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FLOOD STUDIES IN KADUNA, NIGERIA USING REGRESSION ANALYSIS WITH SPSS STATISTICAL PACKAGE

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ABSTRACT
This study examined the flood in Kaduna using the meteorological characteristics of Kaduna River watershed by Regression analysis with Statistical Package for Social Science (SPSS 20). The hydrological parameters used for the study include; precipitation, relative humidity and temperature records from 2010 to 2014 collected from Nigeria Meteorological Agency (NIMET). The results obtained from the flood model created using the meteorological records showed that 2011 has the highest values for discharge and river stage as 22553.1758mm^3/s and 3.7.5353m respectively hence justifying the devastated flood during that period. From the results, correlation coefficient, R=0.497 and coefficient of determination, R^2 = 0.247 for the model. The significant F of the discharge is 0.739 which is higher than 0.5 acceptable limits. These show the significance of the parameters used for creating the models were ok. The model can be adopted for flood studies in the basin for future studies.

Keywords: Flood forecasting, Flood Model, Regression analysis and SPSS

INTRODUCTION

Flooding may occur as an overflow of water from water bodies, such as a river or lake, in which the water overtops or breaks levees/other water retaining structures resulting in some of that water escaping its usual boundaries, or it may occur due to an accumulation of rainwater on saturated ground, or when the size of a lake or other body of water vary with seasonal changes in precipitation and/or snow melt there by causing death, damage to properties or drown domestic animals(Alayande, &Ogunwamba, 2010; Smith, & Ward, 1998).It can occur in rivers when the flow rate exceeds the capacity of the river channel, particularly at bends or meanders in the waterway or can also be applied to the inflow of the tide. Floods often cause damage to homes and businesses if they are in the natural flood plains of rivers. Hence, economic losses and impacts of flood have remained high and constitute a large developmental burden(Hanson, et al., 2008).

Many areas, regions, countries see flood as one of the major natural hazard as identified by the International Communities/ Organizations(Bradshaw et al., 2007; Herschy R., 2002). revealed that damage due to flood exceeded 100,000 deaths, displaced 320 million others, and caused economic damages exceeding US$1,151 billion in 56 developing countries from 1990 to 2000. Floods occur at Cleveland in 2006, Bolivia in January 2007, Namibia in February 2007, Australia in March 2007and Malaysia in late 2006 and early 2007, which displaced about 70,000 people and caused RM1.5bn of loss at Johor and other neighbouring states (Berita, 2007). Chan and Parker (1996)reported similar flood disasters in Kuala Lumpur, Ipoh, Penang, and Kota Bahru; Malaysia.

Parker (2000) observed that in many African countries, floods create great natural threats to life, health and population. The exposure and vulnerability of human settlements and activities to floods is partly explained by the important role which floodplains play in African societies and economics, and partly by the condition of societies and the resilience they are able to present in the face of disaster. Trevor (2010) highlighted occurrences of very high flooding in Nigeria, Niger Republic, China and Pakistan that affected over 17 million people necessitating a call for International intervention.

Flood Forecasting Models

Many different forecasting models which range from simple - stage regression techniques to sophisticated physically - based distributed hydrologic models, have been developed and used to forecast flood in different countries (WMO, 1996). For instance, many countries in the areas covering the North Pacific, Malaysia, and the Philippines have adopted the regression techniques, unit - hydrograph methods, and conceptual models to forecast floods. Many countries in the areas covering the North Pacific, Malaysia, and the Philippines have adopted the regression techniques, unit - hydrograph methods, and conceptual models to forecast floods. Over the last few decades, there has a proliferation of flood forecasting models since the advent of computers. Although forecasting of flood still contains uncertainty due to a number of constraints. An adequacy forecasting model may not perform well if it is inadequately calibrated. Model calibration is often constrained by the following:

1. Lack of adequate calibration data.
2. Rainfall station network may not be dense enough to accurately estimate the catchment rainfall.

3. High discharges during flood events are subject to significant error due to flow gauging difficulty.
4. Dynamic changes in catchment conditions (e.g., urbanization) invariably introduce non-homogeneity in the water level and also in the flow data.

Study Area

Nigeria witnessed several floods for decades (Kazaure, 2015). High intensity rainfall witnessed in 1988, 2001, 2010, 2012, 2016 in many states (Aljazeera, 2010; Gambrell, 2010). Trevor (2010) and Yusha'u (2010) reported flood occurrence in Nigeria.

Kaduna, one of the states affected by frequent floods in Nigeria is a commercial city and has the second largest concentration of industries in the northern part of the country. It has a concentration of commercial/business activities within the Central Business District and many government agencies and private organizations are located within the metropolitan area thereby making it populated. Hence, any flood event in the area may be overwhelming and affect many people.

Fig 1: Map of Nigeria showing Kaduna State

The metropolitan area is located along the banks of Kaduna River that flows through the city thereby dividing it into partly Kaduna North and Kaduna South Local Government areas. The Kaduna River Basin is one of the largest in Nigeria. Its catchments are about 27,592km^{2}.

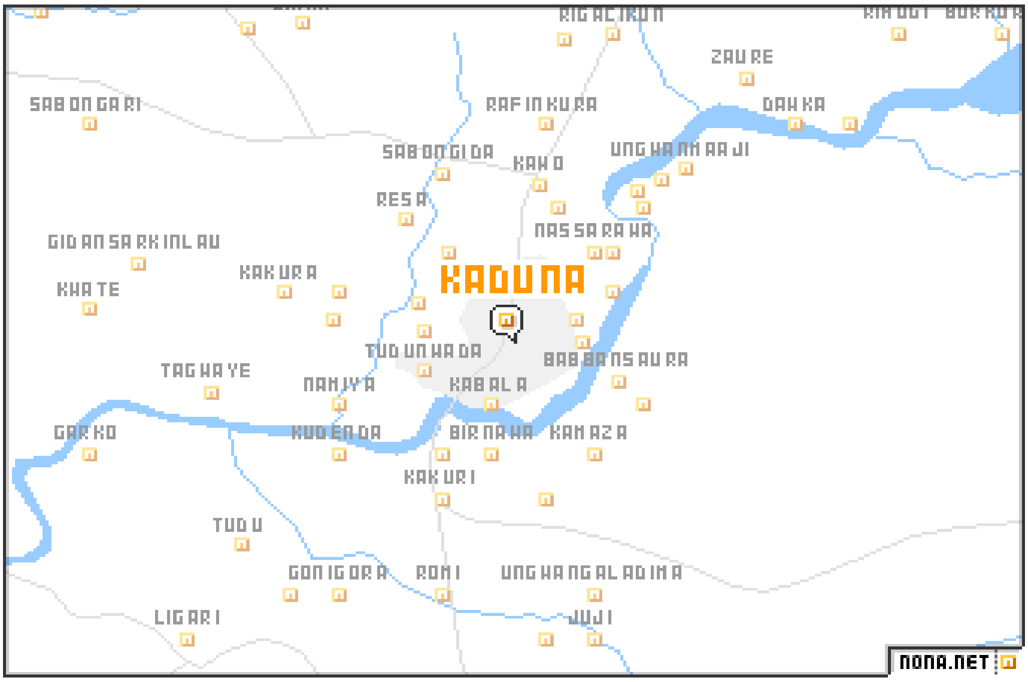

Fig 2: Map of Kaduna Metropolitan area showing River Kaduna

Areas affected by Flood in Kaduna Metropolis

Although flood is an international event and there were recorded cases of flood in Kaduna for decades, this study took particular interest in the 2016 flood that affected communities in Kaduna metropolis along Nasarawa, Mando, Barnawa, Sabon Tasha, Tudun Wada, Kigo road, UngwanRimi, Ungwandosa, SabonKawo, Bakinruwa, Malali, Kabala costain and Tirkania. The flood destroyed about 3,000 houses, killing three persons and damaging millions of naira worth of properties. The plates below show some of the areas affected by flood in Kaduna metropolis.

Plate 1: Flood affected area in Nasarawa, Kaduna. (Source: NEMA Kaduna)

Plate 2: Flood affected area in Nasarawa, Kaduna. (Source: NEMA Kaduna)

Plate 3: River Kaduna bridge at stadium, Kaduna. (Source: NEMA Kaduna)

Plate 2: Flood affected area at Kigo Road Kaduna. (Source: NEMA Kaduna)

Methodology

This study examined the meteorological characteristics of Kaduna River watershed i.e. to determine the River Stage and the Discharge using Regression analysis with Statistical Package for Social Science (SPSS).

Statistical analysis

Statistical Package for Social Science is a software package used for statistical analysis long produced by SPSS inc. It was acquired by IBM in 2009. SPSS is a widely used program for Statistical Analysis in Social Science and Engineering. It is also used by Market Researchers, Heath Researchers Survey Companies, Government Agencies, Education Researchers, Marketing Organizations, Data Miners and Others. Meaningful use of SPSS requires basic understanding of relevant statistical concepts.

The method used for the analysis was Multiple Linear Regression, using SPSS software. The hydrological parameters used for the study include; precipitation, relative humidity and temperature records from 2010 to 2014 collected from Nigeria Meteorological Agency (NIMET).

Table 1.0: Kaduna Meteorological Data (1994 – 2010)

Year	Annual Rainfall (mm)	River Stage (m)	Relative Humidity (%)	Temperature (^{O}c)	Max. Daily Flow (mm^3/s)
1994	1090	7.39	32.7	26.5	2926.31
1995	1190	5.08	33.6	28.9	862.01
1996	1205	5.67	35.5	32.2	1151.79
1997	1300	5.41	36.7	35	1013.98
1998	1150	7	39.5	38.7	2398.85
1999	1300	7.07	41	40	2488.34
2000	1210	5.57	42.8	39.8	1083.83
2001	1450	5.5	41	36.3	1055.51

Regression analysis includes descriptive and inferential components. The descriptive component is to derive and interprete the regression or prediction equation, multiple correlation coefficient (*R*) and coefficient of determination (R^2). Pearson correlation comprises both descriptive as well as inferential components. The descriptive component is to derive correlation coefficient (*R)* and describe the nature of relationship between the variables. The *R*value ranges between – 1 to + 1 as shown in Guildford's Rule of Thumb.

Table 2.0: Guildford's Rule of Thumb

R	STRENGTH OF RELATIONSHIP
> 0.2	Negligible relationship
0.2- 0.4	Low relationship
0.4- 0.7	Moderate relationship
0.7- 0.9	High relationship
> 0.9	Very high relationship

Results and Analysis using SPSS

Statistics

		RAINFALL	DISCHARGE	STAGE	HUMIDITY	TEMPERATURE
N	Valid	8	8	8	8	8
	Missing	3	3	3	3	3
Mean		1236.8750	1622.5775	6.0863	37.8500	34.6750
Std. Error of Mean		39.28987	293.81029	.32060	1.32625	1.79222
Median		1207.5000	1117.8100	5.6200	38.1000	35.6500
Mode		1300.00	862.01[a]	5.08[a]	41.00	26.50[a]
Std. Deviation		111.12855	831.02100	.90678	3.75119	5.06916
Variance		12349.554	690595.894	.822	14.071	25.696
Skewness		.861	.738	.560	-.143	-.583
Std. Error of Skewness		.752	.752	.752	.752	.752
Sum		9895.00	12980.62	48.69	302.80	277.40

a. Multiple modes exist. The smallest value is shown

T-Test

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[DataSet1] C:\Users\User\Desktop\ADEWALE.sav
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One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
RAINFALL	8	1236.8750	111.12855	39.28987
DISCHARGE	8	1622.5775	831.02100	293.81029
STAGE	8	6.0863	.90678	.32060
HUMIDITY	8	37.8500	3.75119	1.32625
TEMPERATURE	8	34.6750	5.06916	1.79222

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
RAINFALL	31.481	7	.000	1236.87500	1143.9692	1329.7808
DISCHARGE	5.523	7	.001	1622.57750	927.8266	2317.3284
STAGE	18.984	7	.000	6.08625	5.3282	6.8443
HUMIDITY	28.539	7	.000	37.85000	34.7139	40.9861
TEMPERATURE	19.348	7	.000	34.67500	30.4371	38.9129

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1193995.145	3	397998.382	.437	.739[b]
	Residual	3640176.115	4	910044.029		
	Total	4834171.260	7			

a. Dependent Variable: DISCHARGE

b. Predictors: (Constant), TEMPERATURE, RAINFALL, HUMIDITY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5514.605	5103.957		1.080	.341
	RAINFALL	-4.170	3.913	-.558	-1.066	.347
	HUMIDITY	6.362	321.250	.029	.020	.985
	TEMPERATURE	29.552	225.166	.180	.131	.902

a. Dependent Variable: DISCHARGE

Regression

[DataSet1] C:\Users\User\Desktop\ADEWALE.sav

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	TEMPERATURE, RAINFALL, HUMIDITY[b]	.	Enter

a. Dependent Variable: DISCHARGE

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.497[a]	.247	-.318	953.96228	.247	.437	3	4	.739	2.273

a. Predictors: (Constant), TEMPERATURE, RAINFALL, HUMIDITY

b. Dependent Variable: DISCHARGE

Correlation coefficient, R= 0.497, R^2= 0.247 ($-1 \leq R \leq +1$)

Flood Model: Q = 5514.605 –4.170(P) + 6.362(H)+29.552(T)

Where: Q = Discharge

P = Rainfall records

H = Relative Humidity

T = Temperature

Model Validation

The model was validated using 2010 to 2014 meteorological data collected from NIMET Kaduna airport on 26th October, 2015 as follows:

Q_{10}= 5514.605-4.170(1276.3)+6.362(389)+29.552(664.7) = 22310.4664 mm^3/s

Q_{11}= 5514.605-4.170(1096.4)+6.362(388.2)+29.552(647.7) = 22553.1758 mm^3/s

Q_{12}= 5514.605-4.170(1484.9)+6.362(385.3)+29.552(655.1) = 21132.5952 mm^3/s

Q_{13}= 5514.605-4.170(1572.1)+6.362(387.7)+29.552(683.6) = 21627.2426 mm^3/s

Q_{14}= 5514.605-4.170(1590.1)+6.362(384.7)+29.552(658.4) = 20788.3862 mm^3/s

Table 3.0: Predicted Discharges from the Flood Model

Year	Annual Rainfall (mm)	Relative Humidity (%)	Temperature (^{0}c)	Predicted Discharge (mm^3/s)
2010	1276.3	389	664.7	22310.4664
2011	1096.4	388.2	647.7	22553.1758
2012	1484.9	385.3	655.1	21132.5952
2013	1572.1	387.7	683.6	21627.2426
2014	1590.1	384.7	658.4	20788.3862

The Discharge of Kaduna river were predicted for 2010, 2011, 2012, 2013 and 2014 as 22310.4664 mm^3/s, 22553.1758 mm^3/s, 21132.5952 mm^3/s, 21627.2426 mm^3/s, and 20788.3862 mm^3/s respectively. The result shows that 2011 have the highest discharge which justified the flood witnessed in the period.

CONCLUSION AND RECOMMENDATION

This study examined the flood in Kaduna using the meteorological characteristics of Kaduna River watershed by Regression analysis with Statistical Package for Social Science (SPSS). A Flood Model for Kaduna was developed using the available meteorological data which include; precipitation, relative humidity and temperature records from 2010 to 2014 collected from Nigeria Meteorological Agency (NIMET).From the statistical results; correlation coefficient, R=0.497 and coefficient of determination, R^2 = 0.247 were obtained. The significant F of the discharge is 0.739 which is higher than 0.5 acceptable limits. These show the significance of the parameters used for creating the models were ok. An analysis on the available hydrological parameters will give us a batter insight into flooding in the basin and will enable us to mitigate the flood problems by applying flood control measures.

It is recommended that other factors such as run-off coefficient, evaporation and wind pressure are to be considered to create more accurate models.

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