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Regression Modelling of Flood Episodes in Ogbaru, Anambra State

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Flooding has caused numerous damages to lives and properties. Ogbaru local government is a riverine area that was adversely affected by flooding due to the storm surges that over-flooded the riverbanks during the flooding incidents that affected most areas in Anambra State in the past. Thus, the aim of this study is to develop a regression model for flood events in Ogbaru Wetland, Anambra State. To achieve this, data was collected from the Nigerian Meteorological Agency's synoptic station (NIMET) for temperature, rainfall, relative humidity and the number of major flood episodes in the area for a40-year period (1971–2010). Multiple Linear Regression was used to analyse the data. The results obtained showed the values for Multiple R, R^2, adjusted R^2, standard error as 0.115618399, 0.013367614, -0.068851751, 1.836772885, 0.115618399, respectively. The correlation results presented relative humidity and rainfall as 0.757133219; number of flood events and rainfall as 0.107747581; number of flood events and relative humidity as 0.085395873. ANOVA used to determine the strength of the regression. Conclusively, it was observed that flooding in the area was caused by a combination of atmospheric variables that contributed roughly 1.34 percent. Also, anthropogenic and environmental variables were responsible for 98.66% of wetland flooding.

Keywords: Flooding; Regression; Rainfall; Wetland; Storm-Surges

I. INTRODUCTION

Flooding has displaced more people worldwide than any other natural disaster or danger. According to Etuonovbe (2011), about 20% of the Nigerian population are at risk of flooding, which is a perennial problem in Nigeria that continuously caused death and displacement of people. Flooding is a common occurrence in most Nigerian cities. According to the National Emergency Management Agency (2012), the Nigerian floods of 2012 were labelled a national catastrophe, affecting over 2.3 million people and killing over 363 persons. The flood swept away some Nigerian cities, affecting 34 of the 36 states of Nigeria, including Anambra State, which was the most devastated. At least 68 people were killed in Central Nigeria's Plateau State, with 25 bodies discovered in the Benue River following the flood, as well as property losses (NEMA, 2012). According to the Anambra State Ministry of Environment (2012), these instances have shown that flooding is wreaking havoc on the nation's population and economy, yet mitigation efforts remain inadequate. Many international gatherings, workshops and fora have focused on the impact of climate change on the global environment. In the meantime, climate change studies have been conducted in a variety of Nigerian sectors. The impact of the phenomenon on water availability was investigated by Aondover (1997), Ezenwaji (2010) and Nnaji (2011), while the impact of climate change was investigated by Adejuwon (2006) and SEI (2008).

The implications of climate change on Nigeria's socioeconomic development have also been investigated by Abatam(2007); Ugwuanyi and Anekeje (2009). Its impacts on both urban and rural surroundings have also been

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studied by Uyigue and Agbo (2007). Climate change and other human activities are now posing a danger to this unique ecosystem. As the world's temperature rises, the sea level rises, devastating coastal wetlands and drying up inland wetland basins that once supported human socioeconomic activities.

The environment of the inland wetland communities of Ogbaru in the North Senatorial zone of Anambra State, Nigeria, which is the subject of this research, has helped to conserve biodiversity by providing crucial habitat for a variety of wildlife species. Wetlands are well-known for their flood protection capabilities. Adaptive strategies are needed to mitigate the negative effects of climate change on agricultural and human activities in the country's wetlands. As a result, the goal of this paper is to create a regression model for flood events in Ogbaru Wetland, Anambra State.

II. FLOODING

A. Impacts of Flooding

Flooding occurs when water overflows and submerges land (Encarta, 2009). Flooding also occurs when the water level in surface water such as a river or lake overflows or destroys levees, allowing some of the water to escape its regular confines or when rainwater accumulates on wet ground in a floodplain (Glossary of Meteorology, 2000). Greater rainfall and extreme weather events caused by climate change amplify the severity of other causes of flooding, resulting in more violent floods and increased flood risk (Hirabayashi*et al.*, 2013).

Floods can occur when a river's flow exceeds the channel's capacity, particularly around bends or meanders. Homes and businesses located in natural flood basins of rivers are frequently damaged by floods. While moving away from rivers and other bodies of water will almost minimise flood damage, humans have lived and worked near water from time immemorial to find food and profit from the advantages of cheap and simple transit and commerce. The fact that people continue to live in flood-prone places shows that the perceived value of living near water outweighs the expense of frequent flooding. Some floods take time to build, while others, such as flash floods, can occur in a matter of minutes with no obvious symptoms of rain. Floods can also be small, affecting a single neighbourhood or community, or huge, affecting entire river basins. In addition to property loss, flooding can result in long-term relocation of populations and an increase in the spread of waterborne infections and vector-borne diseases caused by mosquitoes (WHO, 2021).

Areal, Riverine, Estuarine, Coastal, Catastrophic, and Human-Induced Floods are the most common forms of flood. When rainfall or snowmelt supply water faster than it can infiltrate or drain off, areal floods can occur on flat or low-lying land. During occasions when precipitation exceeds evaporation, endorheic basins may experience areal flooding (Jones, 2000).

Overland flow on tilled fields can result in a muddy flood as sediments are taken away by runoff as suspended matter or bed load, which is what causes riverine flooding. Landslides, ice, debris, and beaver dams are all examples of drainage obstructions that can induce or intensify localised flooding. Due to intense rainfall, peak discharge, and physiographic conditions, the Markham River watershed in the Morobe province of Papua New Guinea became vulnerable to flooding (Tilley *et al.*, 2006; Samanta *et al.*, 2016). It is of utmost necessity to evaluate past flood records so as to forecast the future flood events in any area (Manandhar, 2010).

Storm surges induced by strong winds and low barometric pressure, as well as massive waves colliding with high upstream river flows, are major causes of flooding in estuaries. Severe sea storms or other hazards can cause coastal flooding (e.g., tsunami or hurricane). This category includes storm surges from tropical cyclones or extratropical cyclones. Catastrophic riverine flooding is frequently linked to significant infrastructure failures like dam collapses, but it can also be triggered by drainage channel change induced by a landslide, earthquake, or volcanic eruption.

B. Effects of Flooding in Anambra State

Flooding has a variety of impacts, ranging from primary to secondary to tertiary. When there is physical damage, such as destruction of structures, as in the instance of Anambra State during the flood disaster of 2013, primary effects occur. The recent flooding in Nigeria, which affected 36 states and the Federal Capital Territory (Abuja), was partly caused by climate change as well as the obstruction of natural and constructed drainages. By 2050, it's anticipated that more than two-thirds of the world's population will reside in urban areas, with developing cities predicted to see the majority of this urban growth (United Nations *et al.*, 2019).

Although some accounts claimed it was caused by water spilt from the Cameroun dam. Hadiza Ibrahim, the former Minister for Environment, Nigeria and the National Emergency Management Agency (NEMA) stated that Anambra State is located at the lowest point of the river Niger, making it flood-prone. This was the reason why the floods in Anambra State were so severe (Sun News, 2012). Anambra West, Anyamelum, Anambra East, and Ogbaru were among the affected local government areas. These local governments were flooded with water to a great extent. Chukwuma *et al.* (2021) used an integrated IVFRN-DEMATEL-AN model to conduct a GIS-based flood vulnerability modelling of Anambra State. The model was used to establish a network of relationships between the flood conditioning components and evaluate the extent of each of their impacts on the system.

Internally Displaced Persons (IDPs) numbered in the thousands, with an estimated 10,000 dwellings swamped completely or partially (Oseloka, 2012). Leading industries in the Onitsha Metropolis were drowned and did not function during those times. For these populations, the situation remained dismal and grim. Homes, farmlands and properties worth billions of naira were destroyed. Through the engagement of state-based Army and Navy forces, the police, churches, NGOs, and the State Emergency Management Agency, the Anambra State Government responded to the needs of the impacted communities and IDPs. NEEDS assessments were carried out by the State Emergency Management Agency (SEMA) and its federal counterpart, NEMA, as well as UNICEF. As a result, the state government, NEMA, and other donors sent humanitarian supplies. The state government resumed its evacuation, search, and rescue (SAR) activities for trapped people in partnership with the Nigerian Army and Navy. In the Ayamelum LGA, the Health Centre Umueje, Community Primary School Igbakwu, and the Skills Acquisition Centre Anaku were used as IDP Camp; in the Otuocha LGA, St. Augustine Catholic Church and Unity Primary School Umuoba Anam were used. The Anambra State Government and its local collaborators supplied housing, medical care, and food to the IDPs (Daily News, 2012).

We must be environmentally conscious, where we need to build buffer dams, and residents in flood plains should move to higher ground. Sani-Sidi (2013) stated what could be done to alleviate the impact of floods in the country. State governments, as well as municipal governments, must take emergency management seriously; they must raise awareness and build capacity in order to lessen the vulnerability of citizens. The increasing rivalry for water and the depletion of freshwater supplies, as well as the use of low-quality water, have provided a new challenge for environmental management (Ini *et al.*, 2012). If preventive precautions are not taken, urban floods are predicted to become more frequent and intense, with devastating effects in the informal settlements due to the forecasted erratic rainfall and extreme climatic conditions brought on by climate change (Teng *et al.*, 2017a).

The reasons of flooding in Anambra State are in adequate city planning in terms of building and other structural layouts, clogged drainage system, overpopulation, irresponsibility on the part of the government, and climate change.

Mark *et al.* (2018) reiterated that considering the magnitude of this flood and its effects, pluvial flooding is strongly correlated with the huge human population. Several settlements in Anambra State have been completely drowned by heavy flooding, the worst of which being

Ogbaru, Anyamelum, Anam, and other locations of the lower Niger River, as depicted below.

Figure 1. Picture of buildings and areas submerged.

Figure 2. Picture of the area with total submergence by flood (Anambra State Internet Photo News, 2012).

III. MATERIALS AND METHODS

A. Study Area

Ogbaru Local Government Area is located in Anambra State, between latitudes 5°42' and 6°08'N and longitudes 6°42' and 6°50'E and covers a substantial wetland zone. Because of its alluvial mud content, the relief is a plain region with heights ranging from 0 to 50 meters and swampy conditions. Its geology is mostly alluvium, and the Niger River and its primary tributary, the Ulasi River, are the two major rivers in the area. The vegetation consists of a combination of coastal woods along the Niger River's banks. The climate is hot and humid equatorial, with average high temperatures of 30°C and lowest temperatures of 24°C, depending on the season. The rainy season lasts 9 months, from March to November, while the dry season lasts from December to February, with a total annual rainfall of roughly 1,900mm. A range of agricultural and human activities take place here, and they include fishing, lumbering, crop production, water and land transport, etc.

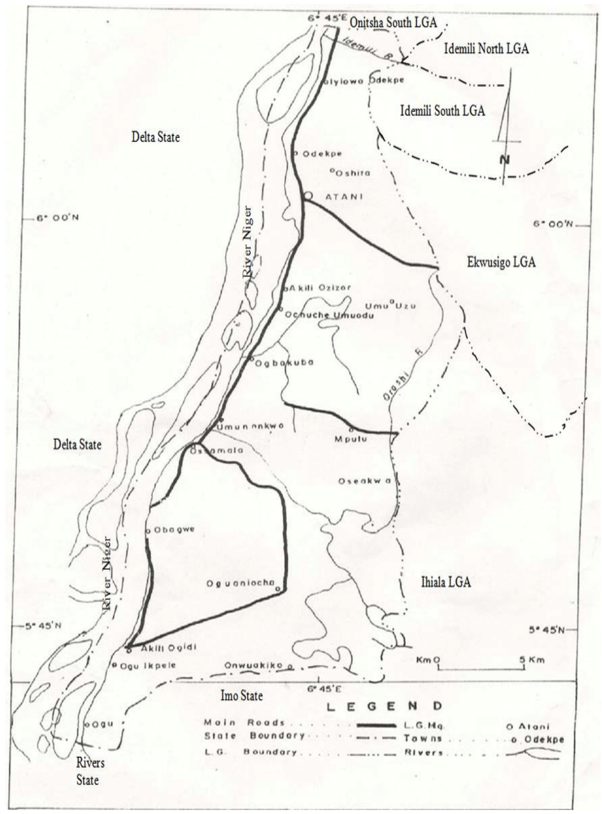

Figure 3. Map of Ogbaru Local Government Area (Source: Ezeokoli *et al.*, 2015).

B. Data Collection

The study used data from the Nigerian Meteorological Agency's synoptic station (NIMET) Enugwu-agidi, Anambra State, for temperature, rainfall, relative humidity, and the number of major flood episodes in the area over a 40-year period (1971–2010). Because it is used by the government and other agencies to forecast meteorological factors for agricultural activities in the area, I considered the data from this station to be reliable.

C. Data Analysis

To determine the contributions of climate components to the destruction of agricultural and human activities, data was examined using Multiple Linear Regression. The dependent variable was the number of flood episodes in the area, whereas the independent variables are Temperature, Rainfall, and relative Humidity. The study used Cluster Analytical Technique and Multiple Regression Analysis.

IV. RESULTS AND DISCUSSION

Table 1 shows the 40-year average of temperature, rainfall, relative humidity, and the frequency of major flood events in the area.

Table 1. 40 year (1971 – 2010) Average Temperature, Rainfall and Relative Humidity together with the number of major flood events in Ogbaru wetland.

Year	Temp (°C)	Rainfall (mm)	Relative Hum (%)	Number of Major Flood Events
1971	29.4	1662	44.4	6
1972	30.1	1612	49.2	4
1973	28.2	1566	39.2	2
1974	28.9	1633	46.9	4
1975	27.3	1687	58.4	6
1976	28.4	1849	56.8	5
1977	28.9	1877	58.1	8
1978	28.4	1820	62.3	8
1979	27.9	1829	54.1	6
1980	27.5	1864	59.3	6
1981	27.2	1842	52.1	4
1982	28.6	1872	60.1	5
1983	26.9	1828	58.9	5
1984	28.1	1794	54.6	3
1985	26.3	1849	58.7	4
1986	28.4	1812	65.4	9
1987	28.5	1756	63.4	7
1988	26.3	1791	64.1	6
1989	26.9	1920	65.9	8
1990	27.1	1846	64.1	7
1991	28.7	1821	64.8	4
1992	28.6	1920	65.7	4
1993	28.4	1872	62.6	3
1994	26.4	1856	68.3	4
1995	28.6	1824	67.2	5
1996	28.6	1881	66.4	2
1997	27.4	1866	67.9	3
2000	27.9	1814	68.3	4
2001	28.7	1869	67.3	2
2002	28.6	1881	67.4	3
2003	28.1	1826	64.2	3
2004	28.4	1883	65.1	5
2005	27.3	1842	62.4	4
2006	27.9	1809	64.1	3
2007	27.7	1832	61.2	5
2008	27.4	1881	66.2	6
2009	28.2	1845	67.2	6
2010	28.3	1861	68.1	7

Source: Nigerian Meteorological Agency Enugwu-agidi Synoptic Station, (2011).

A. Correlation Analysis

Table 2 shows the result of correlating the three climate factors (used as independent variables) with the number of flood episodes (the dependent variable). With the exception of rainfall and relative humidity, the connection in Table 2 is often minimal. This is a normal trend, as higher rainfall means higher relative humidity. Flood and all of the parameters, on the other hand, are weakly connected, but their different correlations are expected. The negative link between flood and temperature, for example, suggests that when the temperature drops, flood rises because higher rainfall is possible.

Table 2. Result of the Correlation Analysis.

	Temp (°C)	Rainfall (mm)	Relative Humidity (%)	Number of Major Flood Events
Temp (°C)	1			
Rainfall (mm)	-0.317631963	1		
Relative Humidity (%)	-0.27460591	0.757133219	1	
Number of Major Flood Events	-0.073839613	0.107747581	0.085395873	1

Relative Humidity and Rainfall, Number of Flood Events and Rainfall, and Number of Flood Events and Relative Humidity all have a positive linear relationship. For these pairs, the Pearson correlation coefficients are:

- Relative Humidity and Rainfall, 0.757133219
- Number of flood events and Rainfall, 0.107747581
- Number of flood events and Relative Humidity, 0.085395873

These numbers imply that the variables have a moderately positive association. With negative Pearson correlation coefficients, the following couples have a negative linear relationship:

- Rainfall and Temperature, -0.317631963
- Relative Humidity and Temperature, -0.27460591
- Number of Major Flood Events and Temperature, -0.073839613

The association between these variables is negative, indicating that rainfall, relative humidity, and the number of major flood events drop as temperature rises.

B. Regression Analysis

The combined atmospheric variables contributed approximately 1.34 % to flooding in the area, according to the Regression Analysis (Table 3). This suggests that anthropogenic and environmental factors account for 98.66% of the wetland floods. This is due to the influence of a huge body of water, which delivers adequate moisture during evaporation, which then returns to the environment as rain, flooding the area.

Table 3. Result of the Regression Analysis (Regression Statistics).

Regression Statistics	
Multiple R	0.115618399
R Square	0.013367614
Adjusted R Square	-0.068851751
Standard Error	1.836772885
Observations	40

C. ANOVA Result

The p-level (sig) of the ANOVA used to determine the strength of the regression is 0.9208, which is higher than the 0.05 level (Table 4). This implies that the regression model is not statistically significant, implying that the null hypothesis is the most likely explanation for the association between Flood and Climatic factors. A p-value greater than 0.05 (>0.05) suggests strong evidence for the null hypothesis. This signifies that the null hypothesis is retained, and the alternative hypothesis is rejected. It is important to emphasise that the null hypothesis cannot be accepted; it can only be rejected or failed to be rejected.

A statistically significant finding does not establish the validity of a study hypothesis (as this implies 100% certainty).

Because there is still a small chance that the results happened by chance and the null hypothesis was right (e.g. less than 5%), the data “support” or “give evidence for” the study hypothesis.

Table 4. ANOVA Table.

	df	SS	MS	F	Significance F
Regression	3	1.645553306	0.548517769	0.16258474	0.920837042
Residual	36	121.4544467	3.37373463		
Total	39	123.1			

V. CONCLUSION

The study looked at climatic data from 1971 to 2010. According to the Regression Analysis, the combined atmospheric variables contributed about 1.34 % to flooding in the area. The findings also imply that anthropogenic and environmental factors account for 98.66 % of the wetland floods. This is due to the impact of a large body of water, which provides sufficient moisture during evaporation, which then returns to the environment as rain, flooding the area. Given the likelihood of a wide range of damages from future flooding in the area, efforts should be undertaken to promote the adaptation methods indicated in this research. It is clear that the traditional adaptation measures are no longer adequate to deal with the growing threat of climate change in the region. As a result, modern measures should be implemented. The State governments and other government agencies' efforts should be focused on places like Okpoko and Ogwuikpele that are prone to flooding.

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