SSR Journal of Engineering and Technology (SSRJET)
Homepage: https://ssrpublisher.com/ssrjet/
Volume 3, Issue 9, 2026 ISSN: 3049-0383

Flood Metrics and Flood Series Effect in Akpoha and Ebonyi Rivers South Eastern Nigeria

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Received: *11.07.2026* | ***Accepted:*** *23.09.2026* | ***Published:*** *27.09.2026*

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DOI: *10.5281/zenodo.22992135*

Abstract **Original Research Article**

This work evaluated the annual Flood metrics and flood series effect in Akpoha and Ebonyi rivers. It adopted flood metrics of the rivers for four seasons to determine the flood series within the period of study. This assessment tried to determine the flood series in the respective seasons within the period of study. The evaluation also provided information on the annual flooding in the affected floodplains given the volume of flood water available at each point. Akpoha and Ebonyi rivers were sampled at different points. The design of 4x4 factorial was applied to determine the relationship between sample points and parameters for control, 2014 and 2015 and 2016 using analysis of variance for Completely Randomized Design. Mean values evaluated for significant differences using Fisher's Least Significant Differences at P < 0.01.T-test was used for confirmation. The rivers sampled at four points, a1, a2, a3, a4 Akpoha as well b1, b2, b3, b4.Ebonyi. The main factors determined were discharge, flow velocity, width and depth. Results showed that the factors were highly statistically significant at 1% level and the confirmatory test via FLSD also agreed to that. Results of evaluation of flood series a1 and a2 showed that the highest No of 1-day maximum flood of 743.01 m3/s, 584.10 m3/s and 748.87 m3/s, 673.91 m3/s were recorded in 2015,P- probability of return are 5.88% and 11.76%.T- the recurrent intervals are 17 and 8.5 respectively.536 m3/s, 513 m3/s,423.33 m3/s and 322.83 m3/s, 320.39 m3/s, 274.10 m3/s were observed at a3,a4, a5, and b3,b4,b5 in 2016 which also showed that the probability of occurrences are 17.54%, 23.26% and 29.41%. Year of occurrences 5.7, 4.3 and 3.4 respectively. The 1-day maximum flood of 26.63 m3/s and 8.14 m3/s in the control (2013). 62.85 m3/s and 56.35 m3/s recorded in 2014 showed 1.3 and 1.9 recurrent intervals and 76.92%, 52.63% probability of return. The discharge result showed that the recurrent interval for control < 2014 < 2015 < 2016 except at a1 a2.and b1, b2, 2016 < 2015 at a8 and b8. The record also showed that the probability of return for the control >2014 > 2015 > 2016. The 1-day maximum flood reflected the amount of water discharged by the water bodies at that point in the control, 2014 and 2015. The control indicated that a very low amount 23.22 m3/s and 6.12 m3/s were observed initially and that large amount of 743.01 m3/s and 748. 87 m3/s were observed in 2016 while medium amount of 62.85 m3/s and 56.35 m3/s were recorded in 2014. The results were recommended to individuals living in floodplains to enable them exploit water benefits from the areas and also take note of the flood series within the floodplains.

Keywords: Floodplain, Flood Series, 1- day Maximum Flood, Recurrent interval, probability of flood return.

INTRODUCTION

Floods were referred to as natural events caused by interplay of changes in climatic and adiabatic factors, channel characteristics (metrics) of rivers and human factors (Akintola and Areola 2004). Flood is an excess water that overflows stream bank and covers adjacent land. Flood was also defined as a very large amount of water that over flooded from a source such as a river to cover a previously dry area, (Powel, 2009). A flood occurs when water in a stream over flows it normal channel and spills into the adjacent area called floodplain, (Padaria, *et al*, 2009). Flood waters usually receded within a short Period of about an hour, hours and days after its occurrence. The international flood initiative (IFI, 2009) described flood as inundation of land by the rise and overflow of a body of water as result of heavy downpour, continuous or incessant rainfall. Flood also was seen as a temporary covering by water of land not previously covered by water, European Union Flood Directive (EUFD, 2009). Floodplain also refers to a flat region of a valley floor located on either side of a river that flows through it and is covered by water during floods especially when the river overflows its banks. Flood occurs in low lying areas of drainage basins and generates the flood waters. The floodplains around the water bodies usually receive water from the tributaries and this can exceed carrying capacities of such channels. Floods in history have wrought great calamities on the Lithosphere's environment and hindered the economic progress of the affected regions. According to Akintola and Ikwuyatum (2006) these calamities resulted in the destruction of human settlements and inflicted great sufferings on humans, great losses on plants and affect the economic improvement of people. The study of floodplain characteristics and clear understanding of it would help to reduce the areas where flood contributes to food scarcity by its role in the destruction of crops around the floodplain. Floods have previously affected the regional, continental and worldwide economies. The flood effects on the economies were made possible by the annual destruction of the crops, plants, building structures and the creation of ecological imbalance within the flooded zones (Osasogie *et al*, 2015). Flood occurrence depends on the elevation of an area and about one third of the land in Nigeria is at an elevation of less than eight meters above sea level, (Ivbijaro, 1999). Flood disaster during its occurrences usually devastated the world economy to the extent that the affected zones depended on the unaffected zones and the various world governments for their survival. Annually, the inhabitants of the areas of study kept on counting their losses. It is also necessary to determine the causes of flood and their consequences with a view to establish actual effect of flooding in the economy of Ebonyi state (Rock et al, 2016). Considering the effect of climate change on the world rainfall distribution, it is then deemed necessary to study the floodplain characteristics where great mass of water is haboured annually and allowed to drain into the bigger water bodies.The scarcity of water in Nigeria led to organizing a workshop to proffer solution on prevailing water Scarcity tagged "Workshop to Proffer Solution to the Shortage of Water Supply in Nigeria". Agarwal and Narain, (1999), had lent their support to the views on water harvesting to facilitate all year round agricultural activities. A close look at the rivers, during rainy seasons showed that discharge from these water bodies could be harvested to boost agricultural production during the dry spells. Flood disaster during its occurrences usually devastated the world economy, (Onwe *et al* 2016). Ezeh and Eze (2015) reported that flood in 2010 racked havocs in parts of Ebonyi state. She also revealed that many states like Anambra, Delta, Benue and Ebonyi were heavily flooded leading to the lost of properties. Real effects of flooding can only be expressed through the affected inhabitant responses, especially those that are confined in the floodplains as their choice for area of habitations. The assessment of their population and the effects of flooding on their agricultural inputs and the damages caused to their properties can serve as clues to the amount of money lost to floods annually. According to Onwe *et al*, (2016), Assessment of flood effect in the floodplains can only be effective when the inhabitants who were directly affected were given the opportunity to get involved in the estimation of the losses to the annual flood disasters.

MATERIALS AND METHOD

Study Area This study area is part of Ebonyi State. Three rivers were selected viz. Akpoha, Ebonyi and Inyaba rivers. The rivers were located generally by latitude $06^0$19'N and longitude $08^0 06^1$E, in the derived savannah zone of the Southeast agro ecological area of Nigeria. The three rivers individually were located at different co-ordinates. Akpoha river in the southern part at distance of 39.3km (24.4 mile) from Abakaliki and 17.9km (11.1miles) from Afikpo lies in latitude $05^0 59^1$N and longitude 08^0 00^1 E; Ebonyi river in the Northern part at a distance of 6.6km (4.1 mile) from Abakaliki lies in latitude 06^0 20^1N and 08^0 10^1E and and Inyaba river in the Central part at a distance of 29.3km (18. 2 miles) from Abakaliki lies by latitude $06^0$21'N and 07^0 49^1E. The population of Ebonyi State was put at 4,678,957. Population of the study areas Ebonyi North, Central and South were put at 1,524,783, 1,391,924 and 1,762,250 respectively, National Population Commission (NPC, 2006). Rainfall pattern of Ebonyi State was bimodal, April-July and September – November with a short dry spell in August normally referred to as "August Break." (Mbah, 2006). The total annual rainfall in the area ranges from 1500mm to 2000mm with a mean of 1800mm (Echiegu 2007). At the onset of rainfall, it is torrential and violent, sometimes lasting for to two hours,(Okonkwo and Ogu, 2002 prediction, the time of start and cessation of rain were both late and early respectively. Ebonyi State, the area of study is characterized by high temperature of 27^0C and maximum mean daily temperature of 32^0C throughout the year. Humidity was high (80%) within the rainy season and with lowest (60%) levels occurring during the dry season before December to April, before the rainy seasons began. According to to the Federal Development of Agricultural and Land Resources, (FDALR, 1987) the zone of study, Abakaliki agricultural zone lies within "Asu River group" and consists of Olive brown sandy shale fine grain sandstones and mud stones. The soil within the area of study is shallow with consolidated 1M of the soil surface. It belongs to the order ultisol and it is classified as types Hapulstult.

Materials for sampling

The materials used for sampling include:- Ranging Poles, Meter tape, Oranges, Hand gloves, Santana bags, Swan water bottles, Cooler of ice blocks and Stop Watch, Masking tapes,Permanent Markets, Bic, Exercise books, Ropes, Thermometer, Weights, Boats, and Questionnaires.

Research Design

The experiment was a 5x4 factorial in Complete Randomized Design (CRD), the factors were the four sample points (4) in each rivers namely; Akpoha a_1, a_2, a_3 and a_4 ; Ebonyi b_1, b_2, b_3 and b_4. Whereas the second factors are the five (5) observed factors that affected the rivers namely, width, depth, flow velocity, flow rate and the discharge,$w_1 \ldots w_4$, $dp_1 \ldots dp_4$,$v_1 \ldots v_4$,$r_1 \ldots r_4$, $dc_1 \ldots dc_4$. The rivers were denoted by A and B the sample points were denoted by $a_1 \ldots a_4$, $b_1 \ldots b_4$.

Sampling Procedure

In- situ sample analysis was conducted in the three sample points, A and B. the insitu analysis was run to determine the following parameters:-

(i) To determine the velocity of flow of the three rivers.

(ii) To Determine the cross sectional areas of the rivers.

(iii To Determine the discharge (volume) of water produced by the rivers for the period of time.

(iv) To Determine the depth of the body waters.

(i) Determination of the velocity of flow of the rivers.

The velocity of the river was determined by running a float and noting the time the float carnages took to cross the channel section. I measured out a straight section of each channel (rivers at a distance of 14.44m with fairly uniform cross section for this purpose. The time taken by the float to reach the end point of the straight section was recorded in seconds (S). A number of the readings on a stop watch were recorded and the mean taken for calculation. Flow velocity equation V= distance/ time (d/t) where v = velocity, d = distance (in meter) and t = time (in seconds). V = m/s

(ii) Determination of Cross Sectional Area.

The cross sectional areas were determined by selecting a straight section river bank. 14.44m length were measured out and the varying widths of the rivers measures at the water surface level and at the bottom level and the mean widths of the channels in cm or m i.e a+b/2 gotten. The mean widths of the River were determined by the aid of a Boat operators. The meter tape or a rope was held across the river and at the edge of where the water reached pegged and the measurement taken from the other side. Equation for cross sectional areas= LxW. Where L is length or distance and W, width of the rivers.

(iii) Determination of River Discharge

According to Suresh, (2005), Method of determining the discharge by determining the velocity of flow of the rivers, the cross sectional area of the river and the depth of the rivers. The discharge Q= AV where A is the cross sectional area and V, the velocity of flow. River and stream gauging is also known as stream flow measurement which is the measurement of discharge-stream flow passing through the stream section in a unit time. However to compensate for the variation in the width and b, a general equation for discharge was used. Discharge equation, Q = 0.85 (a+b/2)H, where Q was the discharge, “a”, the width of the channel at flow surface level in cm/m “b”, was the bottom width of the channel in cm or m, H, the flow depth of the rivers in m and v, the flow velocity in m.

(iv) Determination of the water depth.

Water depth was determined using method. The method to determining the water depth was sounding method. The sounding method used include the application of a lead weight on the end of a long rope. The rope was marked at appropriate intervals so that when it dropped into the water body, the depth would be determined as soon as the lead strikes the bottom. Then the weight was detached and a meter tape used to measure the length that went into the water. The length measured gave the actual length or depth of the water body.

Questionnaire Aministration (vi) Questionnaire as a tool was generated to determine the effect of flooding in the economy of Ebonyi state. Twenty homes were assessed within the three study areas. Sample of five (5) adult members of the Population were drawn from each home. Out of 100 members of the population, fifty (50) of them are sampled through questionnaire. One hundred and fifty questionnaires were generated and administered to the inhabitants of the areas within the rivers each year.Floodplain, Akpoha-A, received fifty (50) questionnaires. Floodplains Ebonyi- B, and Inyaba C, received fifty (50) questionnaire respectively.

Laboratory Analysis

The discharge, velocity of flow and cross sectional area of the rivers were determined in-situ. The responses from the inhabitants of the study areas on the questionnaires were received through face to face administration in the three sample points, Akpoha, Ebonyi and Inyaba.

RESULTS

Table 1; Annual Flood Series Method at Akpoha River Control to 2016

1-day Maximum	Rank Number	Recurrent interval	P (%)
Flood	(m)	T=n+1/m	1/T× 100
743.01	1	17	5.88
584.10	2	8.5	11.76
536.97	3	5.7	17.54
513.31	4	4.3	23.26
423.33	5	3.4	29.41
390.33	6	2.8	35.71
381.16	7	2.4	41.67
372.99	8	2.1	47.62
62.85	9	1.9	52.63
49.87	10	1.7	58.82
47.86	11	1.6	62.5
42.28	12	1.4	71.43
26.63	13	1.3	76.92
23.92	14	1.2	83.33
23.63	15	1.1	90.91
23.22.	16	1.06	94.34

Table 2; Annual Flood Series Method at Ebonyi River Control to 2016

1-day Maximum	Rank Number	Recurrent interval	P (%)
Flood	(m)	T=n+1/m	1/T× 100
748.87	1	17	5.88
673.91	2	8.5	11.76
322.83	3	5.7	17.54
320.39	4	4.3	23.26
274.10	5	3.4	29.41
191.49	6	2.8	35.71
165.50	7	2.4	41.67
158.29	8	2.1	47.62

56.35		9		1.9		52.63
51.44		10		1.7		58.82
33.80		11		1.6		62.5
33.00		12		1.4		71.43
8.14		13		1.3		76.92
7.40		14		1.2		83.33
6.99		15		1.1		90.91
6.12.		16		1.06		94.34

Discussion

The data as presented in the Table showed the outcome in recurrent interval and the probability of flood return in Akpoha and Ebonyi rivers within the period of study. The Table1and Table 2 showed the effect of flooding within the floodplains.The tables also showed the flood series which indicated the possible highest flood of 743.01m³/s and 748.87 m³/s the lowest 1-day maximum flood of 23.22m³/s, and 6.12 m³/s, the rank number (m) 1-16, the recurrent interval (T) of 17years to 1.06years and the probability of flood return of a range 5.88 percent to 94.34 percent within the three years of study. The table indicated that 584.1 m³/s and 673.91 m³/s – 1 day maximum flood recorded 2m rank number. It also recorded recurrent interval of 8.5 and 11.76 % probability of return of flood. The next highest 1 day maximum flood of 536.97 m3/s and 322.83 m³/s recorded a higher level of 3 rank number than 743.01 m3/s,584.1 m3/s and 748.87 m³/s, 673.91 m³/s and a lower period of return of 8.5. A probability of return of 11.76 % was also recorded.1- day maximum flood of 513.31 m3/ s and 320.39 m³/s recorded a higher level of 4 rank number 4.3years of return and a higher percentage of 23.26. A day maximum flood of 423.33 m3/s and 274.10 m³/s recorded rank number of 5, recurrent interval of 3.4 years and probability of return 29.41 %. A lower maximum of 390.33 and 191.49 m³/s with rank number 6 recorded recurrent interval of 2.8 years period and 35.71% probability of return in the area. A 381.16 m3/s and 165.50 m³/s had a rank number of 7, 2.4 recurrent intervals and a high percent probability of return of 41.67. 1- day maximum flood of 372.99 m3/s and 158.29 m³/s had a rank number of 8, 2.1 period of return and 47.62 % probability of return. The high 1-day maximum flood gave lower rank numbers, higher recurrent intervals and reasonable values in the probability of returns. Maximum flood of 62.85 m3/s and 56.35 m³/s which were lower than the first eight values recorded rank number 9 recurrent interval of 1.9 years and 52.63 percent probability. 49.87 m3/s maximum flood recorded a rank number of 10, 1.7 recurrent interval and 58.82 percent probability. The value of 62.5 and 71.43 percent probability were recorded in 47.86 m3/s and 42.28 m3/s and 33.00 m³/s maximum flood which also had recurrent intervals of 1.6 and 1.4 respectively. The group 47.86 m3/s,42.28 m3/ s and 33.80 m³/s, 33.00 m³/s also had rank numbers of 11 and 12.The other maximum flood values of 26.63 m3/s, 23.92 m3/s, 23.63 m3/s, 23.22 m3/s and 8.14m³/s,7.40 m³/s,6.95 m³/s,6.12 m³/s recorded rank numbers of 13, 14, 15 and 16 respectively. The corresponding recurrent values were 1.3, 1.2, 1.1 and 1.06 and their respective probability of return were 76.92, 83.33, 90.91 and 94.34 percents.

Conclusion

Flood series from the study areas were important for flood study and predictions which could help in generating information for flood management within the study areas. The information given by the flood series could also serve as a tool in determining the accuracy of the regime of the rivers. The work also assessed the economic effect of the floodplains and the information obtained could serve as a base data for managing the economic gains and losses within the study areas and other related situations. The inhabitants of the floodplains may approach the Governments both state and federal for assistance considering the level of economic losses incurred in the floodplains annually.

Recommendation

Flood series study as presented here is highly recommended especially in area that is prone to flooding.

The study is recommended for government agencies that are responsible for flood prediction and control.

The information from the study of flood series no doubt will help the individuals living around flood plains as it will help to guide against the effect of flooding.

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