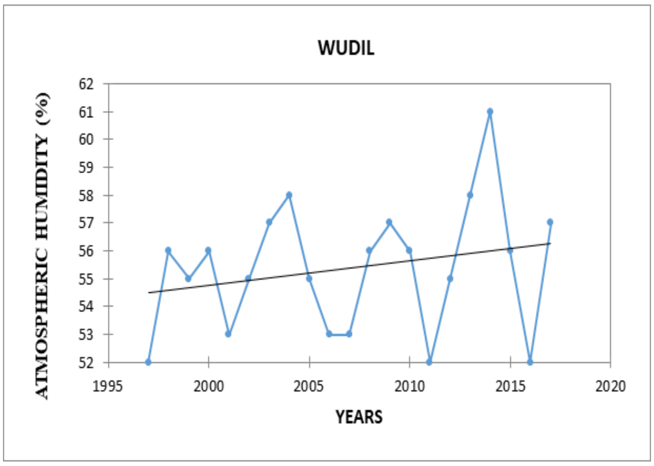

Figure 5. Atmospheric humidity variability of Wudil local government Area, Kano State.

Wudil local government area had its highest annual average atmospheric humidity in 2014, 2013, 2004, 2003, 2007 and 2017. 1998, 1999, 2000, 2002, 2008, 2010, 2012 and 2015 was the years with moderate annual average atmospheric humidity. While the years with low annual average atmospheric humidity includes 1997, 2001, 2011 and 2016.

On the other hand, if the air is very humid the plant does not take up much water from the growing medium, which also means there is little uptake of fertilizer elements. This is a problem for some elements, particularly calcium, as inadequate uptake can lead to nutrient deficiencies. Also low water usage from the growing medium often correlates with climbing growing medium pH, which makes micronutrients such as iron unavailable to the plant. Photosynthesis: This is the process of fixing carbon dioxide and water in the plant leaves to produce sugars that are used for energy and growth. When the temperature is high and humidity is normal, more stomata will open, letting in carbon dioxide for active photosynthesis. If the air is excessively dry and the plant is wilting, the stomatal openings close, thereby reducing photosynthetic activity and ultimately plant growth. The quality of the crop is dependent on the conditions that promote optimal photosynthesis and humidity plays a role in this process, very high relative humidity reduces evapotranspiration, increases heat load of plants, stomatal closure, reduced CO_2 uptake, reduced transpiration influences, translocation of food materials and nutrients. Moderately high RH of 60-70% is beneficial. Low RH increases the evapotranspiration, (Marine et al., 2015). The data of atmospheric humidity were derived through the use of the following formula: 6.11 x 100 (7.5 x TC/ 237.7 +TC), Were TC = Temperature in Degree Celsius (Allen et al., 1995).

4.5. Crop yields trend from 1997 to 2017

This area depends majorly on rain-fed agricultural practices, while rain-fed based agricultural is highly sensitive to spatio-temporal variability of rainfall in the area where rainfall is limiting factor for crop production. In addition to amount of rainfall its distribution in a given season is critical in affecting crop growth and its production. Uneven seasonal distribution of rainfall can expose crops to different degree of dry-spells without significant reduction in total amount of rainfall (Barron et al., 2003).

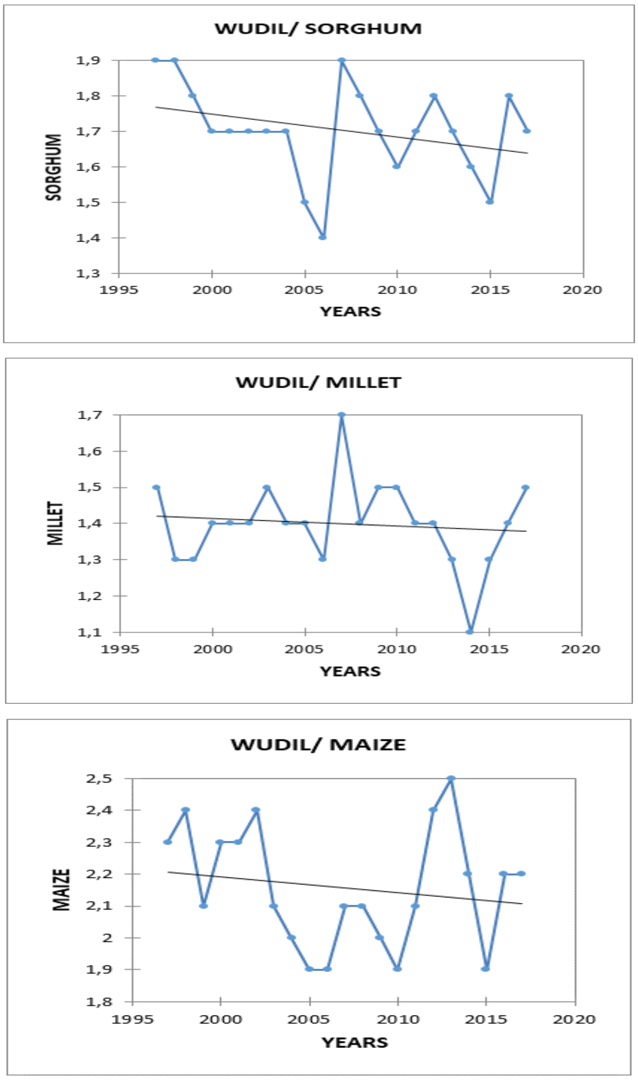

Figure 6. Crop yields trend for the study area over the study periods

Table 1. Describes the impacts of climate variables on crops yields based on coefficient of determination (R2). Root mean square error (RMSE) and standardize coefficients

Crops			Independent variables			
	R^2	RMSE	Rainfall (sc)	temp. (sc)	Evapotrans. (sc)	Humidity (sc)
Sorghum	0.65	0.12	-0.56	0.41	0.37	0.11
Mıllet	0.64	0.11	-0.25	-0.32	0.01	-0.06
Maıze	0.48	0.113	-0.309	0.513	0.604	-0.041

4.6. Impacts of climatic elements on crop yields in Kano State

The R2 is used to indicate to what extent a dependent variable is affected. While the standardize coefficient indicate which climatic variable has more impacts on the dependent variables. Wudil Local government have observed a strong impact of independent variables on Sorghum as in the finding of (Tunde, 2011), this areal most similar finding with that of (Sokoto et al., 2016). Standardization of the coefficient is usually done to answer the question of which of the independent variables have a greater effects/impacts on the dependent variable in a multiple regression analysis, when the variables are measured in different units of measurement, (Mcculloch, 2008).This is also supported by the findings of (Govinda, 2013; Sokoto et al., 2016; Ram, 2016; Samuel, 2016; Haruna et al., 2017) also found a strong impact of independents variables on millet. It also indicated that independents variables have moderate impacts on Maize yield in the study area. The higher the absolute value of the beta (standardize) coefficient, the stronger the effects/impacts; e.g. a beta of -9 has a stronger effects then a beta of +8. (Freedman, 2009).

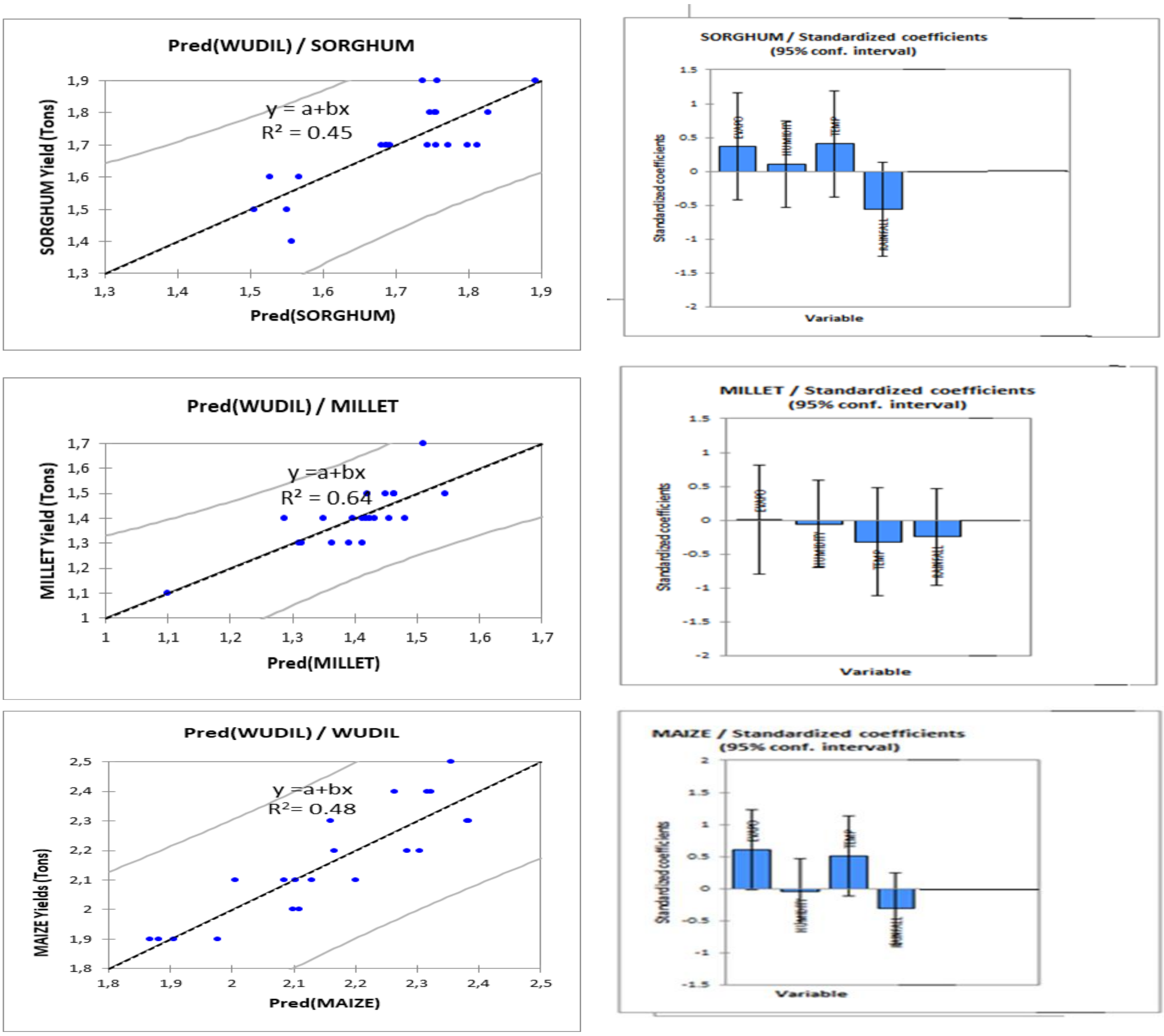

Figure 7. Impacts of climate variability on crop yields

Based on the standardize coefficient values in Table 2 indicated that rainfall has the strong impacts on sorghum yield, followed by temperature, evapotranspiration and atmospheric humidity with weak respectively. Temperature exerts more impacts on annual millet yields variability in the study area followed by rainfall, atmospheric humidity and evapotranspiration which contribute less respectively. Similarly, evapotranspiration contributes more on maize seasonal yields fluctuations, followed by temperature, atmospheric humidity and rainfall with least impacts respectively. This finding were almost similar with that of (Mijinyawa et al., 2015).

5. Conclusion

Rainfall were found with highly temporal variability as no two years with the same annual total, Temperature were found to be at equal range throughout the study period while atmospheric humidity were found to be at equal range with little annual variations. Furthermore, Evapotranspiration were found to be generally high. There are temporal Crop yields variation over the study periods. Both crop yield (Sorghum, Millet and maize) yields were found to be high. This in response to the temporal variation of the climatic elements more particularly annual rainfall amount and duration across the study area.

Rainfall was found to be highly variable temporally in the study area, it is also find out that rainfall contributed most in the annual sorghum yield variability followed by temperature. Similarly, temperature impacted more on millet yield followed by rainfall in the study area respectively. Furthermore, evapotranspiration was found to be the variable that contribute much on maize annual yield in the study area respectively.

Compliance with Ethical Standards

Conflict of Interest

The authors declare that they have no conflict of interest.

Authors' Contributions

Adamu Hassan designed the study. **Luka Fitto Buba** constructed the methodology. **Nura Isyaku Bello** collected the data for the research. **Hamza Isiyaka Ahmad** handled data analysis. **Muhammad Alhaji** handled data analysis.

Tijjani Abdullahi Yahaya collected the data for the research**.**

Ethical approval

Not applicable.

Funding

No financial support was received for this study.

Data availability

Not applicable.

Consent for publication

Not applicable.

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