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Long term effect of Lagdo dam at Jimeta bridge in river Benue

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Abstract

The vital connection in hydrology that represent the value at which the mother earth makes water accessible for humanity and management is of great importance. Downstream aftermath of dam leads to several environmental and socioeconomic uncertainty. The study focuses on analyzing the downstream effects of discharge and flow at River Benue in Jimeta with a view to ascertain the flow of water in the Benue River and to provide early warning changes. The data includes the discharge of previous years prior and after the dam construction, rainfall data, and the topographic map of the study area. The comparative study showed a consistent level of water flow in the Benue River before its construction, After The dam was established, the sequel revealed that there is a significant trend in annual maximum discharge in 1984 with 1,445m^3/sec, these is as a result of control of outflow of the dam for it to reach its maximum level since the commencement of the dam operation began in 1982. In conclusion, the lagdo dam upstream has hydrological effects on the Benue at jimeta. the occasional release of water from the dam leads to irregular flow over a time period. These changes in the characteristics pattern of flow affects aquatic life, nature of the river bed and agricultural activities along the bank of the river. Based on the findings, it is recommended that there should be restoration measures such as check dam for flood control.

Keywords: River Benue; Lagdo dam; Discharge; Downstream

1. Introduction

Water is required by all living creatures for survival. It is also required for economic growth and development. The achievement of the millennium development goals depends largely on improved water supply and sanitation in the developing countries (Parasiewicz, 2001). Issues of drought, flood, and extreme climate change called Elnino have dominated the news in recent times and have caused the death and devastation for thousands of people, homes, farms and marine lives. This has caused governments such as Nigeria to take more stringent action on water resources and total economic management time (O'Keefe B et al., 2009).

Most of the rivers in the world have been dammed to serve as water storage facilities for hydropower generation, drinking water supply and irrigation purposes. Reservoirs are indispensable storage facilities in arid and semi-arid regions of the world where there is irregular rainfall. Extreme drought and floods characterize by these areas resulting in insecure livelihood (Clark, 2002).

Water is a rudimentary resource which supports economic growth and maintains daily life. It is very significant as it is the major component of both plants and animals (Chakhaiyar, 2012). River discharge is the volume flow rate through a river cross section and perhaps the most important aspect of hydrographic surveyors' operation. It is a major link in hydrology that represents the rate at which nature makes water available for human use and management. Inform of flood, it constitutes one of the most destructive natural hazards. (Acreman, 2001) When planning the construction of

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any project, you should pay attention to the environmental problems and how this project will affect the community and the organisms, it is not necessary to pay attention only to the economic value (Richter et al., 2010).

Dam construction affects the river ecosystem. The impacts of dams to the downstream can be generally categorized into physical changes and their biological consequences (Bunn and Arthington, 2002). Physical changes involve river and floodplain hydrology, sediment movement and channel structure (power et al., 1996). Biological consequences include virtually all aquatic and floodplain biota, either through direct physical influence or because of indirect effects on biological interactions and food-web processes (Nilsson and Svedmark, 2002).

Environmental flows have been defined as "the quantity and timing of water flows required to maintain the components, functions, processes and resilience of aquatic ecosystems and the goods and services they provide to people" (TNC, 2016).

The value of maintaining variable flows to benefit river, floodplain and estuary diversity and health has been increasingly recognized (Bunn and Arthington, 2002), yet dams are a prime example of anthropogenic stressors that have potential to significantly alter seasonality of flow in river systems (Tonkin et al., 2017).

1.1. Statement of Problem

Dams, built to change natural flow regimes, are one of the most significant human interventions in the hydrological cycle (McCartney et al, 2001). Prior to the construction of Lag do dam in Cameroun Republic, there was an adequate flow in River Benue. The poor control of the Lag do reservoir, surface runoff and urbanization have in recent pass caused environmental challenges to the immediate communities that reside by the banks of the river. As a result, there is the need to ascertain the effect of discharge with respect to the downstream communities and the general flow condition of the river for sustainable development.

1.2. Research Objectives

- To analyze the trend in annual maximum discharge prior and after the construction of lag do dam with respect to the downstream condition of the river.
- To mitigate high peak flow in order to reduce flood risk in the downstream communities during the rainy season
- To ascertain the effect of irregular flow along the course of River Benue after the construction of lag do dam.
- To analyze weather the rainfall data obtained has significant influence on discharge at the study area in river Benue.

1.3. Research Questions

- What are the contemporary issues related to flooding at river Benue?
- Does the dam have significant effect on the socioeconomic activities such as irrigation?
- After the construction of the dam, Is there irregular flow at the river Benue?

2. Literature Review

In Nigeria, the major dams are concentrated in the drought-prone and semi-arid northern part of the country in a bid to ensure adequate supply of water in the prolonged dry season and also to check flood occasioned by torrential rainfall in the zone. Such dams include kainji Dam, Tiga Dam, Jebba Dam, Kafin zaki Dam, Dadin kowa Dam, and Shiroro Dam, all of which can be classified as large dams based on the international Committee on large dams (ICOLD) criteria for classifying dams (McCartney et al, 2001). Aside these large dams, river flows in Nigeria are punctuated by numerous small dams with a fair representation in every state (ita et al, 1985)

In the hydrological study of Aiba Stream in Iwo (Osun State), Akindele et al, (2013) also reported that an upstream reservoir failed to release water downstream in the dry season which consequently reduced the stream's ability to buffer environmental stress occasioned by drought. Therefore, any alteration in the flow of streams and their hydrological regime would definitely have significant ecological effects on such systems, since the physio-chemical and biological water quality of inland waters are closely linked with their hydrology (Akindele and Adeniyi, 2013a).

Dams have impacts on both upstream and downstream ecosystems. Many of these changes are immediate and obvious, while some are gradual, subtle and more difficult to predict, e.g. changes in the thermal regime, water quality and land

water interactions result in changes in primary production which in turn has long term implications for fish and other fauna higher up in the food chain. Dams may also cause changes in ecosystems at great distances from the dam (McCartney et al, 2001). These changes can affect the biota for long distances down the river (McAllister et al, 2001).

The impacts of these dams on lake chad were particularly underscored by shettima (2009) who reported that the river flow at Gashua in Yobe State, downstream of Tiga Dam fell by about 100 million cubic meters per year on completion of the dam. As a result of this significant reduction in the water flow of the Kano and Hadejia Rivers downstream of Tiga Dam, various ecological and socio-economic activities problems (e.g desert encroachment, migration and conflicts between arable farmers and herdsmen) do arise along the water course. The worst effect is that there is a great reduction in the flow of river Yobe in to the lake Chad (Ojeifo, 2009).

Another effect of dam on Nigeria freshwaters is homogenization of surface waters, as has been observed in lake Tiga (Akindele et al, 2013) where there was little or no variation in the physio-chemical parameters of the lakes lacustrine section up to 10-15 km upstream of the dam. This trend would particularly be noticeable in the reservoirs of great length where the effect of transition from lotic to lentic status is usually nullified by longitudinal distance coupled with a longer water retention time.

3. Research Methodology

This paper primarily focused on the effect of downstream and discharge of river Benue. The in-situ data was acquired from Upper Benue River Basin Development Authority (U.B.R.B.D.A. Yola, 2012) to analyze the trend in flow pattern before and after dam construction, this includes the discharge data, rainfall data and water level data of previous years prior and after the construction of lag do dam, map of Nigeria, map of Adamawa state, and topographic map of river Benue showing the study area of such site.

Therefore, we aim to conduct a data-based analysis to ascertain the river flow regime based on comparative study prior–after establishment of the dam. We investigated the impact of the reservoir on the flow regime downstream reaches of the Benue River. The analyses of the discharge records maximum and minimum occurrence and the rainfall data of each discharge for two different time periods: 1960–1981 (pre-dam) and 1982–2019 (post-dam). The study provides hydrological evidence of the influence of the reservoir downstream of the river.

3.1. Study Area

Jimeta is situated along the bank of river Benue and is also the Administrative Headquarter of the State. It is between latitudes 09° 15'N and 09° 20'N and longitudes 12° 25'E and 12° 29'E with an elevation of 135 meters above sea level. It covers a land area of about 1009km^2 as cited in (Adebayo and Tukur 1999). It is situated at a point where the Benue River carves its valley through the eastern highlands.

3.2. Climate

The climate pattern of the study area is assumed to exhibit a mark similarity in the characteristic of rainfall in the sampling units selected for this study. This assumption is mainly due to their location in the same latitude with insignificant influence by the topography of the area. The annual Precipitation value received in the 59years period of the study show that the mean value for the period is 908.55mm with the lowest value of 657mm recorded in 2002.

The rainy season runs from May through October with insignificant rains in March, April and November. The dry season commence in November and ends in April to May. The average annual rainfall in the study area ranges between 850mm-1000mm with over 41% of rain falling in August and September. Temperature also has a significant temporal variation in the study area; April is the hottest month with an average maximum temperature of 42°Centigrates. December and January are the coldest months with a temperature of 25°Centigrates.Upper Benue River Basin Development Authority Yola. (U.B.R.B.D.A. Yola, 2012).

3.3. Topography

The study area falls within the Benue trough which is generally a low-lying flat terrain of 183.30-200.00 meters above the sea level with gentle undulation and hill ranges punctuating the extension flat flood plain at various locations notably across the river Benue from Jimeta eastward. The land rises steeply to attain a maximum height of 240 meter above mean sea level (U.B.R.B.D.A. Yola, 2012). The flat terrain boarding the river Benue is a favourable locale for wide range of socio-economic activities such as farming, grazing and settlement etc.

River Benue is approximately 1,400 kilometers long and is almost entirely navigable during the summer months. The Benue is the largest and most important affinent of the river Niger which joins at Lokoja after a course of over 800 miles in a general east to west direction from its source in the mountains of Adamawa in Cameroun.

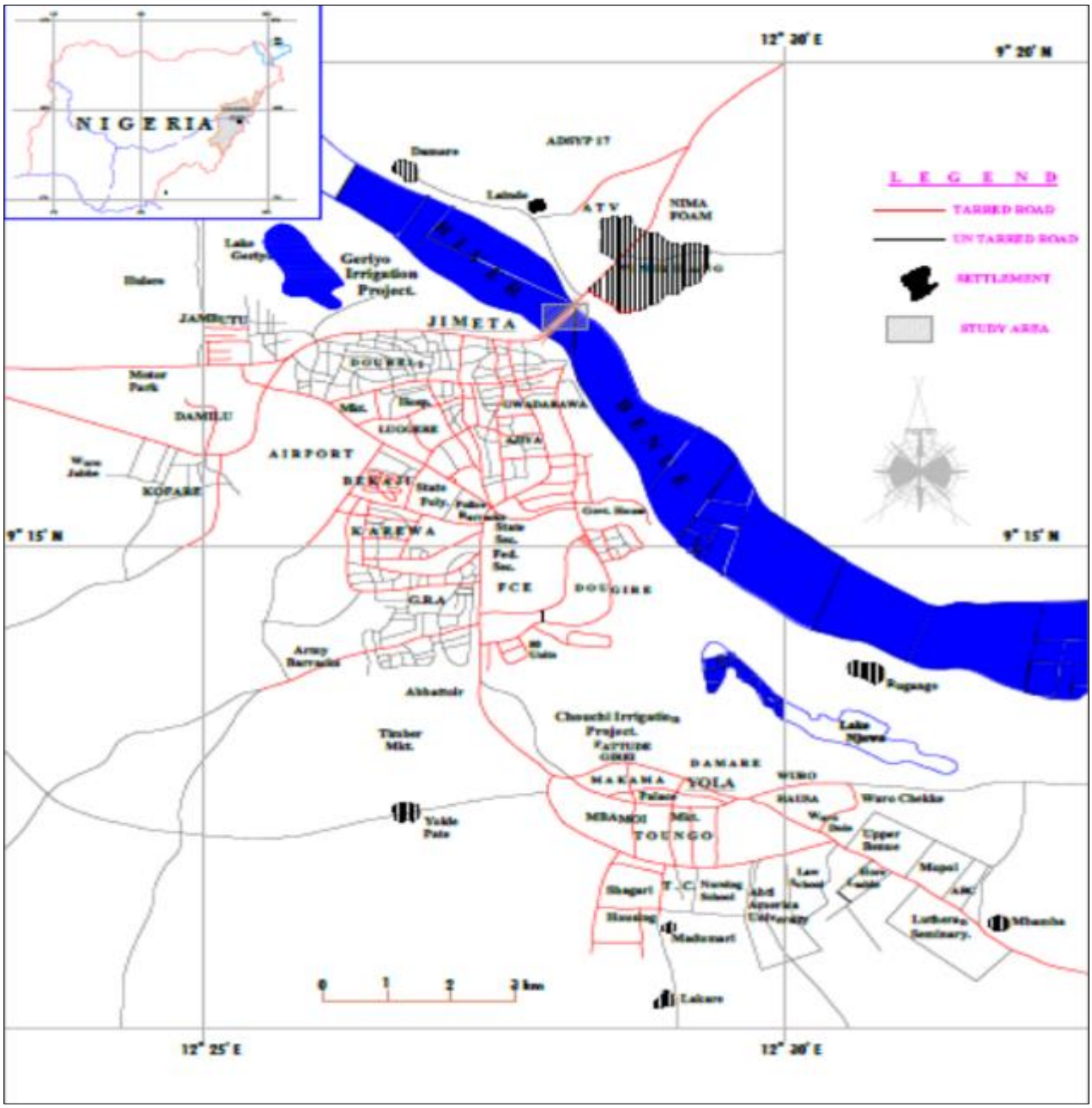


Figure 1 Location of Nigeria, Adamawa state showing the River Benue and site of the Study Area

Table 1 Hydrological Data of River Benue at Jimeta Bridge

Upper benue river basin development authority, Yola		
Hydrological data of river Benue at jimeta bridge.		
Year	**Annual**	**maximum**
	Rainfall-mm	Discharge-$m^{3/sec}$

1960	1116	7695
1961	897	6310
1962	909	4490
1963	1356	7088
1964	996	3728
1965	748	4033
1966	683	5523
1967	0	3249
1968	0	5395
1669	1081	6090
1970	852	8033
1971	771	3366
1972	881	2025
1973	695	3327
1974	759	2470
1975	949	3914
1976	990	3201
1977	893	4420
1978	994	4016
1979	1153	3862
1980	1044	4016
1981	965	2870
1982	962	2000
1983	883	1805
1984	971	1445
1985	971	2205
1986	901	2045
1987	679	1730
1988	1084	4060
1989	982	4100
1990	824	3020
1991	862	5480
1992	967	4363
1993	983	3280
1994	925	6600
1995	1081	3480
1996	1010	5380

1997	978	3800
1998	1023	4960
1999	1113	7040
2000	948	5500
2001	916	4720
2002	657	5250
2003	785	5910
2004	800	3720
2005	799	3110
2006	765	5320
2007	903	5520
2008	809	4000
2009	1063	5000
2010	1063.6	5390
2011	823.2	2320
2012	1084.6	6340
2013	827.7	2260
2014	1015.3	2710
2015	979	2981
2016	1260.1	3500
2017	920.6	2640
2018	961.5	3630
2019	1201.4	3707

4. Results and Discussions

4.1. Rainfall and Discharge

The yearly discharge data was obtained from upper Benue River basin development authority (UBRBDA) Yola metrological department from 1960-2019. after the dam construction in 1982, the lowest annual discharge ever recorded after the construction was 1445m^3 with 155.486m water level in 1984 few years after the dam construction. the rainfall data recorded same year was 971mm. the likely chances of decrease in annual minimum flow are related to low rainfall and discharge as the occurrence of both coincide in time. the annual minimum discharge stipulates a downward trend in the flow at the study area, the establishment of dam at the upstream affects the adequate flow of Benue River in jimeta. the highest discharge obtained after the dam construction was in 1999 with 7040m^3, however there was a significant rainfall data of 1113.30mm, due to an extremely rainy year with flooding across Nigeria, although the rainfall contributes to the discharge in 1999, the water level of 158.866m in1999 shows that the main factor that leads to flood was the release of water from the dam.

The highest rainfall data was in 2016 with an average rainfall of 1260.00mm, however, the discharge of same year was 3500m^3, despite the high rainfall data, it would be observed that there was a little discharge. these indicates that the major contributing factor that leads to flooding at the river Benue in jimeta is the influence of dam upstream. these affects the fauna and flora along the course of the river. the absence of rainfall data in 1967 and 1968 was as a result of Nigerian civil war. the construction of lagdo dam in northern Cameroun started in 1977 and was completed in 1982.

Conversely, the lowest rainfall data recorded after dam establishment was in 1987 with a rainfall data of 679mm between the periods of 1982 to 2019 respectively with discharge of 1730m^3. the annual minimum discharge indicates a downward trend in the flow regime. while the likelihood of decrease in annual minimum flow is related to precipitation and low discharge as the occurrence of both correspond. the result is due to the dam operation to retain water for its purposes which in turn affects the Benue River in jimeta.

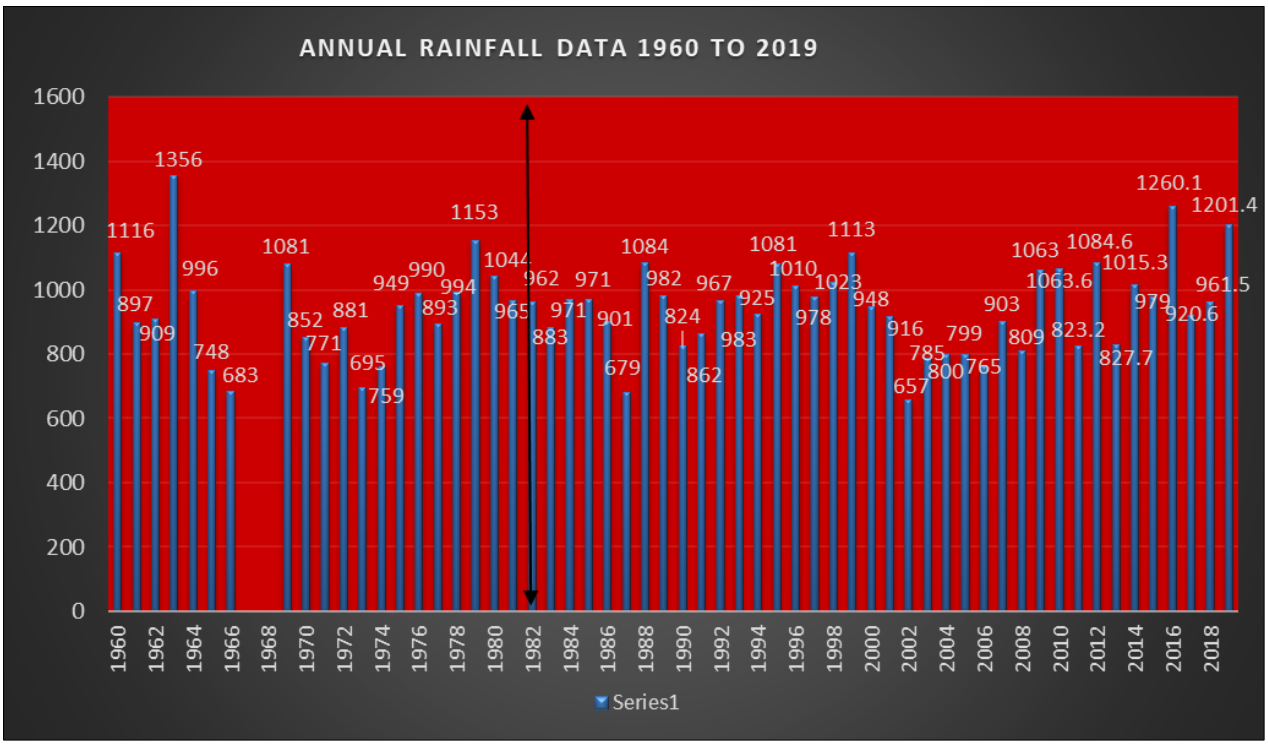
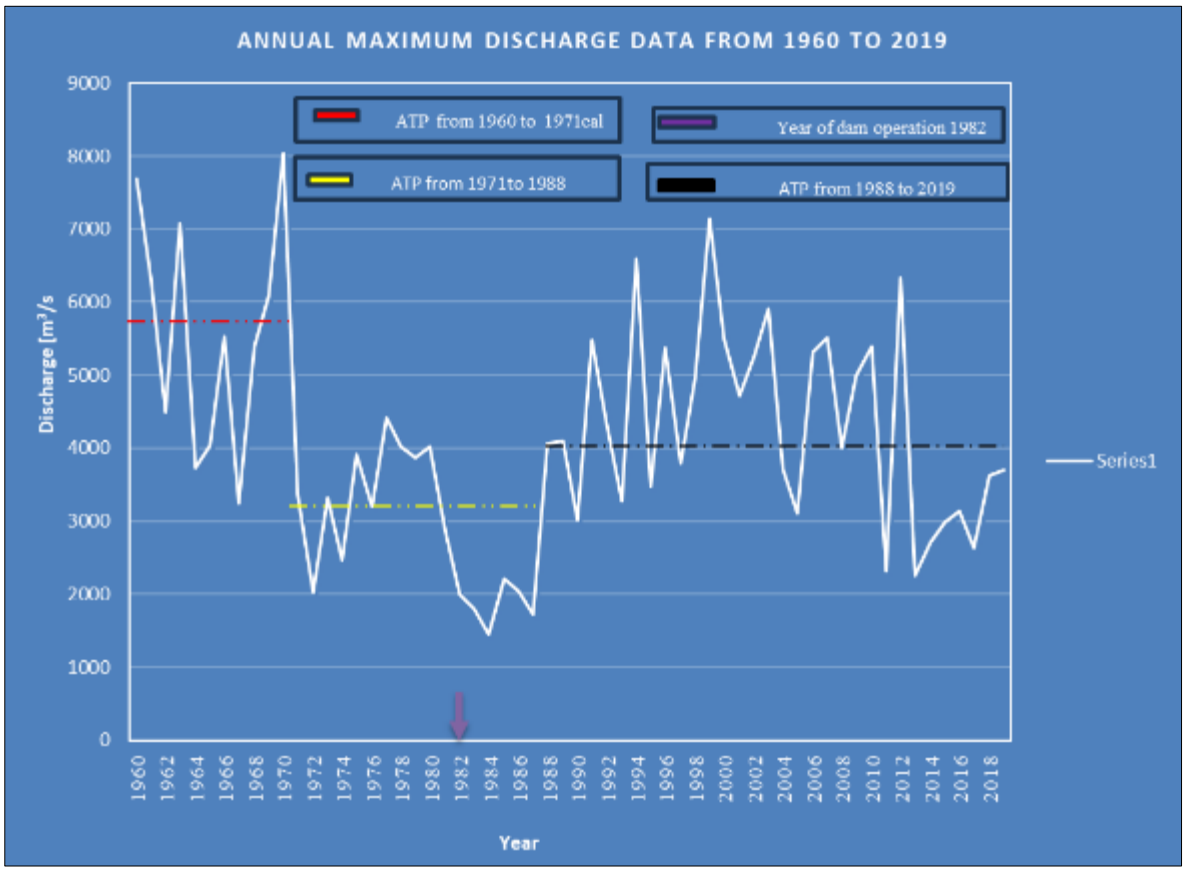


Figure 2 The annual rainfall data from 1960 to 2019 at the site of the Study Area in River Benue.



(ATP stands for average value for each time period)

Figure 3 The annual maximum discharge data from 1960 to 2019 at the River Benue

4.2. Maximum Water Level

The data taken 20 years before the establishment of dam shows that the annual maximum water level was 158.205m in 1960. The annual rainfall data was 1116mm with a discharge of 7695 m^3/sec. However, the water level correlates with high discharge and rainfall data as well. The lowest annual water level recorded before its construction was in 1970 with 157.221m, the discharge obtained at the same year was 8033m^3/sec with a rainfall of 852.00mm. These shows a consistence flow of water level with a high discharge in the study area before the dam was established. But between the period of construction from 1977 to 1982, There was a little downward trend in the annual water level.

The maximum water level after the dam construction was 158.866m in 1999. these can be attributed to both influence of lagdo dam and the rainfall in 1999 as both occur at the same time. However, there was a different pattern that was noted in 2016 with a low water level of 157.146m and a considerable rainfall data of 1260.1mm, yet there was no case of flood recorded in the year 2016 and these indicate that the rain fall at jimeta is not a driving tool that influence flood at the river Benue because the discharge was 3500m^3/sec. This characteristic rainfall pattern is a crucial result, and in addition to dam construction, it needs to be taken into account as a potential controlling factor with respect to further interpretation of flow regime changes. The flood could be as a result of the occasional release of water from the lag do reservoir upstream part of river Benue.

The minimum water level data recorded after the dam operation was 155.486m in 1984, the lowest discharge ever recorded since the commencement of dam operation from 1982 to 2019 was 1,445m^3/sec in 1984. Although there was an average rainfall of 971mm, the low annual flow in 1984 may likely be as a result of control of outflow of the dam for it to reach its maximum level since the commencement of the dam operation began in 1982.

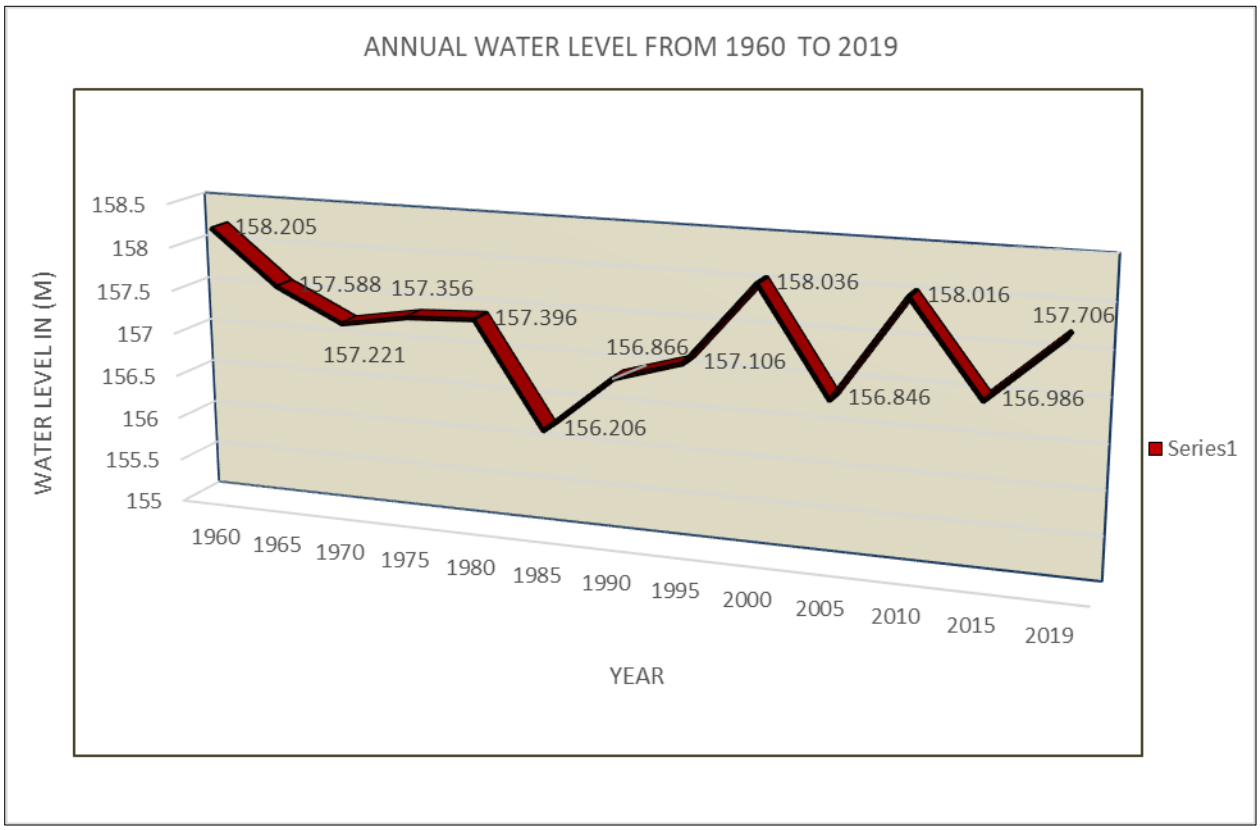


Figure 4 Annual Water level data from 1960 to 2019

5. Results

Based on the findings, there was a considerable level of water flow in the Benue River before the establishment of dam. The aftermath of dam construction leads to irregular flow over a time period. These changes in the characteristics pattern of flow affects the fauna and flora, geomorphology of the river bed and irrigation activities along the bank of the river. Furthermore, the study showed that the rain fall at study area is not a major factor that influence flood at the river Benue. we conclude that the dam upstream has hydrological effects on the Benue at the study area in jimeta.

6. Conclusion and Recommendation

The flow regime of the Benue River downstream of lag do dam from 1960 to 2019 presents different dynamics after the dam starts operating. However, Significant increase in low flow was noted along the channel of Benue River at certain time period which change the duration and extent of water along the course. The increase of low flow and altered flow durations can be attributed to the operation of the lag do dam. Consequently, these factors have constrained irrigation, navigation and fishing activities which were formally undertaken along the river. Similarly, water supply intake structures and irrigation abstraction facilities along the river had been threatened.

Based on the research findings, it is recommended that a check dam should be created across the river so as to control the current of water flow during storm events. there should be construction of silt fence or filter fence at the embankments in order to protect water quality from sediment in storm water runoff. The policy makers should ensure that dredging is executed in the river Benue so as to create more space for adequate flow of the river and buffer zone should be created to prevent the encroachment of human activities such as farming and building around the Benue River.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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