CURBING THE FLOODING MENACE IN ZAMFARA STATE NIGERIA: A CASE STUDY OF THE GUSAU BARRAGE BREAKAGE

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Abstract

Gusau Barrage is a suitable water project which can be employed in curbing flooding menace in Zamfara State. The breakage of the Barrage resulted to a monumental flooding incidence in 2006. This breakage of the barrage was studied through visits and available documents and literature. The research targeted on how the experience of this incidence can be applied in eliminating future occurrences of flooding in the state. The research findings revealed that non-application of the safety devices, poor elevation of the barrage over the highlands, high intensity of rainfall and non-desiltation of the barrage sections resulted in the collapse of the barrage. The collapse of the Barrage resulted in the flooding. This research, therefore, is of the view that future flooding in Zamfara State can be effectively curbed if the barrage is well managed; its hydraulic head raised, the desilting of the river and the introduction of other uses of the water impoundment.

Keywords: Flooding, Barrage, Rainfall, River,

INTRODUCTION

Flooding is a menace that has become an albatross in the economic development of Nigeria. Nigeria as a mono-economic based nation had been strategizing towards the diversification of its economy. As a nation with vast arable land, its inclination in this respect is to engage and development massive agricultural activities. The sensitization in this regard has pushed people and government into cultivation of crops and rearing of animals. But the recent emergence of incessant floodings had hampered this noble objective of massive agricultural development.

Flooding menace had been a recurring event in the history of Nigeria as the government had spent billions of naira to compensate, relocate and rehabilitate the victims of these disasters. There were a nation-wide flooding in Nigeria in year 2006 and this affected all the states of the federation including Jigawa, Adaniawa, Gombe, Zamfara, Sokoto and Kebbi. The Zamfara State flooding menace was the aftermath of high rainfall corresponding to the Gusau Barrage 100 – year design flood. A similar case happened recently where flooding ravaged farmlands in five communities of Ebonyi State especially in the Ivo local government area and submerged both houses and farms.

The Gusau flood disaster, occurred on 30th September, 2006 when a part of the Gusau barrage dismembered across the Sokoto river after a heavy rainfall which lasted for two consecutive days. The Gusau flooding caused a colossal loss which included the loss of lives of livestock, contamination of drinking water and destruction of farms with full-grown crops.

The target of this paper is review the flooding menace that led to the collapse of the Gusau Barrage and proffer engineering solutions that will curb future occurrence.

1.1 GUSAU BARRAGE

A barrage can be defined as a structure designed and constructed across the river channel to serve as a barrier to flow with the sole aim of preventing flooding downstream of the river channel. In line with this definition, the Gusau barrage was meant to prevent flooding downstream and also to impound water for other purposes upstream. The storage capacity of the barrage from the allowable silt level to the water level is 11.56×10^6 m^3. The capacity of the barrage from the unsilted invert level to the proposed silt level is 2.19×10^6 $cm^{3.}$ The barrage has some safety devices which include the sluice gates and spillways.

The construction work on the barrage and its associated appurtenances commenced as far back as 1977 but due to paucity of funds the project could not completed. The project was later completed in 1990 by the Sokoto State Government. The project has been of immense benefit to the people of Gusau and Sokoto State in general on the grounds of water supply as it is the major source of raw water to the Gusau Water Treatment Plant.

1.2 ENGINEERING COMPONENTS OF THE BARRAGE

The Gasau Barrage has five motorized steel gates and each of the gates has 18.5m width and 7m height. It has a weir which was constructed to direct the flow of water and its length is 100m. The catchment area at the Barrage point is 2.082×10^6 m^2 and its discharge for the downstream channel is put at 3.8 x 104 m^3/s.

The silt level of the weir and barrage was designed to create enough space for the impoundment of the water. However, desiltation is important so that the designed silt level would be maintained. This operation is meant to be carried out periodically to maintain the designed levels.

1.3 ENGINEERING METHODS OF CONTROLLING FLOOD

In engineering, flooding can be controlled through the construction of dams, water gates, diversion canals, self closing flood barrier, river defencies, coastal defences, temporary periments barriers and property level protection. Dams are constructed to serve as a barrier to the flow of water in a river. The essence of dams is to impound water so that it can be harnessed for various purposes ranging from power generation, irrigation, fishery and flood control. With dams in place the flow of water downstream is highly regulated and controlled. This helps to reduce flooding in a flood prone environment.

Levees are walls in the river banks constructed to prevent flooding of settlements and other sensitive areas. The levees perform functions similar to coastal and river defenses. Diversion canals are at times constructed to reduce the volume of water in the river so that possibility of flooding will be eliminated.

1.4 FLOOD MANAGEMENT TECHNIQUES

Flood management techniques are normally targeted at increasing the volumetric capacity of the river canal and/or provision of engineering structures that can prevent flooding. Flood management techniques are bifurcated into hard and soft engineering.

1.4.1 Hard Engineering Alternatives: The hard engineering alternatives are principally structures which can be employed in checking flooding. These alternatives are ordinarily more capital intensive but create an awesome impact on the river and the environmental landscape. The hard engineering alternatives include the construction of flow barriers on rivers (i.e. dams, barrages), flow direction structures (weirs) and levees. It is not the best practice to alter the river channel as it may precipitate greater danger of flooding downstream. It is only advisable to alter the channel if it is on the grounds of diverting floodwaters away from settlements.

Dams are typical examples of hard engineering alternatives in managing rivers and the flooding arising from them. Dams control amount of discharge downstream and this goes a long way to reduce flooding. The discharge of overflow can be done in an environmentally friendly manner through gates introduced at the body of the dam. When river valleys are flooded all surrounding settlements and agricultural land are lost unless there is an immediate effort to reduce the discharge within the valley.

1.4.2 Soft Engineering Alternatives: are options that are described as ecologically-based approaches which are used to reduce flooding. Soft engineering alternatives include afforestration, river training, planning water resources and ecological policies. Afforestration encourages the planting of trees near the rivers and controlled cutting of trees close to the river bank. This creates interception of rainwater and thereby lowering the river discharge. With afforestration the drainage basin quality is tremendously enhanced and this induces factors that can reduce flooding.

Managed flooding is an example of soft engineering technique in which the river is not allowed to flood in areas close to settlements while natural flooding is tactically allowed and encouraged in areas where colossal losses are not anticipated. This technique called managed flooding is also called ecological flooding. In this ecological flooding, local and natural authorities encourage policies that control urban development on flood plain areas and its surroundings. This disallows developments that enhance flooding and the consequences of risks that occasion damage to properties and public lives. It will be in the best interest of the public if physical structures are put in place to delineate the restricted areas.

Due to huge capital involved in hard engineering alternatives, environmental groups and residents prefer soft engineering options to the hard engineering alternatives. Following the multidimensional and long term benefits derivable from hard engineering alternatives, government prefers to employ them as a means of checkmating flood menace.

1.5 CAUSES OF FLOODING

Flooding is a menace that can be caused by such factors as climatic change, heavy persistent rainfall, unprecedented high tides, failure of flood control structures/retention ponds, accelerated snowmelt, severe winds on water bodies and deforestation.

Flooding occurs in many rivers periodically and the areas that are covered by the flooding are called flood plains. Flooding is normally exacerbated on areas where soils are bare and impervious. Heavily vegetated areas tend to withstand and reduce flooding which emanates from heavy and persistent rainfalls which compel the river to overflow its banks and go on to submerge the adjoining areas. Inadequate management and maintenance of dams, barrage and levees can cause flooding.

2.0 METHODOLOGY

INSPECTION VISITS:

Reconnaissance visit was paid to the flooded area and the collapsed barrage. Further visits were made for interviews and the general inspection of the area.

2.1 DATA COLLECTION

Relevant data on the collapsed barrage and rainfall were collected from appropriate government agencies and available literature.

2.2 LEVELLING SURVEY

Levels were taken at the various sections of the Gusau Barrage and at the various heights of the spillways. Normal leveling instruments used include such instruments as dumpy level, leveling staff, and the GPS which was used to determine the location co-ordinates of the points.

2.3 DESCRIPTION OF STUDY AREA

The case study -Gusau Barrage is located in the city of Gusau the capital of Zamfara State of Nigeria. The city is located on the longitude 6°40'E and latitude 12°10'N. Zamfara State is in the North - Western region of Nigeria. It is bounded in the West by Kebbi State, in the East by Katsina State, in the South by both Kaduna and Niger State and in the northwest by Sokoto State.

Rainy and dry seasons are the major characteristics of the climate of Zamfara State. The rainy season is caused by the moisture - laden South West trade winds and the rainy season occurs between April and October annually. The dry season is occasioned by the North East trade winds which blow dry and dusty harmattan winds to the area within the months of November to March of every year. The study area lies within Sudan savanna vegetation zone of Nigeria. This zone is characterized with fine - leaved thorny tree and grass like plants. The trees of the area typically have twisted trunks thick barks and large root system. The map of Nigeria depicting the study area is shown in figure 2.1

3.0 RESULTS AND ANALYSIS

3.1 Presentation of Results

The Sokoto River houses the Barrage and the major source of water to the river is the rainfall. The long term annual rainfall data for Sokoto basin were collected and presented in table 3.1

Table 3.1: Monthly Rainfall Data Over Sokoto River Basin (NIMET 2007)

Month	**Periodic Range Data in mn4. City Involved**			
	Kaduna (1931-2004)	**Zaria (1980 - 2007)**	**Gusau (1990-2007)**	**Sokoto 1915- 1979**
January	0.05	0.00	0.00	0.00
February	2.16	0.13	0.00	0.00
March	8.40	6.87	0.75	0.00
April	64.21	31.77	14.75	9.59
May	113.26	112.04	88.91	43.46
June	116.27	138.81	126.25	88.43
July	230.10	223.68	223.66	168.74
August	288.03	290.78	303.30	233.09
September	251.95	168.85	195.57	132.32
October	63.30	44.86	34.75	17.68
November	7.21	0.09	0.40	0.00
December	0.20	0.10	0.00	0.00

Source: Nigerian Meteorological Agency

In line with the purpose of the project, the Gusau barrage is a storage structure and the most important numerical information on this structure is the Probable Maximum Flood which is normally produced by the Probable Maximum Precipitation. The excerpts of probable maximum precipitations is presented in Table 3.2.

Table 3.2: Rainfall Data in Gusau (mm) in 2006

Date	**May**	**June**	**July**	**August**	**September**	**October**
1	0.00	0.00	0.00	0.00	0.00	0.00

2	0.00	0.00	7.50	0.00	0.00	0.00
3	0.00	0.00	28.40	0.00	19.90	0.00
4	0.00	1050	5.00	0,00	49.80	0.30
5	0.00	0.00	0.00	-	-	0.00
6	0.00	0.00	9.00	35.60	0.00	0.00
7	0.00	-	0.00	2.60	13.30	14.10
8	0.00	8.90	0.00	58.60	0.00	-
9	0.00	0.00	0.00	0.00	4.20	0.00
10	0.00	0.00	0.00	3.30	15.10	0.00
11	0.00	0.00	0.00	1.60	-	2.30
12	0.00	0.00	2.0	17.70	9.80	0.00
13	0.00	0.00	0.00	24.80	0.00	0.00
14	0.00	0.00	3.30	182.90	-	0.00
15	0.00	0.00	1.20	0.00	0.00	0.00
16	0.00	0.00	46.50	0.00	-	0.00
17	25.80	0.00	0.00	0.00	0.00	0.00
18	0.00	-	16.20	0.00	0.00	0.00
19	-	30.10	1.20	0.00	31.10	0.00
20	0.00	0.00	0.00	0.00	3.60	0.00
21	0.00	0.00	14.70	6.90	0.00	0.00
22	0.00	39.70	0.00	0.00	*0.00*	0.00
23	11.20	1.40	1.50	1.70	2.80	0.00
24	0.00	0.00	9.60	-	0.00	0.00
25	0.00	0.00	24.0	1.90	0.00	0.00
26	0.00	0.00	0.80	1.20	0.00	0.00
27	0.00	0.00	1.90	32.8	0,00	0.00
28	0.00	0.00	0.00	2.90	0.00	0.00
29	-	-	0.00	100.00	24.60	0.00
30	0.00	0.00	29.90	-	1.20	0.00
31	0.00	-	0.00	26.50	-	0.00

Total	**37.00**	**90.60**	**202.70**	**518. 10**	**175.40**	**16.70**

Excerpts from NIMET, 2007

The rainfall data in table 2 can be put into a hyetograph as shown in fig. 3.1;

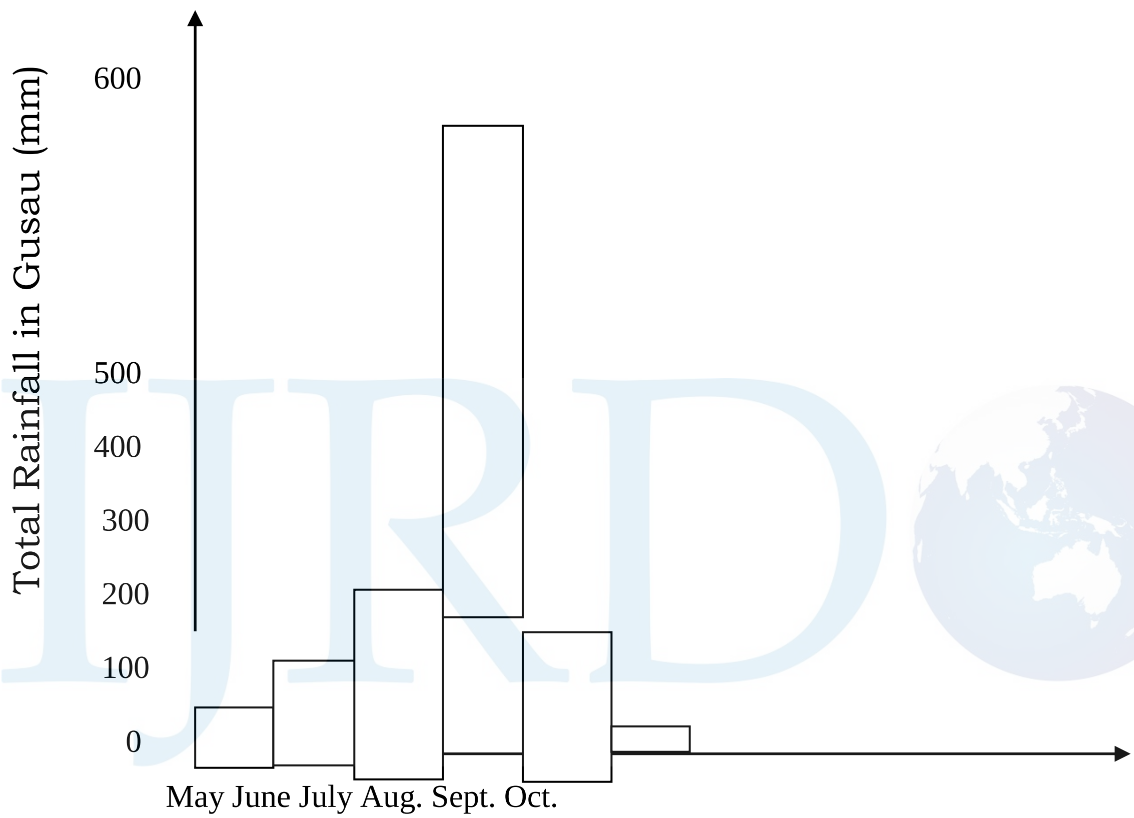

Figure 3.1: Hyetograph showing Probable Maximum Precipitation in Gusau in 2006.

3.2 ANALYSIS OF RESULTS

From table 3.1 it can be observed that Sokoto River Basin witnesses rainfall as early as April annually and the peak rainfall occurs in August and reduces to zero in October.

Under the sub-river basins of Kaduna, Zaria, Gusau and Sokoto, it was deduced that the peak precipitation occurs in the month of August as Kaduna, Zaria, Gusau and Sokoto had the peak rainfalls of 288.03mm 290.78mm, 303.3mm and 233.09mm respectively.

Prior to the collapse of the Barrage on 30th September 2006, Gusau recorded massive monthly rainfall intensity of 518.10mm in August as against the rainfall intensity of 202.70mm recorded in July and 175.40mm recorded in September. This represents a geometric rate increase of *155.6%* over the July rainfall and 195.3% over the September rainfall.

The probable maximum precipitation is a concept that can be used to investigate the cause of the barrage collapse. Probable maximum precipitation is defined as the theorical greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of the year. It is the probable maximum precipitation that produces the probable maximum flood. It was observed from Table 3.2 that Gusau recorded a high intensity of 182.9mm rainfall seven days to the collapse of the barrage.

The hydraulic head of the barrage was highly inadequate as its embankment was easily submerged by the 182.90mrn rainfall which is relativelv below the 190mm developed for the basin. The hydraulic head of the barrage was further reduced due to poor maintenance arising from the non-desiltation of the barrage sections. The elevation difference between the adjoining highland and the crest of the barrage is very small and highly inadequate.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

The Gusau Barrage is a brilliant and people-oriented project designed to impound water for treatment and check flooding downstream. This project served this purpose except for the high intensive rainfall which corresponded to the barrage 100-year design flood. The aftermath of the high intensive rainfall should have been averted if all the designed safety devices were put into maximum use. The flooding menace in the state can be curbed if the barrage is given the desired elevation above the highlands, all the upstream sections fully desilted and the safety devices re-engineered to be functional and put into adequate use.

4.1 RECOMMENDATIONS

Following the findings of this research, these recommendations are made;

(i) The desiltation of the barrage should be carried out periodically to allow it function at its designed capacity.

(ii) Staff should be trained for the operation of the safety devices and made to be resident at the barrage project.

(iii) The usage of the impounded water needs to be amplified and other purposes of water use introduced.

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