

Effects of Climatic Elements Variability on Surface Water in Selected Catchment Areas in Kaduna State, Nigeria

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Abstract

In Kaduna State Nigeria, the climate in recent years has witnessed significant variability across the various catchment areas due to population pressure and anthropogenic activities. Thus, the objective of this study is to assess the relationship between climatic elements on surface water in selected catchment areas in Kaduna State. The Meteorological data for the study were sourced from twelve remotely sensed stations around Kaduna State for thirty-seven years and Hydrological data from the State's Water Board (KSWB) for thirty-seven years. The data computation, relationship between climate variability and water resources were established using Structural Equation Model (SEM) which has the statistical power to find the relationship between a phenomenon and other related parameters. Findings revealed that climatic variables have no significant impact on the water level across the three catchment areas of Galma, Kaduna Central and Amere/Mada since none of climatic variables have a significant effect which culminated to a negative water level in the catchment area but both rainfall and solar radiation have a positive relationship with water level which give rise to positive water level in the catchment area. Therefore, water resources availability in the catchment areas will not be under stressed by climate variation. The large amount of available water during the rainy season; crop varieties that can withstand much water should be planted in areas of high rainfall; and government policies related to agriculture and water resources development should be based on increase in rainfall and water resources trends in Kaduna State.

Key words: Climatic elements, Climate variation, Surface water, Catchment areas

INTRODUCTION

It is known and established in literature that there is inherent relationship between climate change and surface water. This is even more so as empirical studies in recent past have shown the impact of the former on the later (Hagemann *et.al.* 2013; Adam *et. al.*, 2016). Water resources of the world in general and in Nigeria are under heavy stress due to increased impact of climate change but the severity of the impact varies from one region to another. According to the Intergovernmental Panel on Climate Change (IPCC) (2014), climate change is defined as “change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean or the variability of its properties that persists for a next ended period, typically decades or longer”. It refers to any change in climate over-time, whether due to natural variability or as a result of human activity. This usage differs from that of the United Nations Framework Convention on Climate Change (UNFCCC, 2012), where climate change refers to a “change of climate that is attributed directly or indirectly to human activity that alters the composition of the global

atmosphere which is in addition to natural climate variability observed over comparable period of time”. This study adopts IPCC (2014) definition.

Climate change is increasing the frequency and severity of extreme hydrological events such as floods and droughts around the world (Guoyong *et. al.*, 2016). Water is an indispensable element of life; the water resources of catchment areas are highly dependable and sensitive to climate variability and change; due to interconnection between the climate system, hydrological cycle and agricultural practices. Thus, if the trends in climate contexts that took place over the last three decades continue to prevail unabatedly, West Africa, Nigeria inclusive will no doubt experience decreased freshwater available for agricultural purposes (Ayansina *et. al.*, 2018). More so, the change in climatic elements has led to manifestation of extreme events such as drought and flood. Consequently, there is need to continuously undertake research in this area in order to unearth the likely impact of climate variability on surface water in Kaduna State. This will help in advancing timely adaptation strategies, mitigation measures and

formulation of policies to tackle the effect of climate change. Hence, this study aims to assess the effects of climatic elements (rainfall, temperature, relative humidity and solar radiation) variability on surface water in Kaduna State.

MATERIAL AND METHODS

Study Area Kaduna State is located between latitudes 9° 02'N and 11°32' North of the equator

and between longitude 6°15'E and 8°50'E East of the Greenwich meridian in the North western region of Nigeria. Kaduna State is bordered to the North by Katsina, Zamfara and Kano States, to the West by Niger state, to the East by Bauchi and to the South by Plateau, Nasarawa and Federal Capital Territory, Abuja (Yusuf, 2015) respectively (see Figure 1).

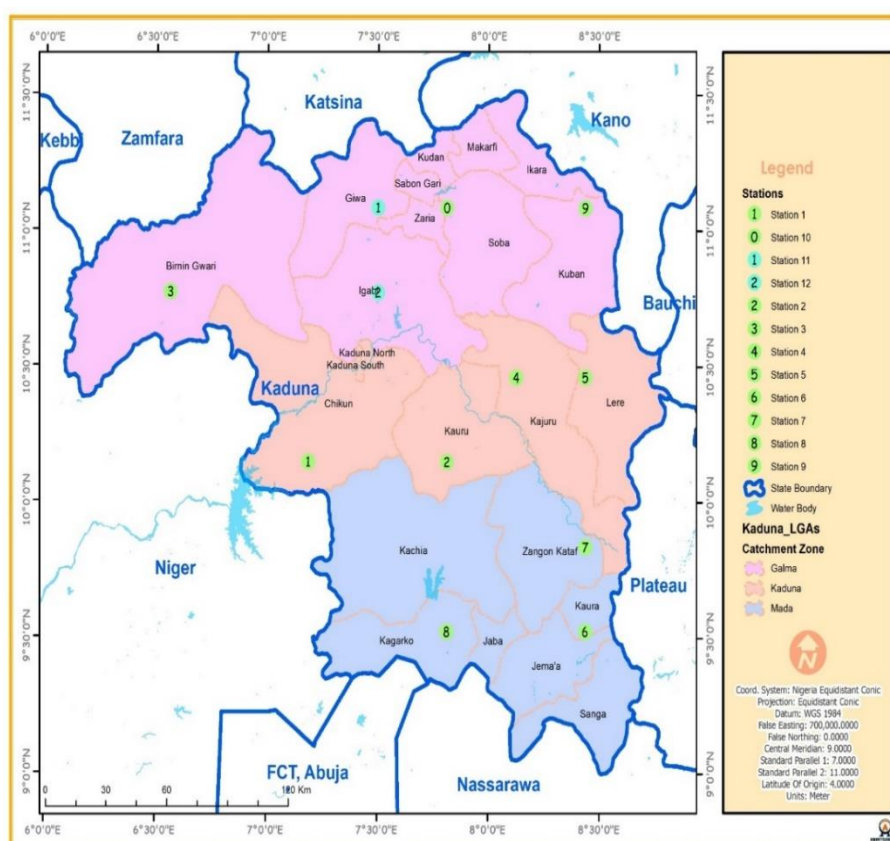


Figure 1: Map of Catchment Areas/ Remotely Sense Stations within Kaduna State.

The climate of the study area can be described as the Sub-Humid type (Nigeria Vision 20:2020, 2009) characterized by tropical wet and dry or savannah climate (Aw). Rainfall is the most important climatic variable and its seasonality and amount are of overriding interest to farmers, pastoralist and foresters. As both South Maritime and North Continental air masses are dominant for roughly half a year over Kaduna, there are two contrasting seasons. From April or May, the moist south-westerly winds bring rain and both cultivation and tree growth respond immediately. However, from month of October to April/May, the study area is subjected to cool dry North-easterly wind which yield virtually no rain. This is the period that irrigation farming mostly takes

place (Yusuf, 2015). The variation on the onset of rainfall is attributed to the fluctuations of the boundary between these two air masses. The annual rainfall received in Kaduna State range from 1000mm-1270mm, with a raining period of 160-180 days. The peak of the raining season occurred during the month of August (NiMET, 2018).

The combined Temperature and Rainfall of the State shows that, the mean maximum and minimum temperature experience in the State increases during the first part of every year to its peak during the hot season in late March and April. At the beginning of the rain, mean maximum temperature usually fall below 33.0°C and subsequently minimum temperatures are

experienced during rainy season, which remains fairly constant (Yusuf, 2015). Toward the end of rainy season, daily maximum temperature rises throughout the little hot season which allow crops to ripe (KDSG, 2018).

Kaduna State has a dense network of rivers/drainages with Rivers Kaduna, Galma, Gurara and Amere/Mada being the four major rivers. The sources of these rivers include Kauru, Lere and Plateau State area which form the source of the biggest river Kaduna; The Zangon Kataf/Kaura to Plateau state area which form the source of the river Shayu, Kagom, Mada and Sanga; Kachia and Kagarko from where rivers Gurara and Dinya flow; Birnin Gwari areas form the source of rivers Udawa/Baban ,Damari ,Kusheriki, Kwingi and Mairiga; then the Ikara, Kubau and Lere/Plateau areas provide the source for rivers Karami, Galma and Kubani. All of these rivers have their tributaries and distributaries which forms the dense network of drainage in the state (Yusuf, 2015). Thus, allowing the Southern part of the State to be drained by the Amere/Mada River which takes its source from Jos plateau and meanders through the interlocking dissection of

the Jema'a platform (Yusuf, 2015). The relief consists of two main rivers, Sanga (same as the Kogum River) and Amere (same as the Mada River and River Wonderful), both sourced from the plateau, with the former merging with the latter close to the Kogum River Station and finally emptying into the Benue River (Yusuf, 2015). The south east corner of Kaduna State comprises the headwaters of the Gurara River catchment that drains to the Niger River and the Mada River catchment that drains to the Benue River (Yusuf, 2015).

Method of Data Collection

The climatic data are records taken for thirty-seven years (1984-2021) temperature, rainfall, relative humidity and solar radiation, Kaduna State boundary map and hydrological data was also obtained. The climatic data were obtained from NASA (National Aeronautics and Space Administration) through the net, <http://power.larc.nasa.gov/data-access-viewer/>. The Data were collected from twelve (12) remotely sensed stations around Kaduna state.

Table 1: Types of Data Sets

Climatic Parameters		
1. Temperature data	°C	National Aeronautics and Space Administration (NASA)
2. Rainfall/ Precipitation Data	Mm	NASA
3. Relative Humidity Data	Mm	NASA
4. Solar Radiation Data		NASA
5. Hydrological Data		Dept. of Hydrology (KSWB)

(Source: National Aeronautics and Space Administration, 2023).

Method of Data Analysis

The study compared the relationship between climate variables (temperature, rainfall, relative humidity, solar radiation and water level in the study area for over three decades. The relationship between climate variability and water resources were established using SEM (Structural Equation

Model) which has the statistical power to find the relationship between a phenomenon and other related parameters. The SEM analysis was employed to show the changes in the climate parameters that influence water resources in Kaduna State.

The SEM (Structural Equation Model) model is thus defined as:

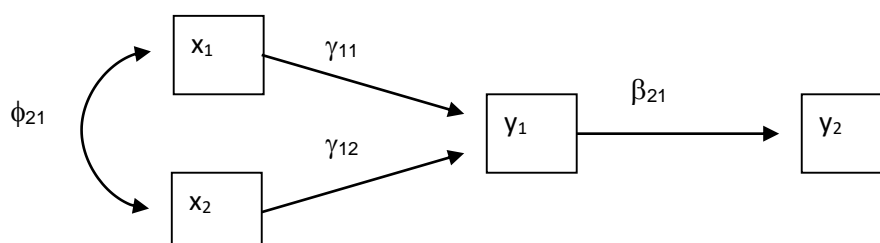
$$\begin{bmatrix} y_1 \\ y_2 \\ \dots \\ y_p \end{bmatrix} = \begin{bmatrix} 0 & \beta_{12} & \dots & \beta_{1p} \\ \beta_{21} & 0 & \dots & \beta_{2p} \\ \dots & \dots & \dots & \dots \\ \beta_{p1} & \beta_{p2} & \dots & 0 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ \dots \\ y_p \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \dots & \gamma_{1q} \\ \gamma_{21} & \gamma_{22} & \dots & \gamma_{2q} \\ \dots & \dots & \dots & \dots \\ \gamma_{p1} & \gamma_{p2} & \dots & \gamma_{pq} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \dots \\ x_q \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \zeta_2 \\ \dots \\ \zeta_p \end{bmatrix} \dots\dots\dots 1$$

$$\mathbf{y} = \mathbf{B}\mathbf{y} + \mathbf{\Gamma}\mathbf{x} + \boldsymbol{\zeta}.$$

Where we have p simultaneous equations. Note that for each of the causal parameters, the γ 's and the β 's, the subscripts follow the same pattern. The first subscript refers to the equation, in other words the y variable which is the effect. The second subscript refers to the cause. The p -by- p \mathbf{B} matrix contains the coefficients of the regressions of y variables on other y variables with 0's on the

diagonal which implies that a variable cannot cause itself. The p by q matrix $\mathbf{\Gamma}$ contains the coefficients of the y 's on the x 's. The error vector, ζ , is p by 1. These errors are different than factor analysis errors, they represent *errors-in-equations*, in the way that these equations are specified. Thus, they are also called *specification errors*.

Where the path diagram for a SEM causal model is described below:



There are several integrated analytic techniques within SEM. These include between-group and within-group variance comparisons, which are typically associated with ANOVA. It also includes path analysis (regression analysis) whereby equations representing the effect of one or more variables on others can be solved to estimate their relationships. A Path analysis, thus, represents the hypothesized causal relationships among variables to be tested. Factor analysis is another special case of SEM whereby unobserved variable (factors or latent variable) are calculated from measured variables. These analyses can usually be performed using data in the form of means or correlations and covariances (i.e., unstandardized correlations).

A technique that may test for differences among many groups or categories was utilised to compare these variables (relative humidity, maximum temperature, minimum temperature, precipitation, and solar radiation) statistically. Analysis of variance (ANOVA) is one such technique that may assessed, if there are statistically significant variations between the means of several groups based on a sample of data. ANOVA may also determine the likelihood of getting a result as severe or more extreme than the observed one by chance alone, or the p -value, for each comparison. Assuming there is no difference between the groups, a p -value near to zero suggests strong evidence against the null

hypothesis, whereas a p -value close to one implies weak evidence.

To perform ANOVA, certain assumptions need to be fulfilled: a sample of observations for each variable (maximum temperature, minimum temperature, relative humidity, precipitation, and solar radiation) for each group or category that are to be compared (such as different locations, seasons, or years); and, verify for normality, homogeneity of variance, and independence of observations. Pearson Product Moment correlation (r_p) was used to test for the relationship between climatic elements and other derived variables. Relationships were sought between rainfall, maximum temperatures, minimum temperature, relative humidity, and solar radiation using the Pearson product moment correlation.

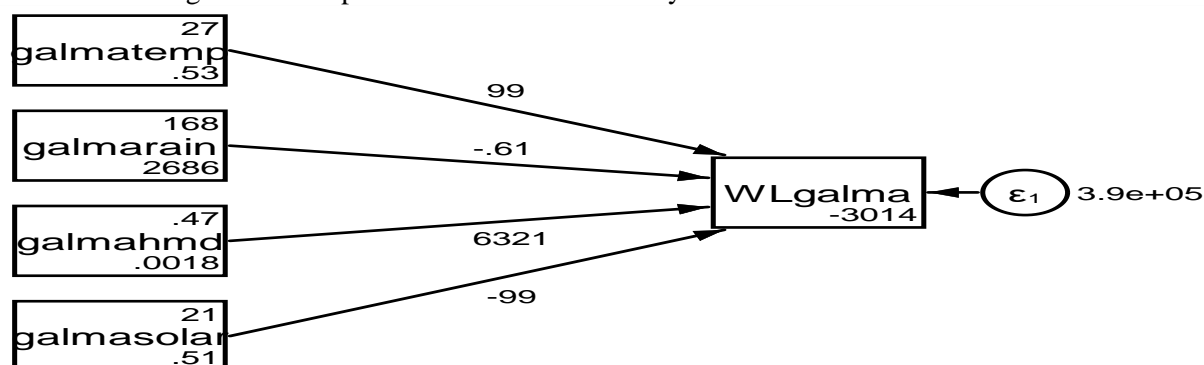
RESULTS AND DISCUSSION

Relationship between Climate Elements and Water Resources

Analysis of the relationship between climate variables on surface water resources in Kaduna State was carried out using Structural Equation model. The structural equation model (SEM) is used to establishing the details of relationship that exist between Water Level (WL) and the corresponding impact of the climatic variables as the independent variables.

Galma Catchment Area

Table 2: Showing Relationship between climate variability and water resources in Galma



Source	SS	df	MS	Number of obs	=	31
Model	1893787.01	4	473446.751	F(4, 26)	=	1.01
Residual	12176764.8	26	468337.107	Prob > F	=	0.4199
				R-squared	=	0.1346
				Adj R-squared	=	0.0015
Total	14070551.8	30	469018.393	Root MSE	=	684.35

WLgalma	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
galmatemp	98.70254	312.4005	0.32	0.755	-543.446	740.8511
galmarain	-.6123146	4.611185	-0.13	0.895	-10.09074	8.866112
galmahmd	6320.744	5571.896	1.13	0.267	-5132.453	17773.94
galmasolar	-98.56624	270.8376	-0.36	0.719	-655.2809	458.1485
_cons	-3013.597	13104.12	-0.23	0.820	-29949.51	23922.31

Source: Researcher Analysis, 2023

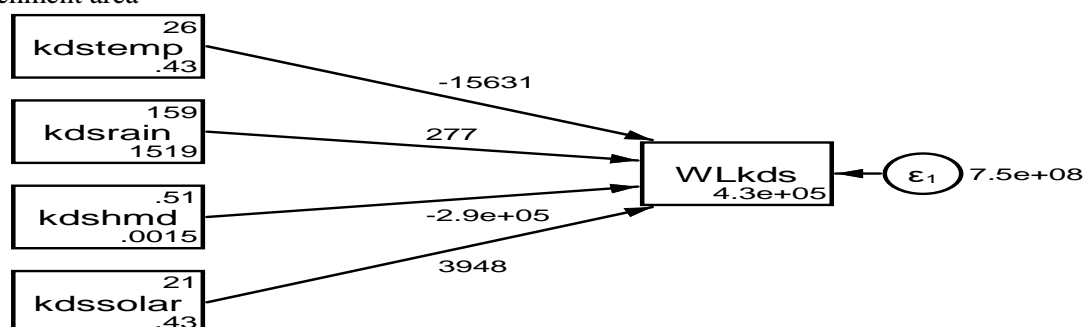
The result of the analysis of climatic parameters for the Galma stations (3, 9, 10, 11 and 12) is presented in Table 2, it was observed that temperature returns a positive coefficient of 98.703 which implies a positive relationship with the water level in Galma. The coefficient returns a p-value of 0.755 which is greater than 0.05 (5%) level of significance and indicate positive trend in water yield which thus implies that the relationship between water level and temperature in Galma is not significant and thus cannot be generalized. Similarly, the rainfall returned a negative coefficient of -0.6123 which implies that a unit increase in rainfall in the catchment area will result to a about 0.6123 decrease in the water level. Although the rainfall coefficient returns a p-value of 0.895 which is greater than 0.05 (5%) and thus making this finding not generalizable. The observed variability in rainfall in this study was in contrast with the study conducted by Suleiman and Ifabiyi (2014). They found that variability is greater between the months of May to October of which coincides with the rainy season. Similar observations in irregular pattern of annual rainfall were made by Eze (2006).

Also, the Humidity returns a positive coefficient of 6320.744 which implies that for actual unit change in humidity, the water level will increase to 6320.744 units. However, the humidity coefficient is not significant since the p-value of 0.267 is greater than the 0.05 (5%) level of significance and thus implies that humidity does not significantly affect the water level in the catchment area. Lastly, the impact of solar radiation on the water level returns a coefficient of -98.566 which is a negative type of relationship and thus implies that a unit increase in solar radiation will result to about 98.566 impact on the water level in the catchment area and this finding is also adjudged to be not significant since the p-value of 0.820 is observed to be greater than 0.05 (5%) level of significance.

As seen from the findings above, it can be concluded that the climatic variables have no significant impact on the water level in Galma since none of climatic variable have a significant effect which culminated to a negative water level in the catchment area.

Kaduna Central Catchment

Table 3: Showing Relationship between climate variability on water resources in Kaduna Central Catchment area



Source: Researcher Analysis, 2023

Source	SS	df	MS	Number of obs	=	31
Model	3.6883e+09	4	922076968	F(4, 26)	=	1.04
Residual	2.3099e+10	26	888430297	Prob > F	=	0.4067
				R-squared	=	0.1377
				Adj R-squared	=	0.0050
				Root MSE	=	29807
Total	2.6787e+10	30	892916519			

WLkds	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
kdstemp	-15630.74	17226.71	-0.91	0.373	-51040.75 19779.27
kdsrain	276.982	248.8017	1.11	0.276	-234.4373 788.4012
kdshmd	-290452.5	256060.5	-1.13	0.267	-816792.3 235887.3
kdssolar	3947.866	11852.12	0.33	0.742	-20414.52 28310.25
_cons	427805.8	587635.6	0.73	0.473	-780096.4 1635708

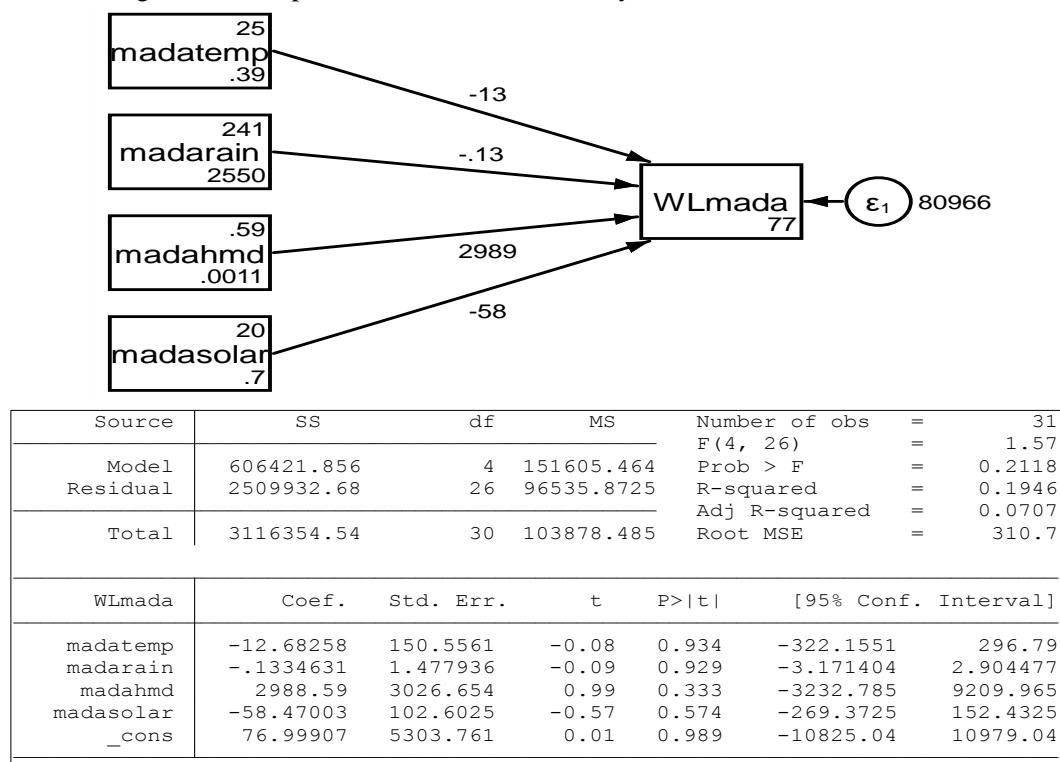
The result of the analysis of Climatic parameters data for the Kaduna Central stations (1, 2, 4 and 5) is presented in Table 3, the trend analysis result indicates a negative coefficient of -15631 for temperature which implies a negative relationship with the water level in River Kaduna catchment area. The coefficient returns a p-value of 0.373 which is greater than 0.05 (5%) level of significance which therefore implies that, the relationship between water level and temperature in Kaduna catchment area is not significant and thus cannot be generalized. Rainfall returned a positive coefficient of 277 which indicates that a unit increase in rainfall in Kaduna catchment area will result to about 277 increases in the water level in Kaduna catchment area. Although the rainfall coefficient returns a p-value of 0.276 which is greater than 0.05 (5%) level of significance and thus making this finding generalizable. Similarly, the Humidity returns a negative coefficient of -290452.5 which infers that, for actual unit change in humidity, the water level will witness a decrease of 290453 units. However, the humidity coefficient is not significant since the p-value of 0.267 is greater than the 5% level of significance and thus implies that humidity does not

significantly affect the water level in Kaduna Central. Lastly, the impact of solar radiation on the water level returns a positive coefficient of 3947.866 which indicates a positive relationship with water level which implies that a unit increase in solar radiation will result to about 3948 impacts on the water level in Kaduna Central and this finding is also adjudicated to be not significant since the p-value of 0.742 is observed to be greater than 0.05 (5%) level of significance. The findings collaborated the work of Omonijo, (2014), which posited fluctuations in the amount of annual rainfall and number of rain-days which could be linked to climate variation. Although, these fluctuations have not caused any serious delay or shift in the onset of rains and cessation in the study area. In view of this, rainfall duration and number of rain-days are still very favourable for the agricultural activities the study area is known for.

From the above finding, it can be convincingly said that the climatic variables such as temperature, relative humidity have a negative relationship with water level while rainfall and solar radiation have a positive relationship with water level which give rise to positive water level in the catchment area.

Amere/Mada Catchment Area

Table 4: Showing Relationship between climate variability and water resources in Amere/Mada



Source: Researcher Analysis, 2023

The result of the analysis of climatic parameters data for the Amere/Mada stations (6, 7 and 8) is presented in Table 4, It was observed that temperature returns a coefficient of -12.68258 which is negative and therefore implies a negative relationship with the water level in Amere/Mada catchment area. The coefficient returns a p-value of 0.934 which is greater than 0.05 (5%) level of significance which thus implies that the relationship between water level and temperature in Amere/Mada is not significant and so cannot be generalized. Similarly, the rainfall returned a negative coefficient of -.1334631 which implies that a unit increase in rainfall in Amere/Mada will result to a about .1334631 decrease in the water level in the catchment area. Although the rainfall coefficient returns a p-value of 0.929 which is greater than 0.05 (5%) and hence making this finding not generalizable. Also, the Humidity returns a positive coefficient of 2988.59 which implies that, for very unit change in humidity, the water level will see an increase of 2988.59 units. However, the humidity coefficient is significant since the p-value of 0.333 is greater than the 0.05 (5%) level of significance and therefore implies that humidity significantly affects the water level in the catchment area. Lastly, the impact of solar

radiation on the water level returns a coefficient of -58.47003 which is a negative type of relationship and thus implies that a unit increase in solar radiation will result to about 58.47003 impact on the water level in Amere/Mada and this finding is also adjudged to be not significant since the p-value of 0.574 is observed to be greater than 0.05 (5%) level of significance and culminated into positive water level in the catchment area.

The structural equation model equally established no significant relationship between climatic elements (Temperature, rainfall, relative humidity, and solar radiation) and water level in the three catchment areas in the State. The relationship between climatic variables and water level across the state shows that Galma water level presented negative relationship of (-3014) and both Kaduna Central and Amere/Mada catchment showed positive relationship of (4.3) and (77) significant relationship respectively. The finding is in tandem with the work of Hassan, (2012), who asserted that temperature and humidity have appreciated during the study period owing not to global warming alone but also to anthropogenic activities, particularly deforestation through the activities of fuel wood and charcoal business within the study area.

The results in Table 2, 3 and 4, show that the four climatic elements; rainfall, temperature, solar radiation and humidity, jointly provided a substantial explanation for the variations in surface water level in Kaduna State with a coefficient of determination of 4.3%, and (adjusted) of 77%. However, a close scrutiny of the Table reveals that rainfall made the highest contribution to the structural equation model with a coefficient of 80.966, 7.5 and 3.9, which is highly significant at the 0.01 level. This is not surprising as earlier studies have shown rainfall to be one of the most important parameters in water level availability, especially in semi-arid parts of northern Nigeria (Mortimore and Adams, 2001). On the other hand, temperature shows an inverse relationship with water level with a negative regression coefficient of -3.69, although the relationship is also highly significant at the 0.01 level. The inference from this “cat and mouse” behaviour of rainfall and temperature in relation to water level is that while rainfall increases water level, temperature subtracts through evaporation.

Udoeka (1995) had earlier observed that the rate of change in water bodies, soil and groundwater in an area over a specified time interval is equal to the rate of water supplied in the form of precipitation minus the combined outflow from the area in terms of runoff and evapotranspiration. Results in Table 2 and 4 also show that humidity has a slightly positive, but insignificant relationship with water level. From the foregoing, it can be asserted that there is a relationship between climate variation and water level in the surface water in the Kaduna State.

However, it should be noted that water level in lakes and other surface water is not just a function of climatic parameters alone. Other parameters that could be significant include the basin size (i.e. the catchment area), the geological structure, off-channel uses and the management skills. To provide a holistic treatment of the question of diminishing water resources in the State, these other variables will need to be considered using an integrated, comprehensive simulation model.

Ayansina and Ogunbo (2009) also investigated the seasonal rainfall variability in guinea savannah of Nigeria and concluded that rainfall variability continues to be on the increase as an element of climate change. Egbinola and Amobichukwu (2013) also focused on the assessment of climatic variation in Ibadan region based on the variation of rainfall and temperature within the period 1970-2012. Time series analysis was used to determine the trend and the 5-year moving average was used to smoothen the time series and to eliminate fluctuations. The result revealed there is an upward trend in total rainfall within the period of study and also there is an upward trend in average minimum temperature.

Hypothesis Testing Analysis

Analysis of variance was conducted to ascertain variation between climatic elements (temperature, rainfall, relative humidity, and solar radiation among the three catchment areas. Pearson Product Moment Correlation was used to test the significance relationship between the climatic parameters in the study area. The results are presented in Table 5 and 6.

Table 5: 37-year variation in temperature, rainfall, relative humidity, and solar radiation

		Sum of Squares	df	Mean Square	F	Sig.
Relative Humidity	Between Groups	10351.651	37	279.774	13.991	.000
	Within Groups	8338.703	417	19.997		
	Total	18690.354	454			
maximum Temperature	Between Groups	519.352	37	14.037	3.357	.000
	Within Groups	1743.446	417	4.181		
	Total	2262.798	454			
Minimum Temperature	Between Groups	713.447	37	19.282	1.688	0.009
	Within Groups	4762.841	417	11.422		
	Total	5476.289	454			
Precipitation	Between Groups	232597173.9	37	6286410	51.545	.000
	Within Groups	50734972.89	416	121959.1		
	Total	283332146.8	453			
Solar Radiation	Between Groups	1716281643	37	46385990	2.296	.000
	Within Groups	8424194017	417	20201904		
	Total	10140475660	454			

The findings of this study show that the five climatic parameters were statistically different at a p-value of less than 001, contradicting the null hypothesis, which holds that there are no significant differences between the five climatic elements. The null hypothesis is therefore rejected because there is significant variation between the climatic elements in the study area. This is similar in the work of Abaje, *et.al* (2010) who investigate the rainfall trend in

Kafanchan from 1974-2008 using the relative seasonality index. Their investigation revealed rainfall regime for the area is markedly seasonal with long drier season. Also (Suleiman, *et. al.*, 2021; Ologunorisa, 2004). Eludoyin (2009) studied monthly rainfall distribution in Nigeria between 1985-1994 and 1994-2004, the study noticed some fluctuations in most months within the decades.

Table 6 Correlation between Climatic Parameters for 37 Years

	Relative Humidity	Maximum Temperature	Minimum Temperature	Precipitation	Solar Radiation
Relative Humidity	1				
Maximum Temperature	-.148** 0.002	1			
Minimum Temperature	0.085 0.069	-0.004 0.939	1		
Precipitation	.504** .000	-0.063 0.182	-0.006 0.892	1	
Solar Radiation	0.031 0.504	0.026 0.586	0.014 0.763	.234** .000	1

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

Source: Researcher's Analysis, 2023

Relationships were sought between rainfall, maximum temperatures, minimum temperature, relative humidity, and solar radiation using the Pearson product moment correlation. The results indicates that maximum temperature, precipitation and solar radiation were found to be significantly correlated and statistically significant ($r = -.148$, $<.002$, $r = .504$, $<.001$ and $r = .234$, $<.001$) maximum temperature and relative humidity were found to be very low negatively correlated and statistically significant, precipitation and relative humidity, moderately positive correlated and solar radiation and precipitation were found to be very low positively correlated and significant. For the relationship between maximum Temperature and Relative humidity, this shows that an increase in one led to a decrease in the other. That is, as one variable increases in value the other decreases in value. However there seem to be a general slight upward trend indicating possible climate change. The null hypothesis is therefore rejected because there is a significant relationship between the climatic elements and climate variation in the study area.

CONCLUSION

From the findings above, we can conclusively say that the climatic variables have no significant

impact on the water level in the three catchment areas since none of climatic variable have a significant effect. Therefore, water resources availability in the catchment areas will not be under stressed by climate variation. Hence, the surrounding community in the catchment areas will be more secured under climate change than other catchment areas in the State. This will lead to the overall economy of the State to move further one step in enhancing the sustainability of food security. Especially small-scale farmers dependent on harnessed water during rainy season for later use. This led to the situation whereby, weather of the study area experience climate variation and not climate change as attributed to by Abaje *et al.*, (2016); Odjugo (2010a) and equally the result is in tandem with the findings of Aremu (2019); Adakayi (2012); Ayoade (2003) which posited that, a situation where elements just vary and are still in existence cannot be called "change" meteorologically. Furthermore, temperature in the tropical areas of Sub-Saharan Africa which Nigeria and Kaduna State inclusive falls into, is high both at wet and dry period and so, not a good indicator of climate change. The large amount of available water during the rainy season; crop varieties that can withstand much water should be planted in areas of high rainfall;

and government policies related to agriculture and water resources development should be based on increase in rainfall and water resources trends in Kaduna State.

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