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Assessment of Flooding Impact of River Ngadda in Borno State

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Abstract
Flooding is a threat to the environment that requires appropriate measures to be taken to mitigate it effects. Flood frequency analysis of River Ngadda was carried out using available historical streamflow data (1981 – 2000). Preventive measures to mitigate the impact of flooding were also proposed. Statistical analysis revealed that River Ngadda experienced flood in 7 years from the period of 1981 to 2000 with an annual mean flow discharge of 7728.7m^3/s and skewness of 0.86. Furthermore, results showed that River Ngadda experienced another 7 years of flood from the period of 2001 to 2022 with annual average streamflow and skewness of 4241.44m^3/s and 1.04 respectively. To this end, the present study suggested that government should ensure compliance to the environmental management policies that are properly enforced in the country. Equally, development control activities should be taken seriously to avoid erecting on flood plains and flood-prone areas. Finally, regular environmental education should be given priority in society as it is always ascribed that knowledge is power, and with power, there is no limit to achievement.

Keywords: Flood, Assessment, Streamflow, Analysis, Mitigate

1. Introduction

Floods are extremely high discharge rates in a constantly changing environment, resulting in the inundation of land next to streams, rivers, or lakes. It is typically brought on by heavy or prolonged rainfall (Kattumuri, 2018; Jiang *et al.*, 2023). It occurs when a body of water moves across and above an area that is not often inundated. According to Merten et al. (2021), floods are purely environmental hazard that result from several basic causes of which the most frequent are climatologically in nature, but very often induced by man's improper utilization or abuse of the environment. Flood is considered the world's worst global hazard in terms of its magnitude, occurrence and geographical spread, loss of lives and properties, and displacement of people and socio-economic activities (Mukoro *et al.*, 2015). In Nigeria, flooding is a growingly serious and common issue. Nigeria has suffered the same fate like the rest of the world as floods have almost become annual events most especially in urban centers (Egya, 2021). They are made more likely by human activities such as population increase, fast industrialization and urbanization, exploitation of natural resources, and placement of infrastructure. Poor drainage conditions and indiscriminate garbage dumping on drainage systems are the two main causes of flooding in Nigeria (Twaibu & Okidi, 2021). Unfortunately, the urban poor are more affected, making it doubtful that recovery would be realized without outside assistance (Sethi & Creutzig, 2021). In the city of Maiduguri, River Ngadda is an important waterway. When it overflows, neighbouring lands could be destroyed and properties lost.

Thirteen states including Benue, Borno, Delta, Ebonyi, Lagos, Imo, Jigawa, Kano, Katsina, Oyo, Sokoto, Taraba, and Yobe reported flooding incidents in August 2022; of these thirteen states, eight (Zamfara, Oyo, Delta, Ebonyi, Borno, Imo, Taraba, and Benue) were the worst hit, having suffered the highest numbers of casualties (NIMET, 2022). Sadly, children and the elderly made up a disproportionate share of the deaths from the flood, which also caused thousands of people to be homeless and ruined property worth millions of Naira.

Obi et al. (2021) have observed that one way to mitigate the effects of flooding is to ensure that all vulnerable areas are identified and adequate precautionary measures are taken to ensure either or all adequate preparedness, effective response, quick recovery, and effective prevention. In order to facilitate the mitigation process, the authors emphasized the need for information on important indices of flood risk identification which are elevation, slope orientation, proximity of built-up areas to drainages, network of drains, presence of buffers, extent of inundation, cultural practices as well as attitudes and perceptions.

Moreover, as government with stakeholders' efforts towards confronting the hazard have not yielded satisfactory results, they have been criticized as ad-hoc, poorly harmonized, non-generalizable, and not well recognized (Danhassan, 2023). Nevertheless, in the light of 'best practices' in flood risk assessment and 'lessons learned' from other countries' experiences of flooding, it can be debated that such stake holders' determinations are limited due to lack of quality information or data, that is necessary to systematically confront flooding, poor sensitivity of flooding among the general populace, lack of funds and enhanced technology as well as poor political will power that will help enact laws that can address flooding. As a relationship exists between urbanization and hydrological characteristics; increased runoff, increase in frequency and flood height, successful flood mitigation requires professional knowledge about the expected frequency, and magnitude of flood events along River Ngadda course. The study will further examine the significant indicators of flooding along River Ngadda. Thus, identifying gabs in governance needed to mitigate flooding impacts.

2.0 Material and methods

2.1 The study area

In Borno State, the River Ngadda is located between Latitudes 11.837°N and 11.818°N and Longitudes 13.147°E and 13.186°E (Figure 1). It comes from the Sambisa Swamp from flood spills of Rivers Yedzaram and Gambole (Musa et al., 2022). Seasonal flooding has been observed in this area in the past. This includes the Alau Dam burst in 1994, which overflowed and caused the river to peak, bringing floods; resulting to loss of lives and property destruction (Tanaka et al., 2022).

Figure 1: Map showing Maiduguri city with River Ngadda

2.2 Data collection

Available streamflow data were collected from Borno State Ministry of Water Resources for the period of (1981 to 2000).

2.3 Method of data analysis

Steps followed in developing empirical flood frequency curve are;

(i) Compile a list of annual floods.

(ii) Set up a flood frequency computation table as follows:

Water Year	Date	Peak Discharge, Q (m^3/s)	Rank, M	Return Period, Tr (Yr)

(iii) Determine the peak flood (highest instantaneous peak discharge) for each water year using published gauging data (e.g., USGS or DWR data publications) under "momentary maximum" or "annual maximum".

(iv) Enter that value in m^3/sec in the "Peak Q" column.

(v) After each flood from each year has been entered into the computation table, rank the discharges from largest to smallest. Allow rank M=1 for the largest deluge. With regard to rank, the smallest flood will have M=N, where N is the total number of years for which we have flood data. Give the tied events distinct but nearby ranks if there is a tie.

(vi) Compute the recurrence interval (or return period) of each flood using Equation (1):

$$T_r = \frac{(N+1)}{M}\ (years) \quad (1)$$

Where; $N = total\ number\ of\ floods,\ M = rank$

(vii) Plot each flood discharge versus it's T_r on a sheet of extreme-value flood frequency paper that is either arithmetic or logarithmic. Fit a curved line smoothly through the points. Then determine the best fit for this curve.

3.0 Results and Discussions

3.1 Historical and predicted streamflow data of River Ngadda

Tables 1 and 2 showed historical streamflow discharge records and arithmetic result of River Ngadda's streamflow from 1981 to2000.

Table 1: Result of historical streamflow data of River Ngadda from 1981 to 2000

Year	Discharge	Year	Discharge
1981	6325.28	1991	5392.63
1982	8302.20	1992	7425.87
1983	1620.44	1993	6584.94
1984	7399.50	1994	9346.39
1985	6640.23	1995	6339.11
1986	5349.88	1996	5709.30
1987	4981.35	1997	4965.65
1988	7436.24	1998	4900.44
1989	9045.11	1998	5222.14
1990	6333.51	2000	4703.87

From Table 1, floods were recorded in the years 1981, 1982, 1984, 1985, 1986, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996 and 1999. With high floods in 1989 and 1994.

Table 2: Arithmetic result of historical streamflow data of River Ngadda.

Sum	Mean flow (m^3/s)	Standard Deviation	Skewness
54100.86	7728.70	0.49	0.86

From the results shown in Table 2, River Ngadda discharges a total sum of 54100.86m^3/s, an average streamflow of 7728.70m^3/s and skewness of 0.86 for the periods of 8 years flood recorded in River Ngadda (1981 - 2000).

Similarly, Tables 3 and 4 showed the result of predicted streamflow data and arithmetic result of River Ngadda for the period of 22 years (2001-2022).

Table 3: Result of predicted streamflow data of River Ngadda from 2001 to 2022.

Year	Discharge	Year	Discharge
2001	4108.18	2012	5907.73
2002	4443.41	2013	4034.69
2003	3134.92	2014	3901.51
2004	5367.10	2015	4066.98
2005	3955.84	2016	4033.31
2006	5207.21	2017	5319.80
2007	4943.55	2018	3803.25
2008	4586.74	2019	3628.52
2009	4378.95	2020	3473.43
2010	4537.43	2021	3252.47
2011	5747.15	2022	5810.85

From Table 3, it was revealed that River Ngadda discharges a total sum of 29690.09 m^3/s, an average streamflow of 4241.44 m^3/s and skewness of 1.04 for the period of 7 years flood record 2004, 2006, 2009, 2011, 2012, 2017, and 2022. The result was in agreement with a study by Obroh & Sambo (2022).

Table 4: Arithmetic results of flood records of River Ngadda from 2001 to 2022

Sum	Mean flow (m^3/s)	Standard Deviation	Skewness
29690.09	4241.44	0.59	1.04

Results in Table 4 showed streamflow data of River Ngadda with flood records of seven (7) years. Flood was recorded in the years; 2004, 2006, 2009, 2012, 2017, 2020 and 2022 respectively. With high flood that led to the loss of lives and properties in 2012 and 2022.

3.2 Results of calculated return periods

Results of historical and predicted streamflow data of River Ngadda from 1981 – 2000 and 2001 – 2022 are presented in Tables 5 and 6 respectively.

Table 5: Results of return periods from 1981 to 2000 at different flood intervals

Year	Q (m^3/sec)	Rank, M	Return Period, Tr (years)
1986	5349.88	7	1.14
1989	9045.11	2	4.00
1990	6333.51	3	2.67
1991	5392.63	8	1.00
1993	6584.94	6	1.33
1994	9346.39	1	8.00
1995	6339.11	4	2.00
1996	5709.30	5	1.60

Table 6: Results of return periods from 2001 to 2020 at different flood intervals

Year	Q (m^3/sec)	Rank, M	Return Period, Tr (years)
2004	5367.10	4	2.00
2006	5207.21	6	1.33
2007	6943.55	7	1.14
2011	5747.15	3	2.67
2012	5007.73	1	8.00
2017	5319.80	5	1.67
2022	5810.85	2	4.00

Similarly**,** plot of discharge (m^3/s) against year is presented in Figure 2.

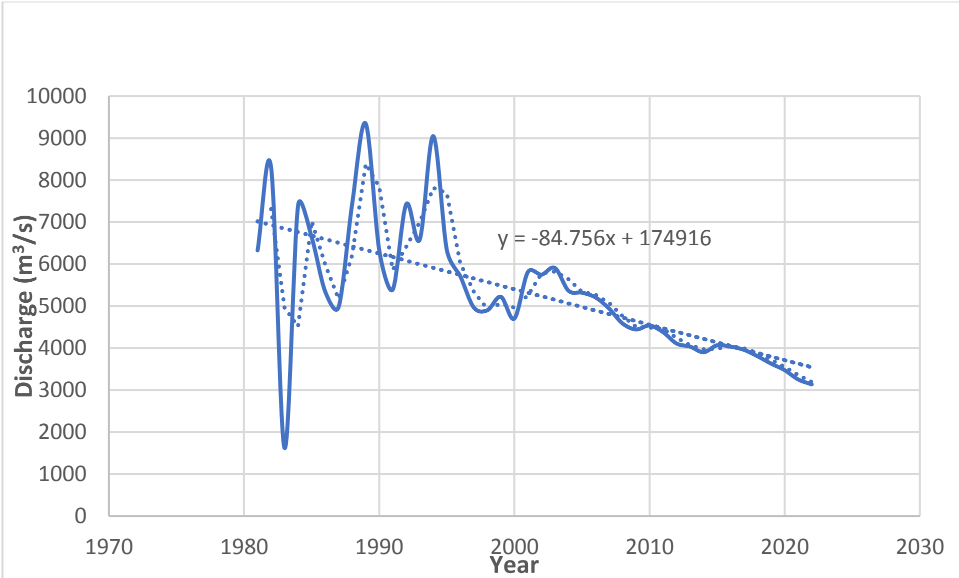

Figure 2: Graph showing discharges along River Ngadda over the years

From Figure 2, River Ngadda experiences a trendline slope equation of Y = -84.756x + 174916 for the selected period. More so, from the historical results of River Ngadda from 1993 to 1996, the flood experienced one year difference, and then after, the flood experienced a three to two years break from 1986 to 1991. Also, River Ngadda streamflow had a different experience from 2004 to 2022. From the first record of the predicted value (2004), flood experience was recorded for the second time in 2006 (that is 2 years after the first predicted flood record). The third flood was recorded in 2007 (that is a year after the second flood record). The fourth flood was recorded in 2011 (that is 3 years after the third flood experience). The fifth flood record was in 2012 (1 year from the fourth flood record) and finally, the sixth and seventh record were in 2017 and 2022 respectively, which gives an interval of five years of returning period each. Similar findings were observed by Jimme et al. (2016).

3.3 Preventive Measures to Mitigate River Ngadda Flood

Flooding can be prevented in many ways, but much more that while wanting to prevent flooding, the first thing that should come to our mind is effective mitigation measures and proper planning. Flooding can be stopped or brought under control when proper planning is put into consideration. River Ngadda flooding can be prevented with improved drainage, building dykes and levees, building canals, harvesting water, afforestation, proper implementation of Government flood control policies, proper maintenance of existing drainages, and avoiding building structures on waterways.

4.0. Conclusion

The study aimed at assessing flooding impact of River Ngadda in Borno State. River Ngadda experienced 7 years of flooding from the period of 1981 to 2000 with annual average streamflow and skewness of 7728.7m^3/s and 0.86 respectively. Equal experiences were also recorded over 21 years from 2001 to 2022 with annual streamflow and skewness of 4241.44m^3/s and 1.04 with floods recorded in the years 2004, 2006, 2009, 2011, 2012, 2017 and 2022. It was observed that River Ngadda flooding was caused by excessive rainfall, poor environmental planning, management and weak policy implementation by institutions concerned with flood management.

5.0 Recommendation

Appropriate measures should be put on ground to stem the level of its occurrence in Nigeria. Specifically, the government should ensure that environmental management policies are properly enforced in the country. Developmental control activities should be taken seriously to avoid the erection of buildings on flood plains and flood prone areas.

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