SOME HYDROMETEOROLOGICAL IMPACTS OF THE SHIRORO DAM ON ITS IMMEDIATE ENVIRONMENT

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A THESIS SUBMITTED TO THE POST GRADUATE SCHOOL FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, IN FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF TECHNOLOGY IN REMOTE SENSING APPLICATION.

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MARCH 2002.

CERTIFICATION

This thesis entitled "Some Hydrometeorological impacts of the Shiroro Dam on its immediate environment" by Adamu Mohammed Ahamed meets the regulations Governing the award of degree of master of Technology of the Federal University of Technology; Minna, and is Approved for it's contribution to knowledge and literary presentation.

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Finally my sincere thanks and appreciation to my family for their understanding and encouragement.

DEDICATION

This thesis is dedicated to the memory of my late brother Mohammed Ndana Enagi.

ABSTRACT

The Research examines the changes that have taken place on the environment as a result of the Dam Construction.

Analysis of the responses were based on both pre and post dam meteorological and hydrological data which were computed in order to find the mean monthly and mean annual variations of pre and post dam construction.

The students 't' test at 5% level was employed to find out if there exist any significant difference between the period of study.

The analysis reveals that tremendous changes have taken place between the pre and post dam periods; Meteorological analysis shows that some micro climate changes have occurred in the environment. For instance the first variable which is rainfall revealed that the month of March which hitherto has no rain pre-dam periods has now become an additional number of rainy month hence it shift from pre dam period this implies an increase in the amount of rainfall at post dam.

Another major variable is temperature, which revealed a marginal fall of 3.50°C annually since the damming of the lake. The relative Humidity mean annual, increase by 20.5% while evaporation by 145.75mm hence, beside temperature which remain low both rain fall, humidity and evaporation increased.

The hydrological variable revealed that during dry season the lake level remain low while during raining season especially the month of August and September the gauge height rises and hence the back wash up stream and the discharge during this month result into annual flooding of down stream environment.

TABLE OF CONTENT

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

LIST OF TABLE

LIST OF FIGURES

CHAPTER ONE

1.1 INTRODUCTION

The environmental impacts of a project are those resultant changes in environmental parameters in space and time, compared with what would have happened had the project not been undertaken. Such environmental receptors as regards Shiroro Dam includes water quality, change in river and ecosystem regimes; hydro meteorological effects and changes in soil quality which are the physical factors associated with water development projects (HYPPADEC; 2001).

Environmental impact assessment, (EIA) involving dams generating electricity, the basic parameters for assessment are the instrumentation of elements of weather such as rainfall, temperature, relative humidity, rain days, evaporation winds. These are the meteorological input for assessment while the hydrological parameters are the gauge height and the discharge of the lake. (Adefolalu, 2001).

Other associated problems related to dam construction are biological and human system which result into (niche) breeding of mosquitoes which act as intermediate host for diseases like malaria, while plants growth around water bodies provide a suitable habitat for tsetse fly to transmit trypanosomiases to human and domestic animals living around the river banks.

While the human factors relating to dam construction creates displacement to local inhabitants from releases from the dam hence clean water flows down the causing erosion to riverbed and banks. (HYPPADEC; 2001).

The environmental impact assessment is an attempt to evaluate the already proposed project, the basic rule underlining E.I.A. is that it is a "FULL disclosure" (Larry, 1977) implying that it is both the positive and negative ramifications of a given proposed action should be explored in complete detail, in addition attention must also be directed towards the primary and secondary impacts associated with proposed action.

Primary and secondary impacts are referred to as direct and indirect consequences, (Larry, 1977) he further stated that "any adverse environmental effects which cannot be avoided should the proposal be implemented be pointed out; and these leads to the next stage of ""alternatives to the proposed action" which should be compared on common basis. (Larry, 1977).

1.2 BACKGROUND OF EARLY DAMS

A dam is a structure designed and constructed as an effective means to regulating the flow of river and storage of water which would other go to waste through loss to sea (Abubakar, 1997) he noted that throughout history, society has been the instigator of engineering works especially dams construction; he further stated that the construction of dams became a necessity when the assurance of dependable sources of water became a societal requirement.

Evidence exist that dams were used at least 5000years ago in cradles of civilization in Babylonia, Egypt, Persia, India, and China. In

2,900 BC a 15m high masonry structure was built on the Nile near Kosleish for the water supply of Memphis (Abubakar, 1997). A 6m high rock filled dam built in 1300BC on the Orontos in Syria is still in use, Abubakar, 1997.

Early dams in Europe were limited to reservoir for towns driving water mills and replacing water losses in navigation canals, not until those century however have dams. In many parts of the world become truly multipurpose, with emphasis o power generation, irrigation and water supply (Abubakar, 1997).

Dams retain water creating a reservoir a fall (kinetics energy which activates turbine producing electrically, (Maxwell, 1987).

1.3 STATEMENT OF PROBLEM

The dam is specifically designed and constructed to meet electricity demands of Nigeria resulting, from the growth of industries and rapid urbanization (HYPPADEC; 2001).

Thus, before construction of the dam the reservoir sites has been a terrestrial ecosystem but now turned into aquatic system the water storage has caused changes in the water quality and alteration of the natural flow of the river has affected the inhabitant as well as the animals and fish life, with flooding been a yearly phenomena.

1.4 AIM

The study is aimed at assessing some hydrometeorological impact of Shiroro dam on the environment.

1.5 OBJECTIVES

The specific objectives are:

i. To identify the effect of local microclimate change on the environment.

ii. To assess the impact of flood on the environment.

1.5 JUSTIFICATION

The construction of dams in the country are given too much structural engineering consideration with little or no environmental impact assessment (Abubakar, 1997).

Thus, it is important to have adequate information on many complex decisions as such knowledge is very important in order to overcome problems of haphazard; uncontrollable development deteriorating environmental quality; loss of terrestrial and aquatic lives destruction of farmlands and those of human settlements.

Environment and development are not separate challenges they are inexorably linked; development cannot subsist upon a deteriorating environmental resource base, the environment cannot be protected when growth leaves out of account the cost of the environmental destruction; the devastating impacts of the Hydroelectric power station on the environment take many forms for instance physical, biological, chemical and social consequences;

which has plunged the environment into serious degradation and untold hardship, hence the need for environmental impact of this project which was commissioned in 1990 before the enabling decree E.I.A. decree No 86 of 1992 through the analysis of some hydro meteorological variables.

1.6 SCOPE AND LIMITATION OF THE STUDY

The study cover the dam site i.e. upstream and to down stream of Kurmin Gurmana village.

Hydrological and meteorological data such as (lake level)gauge height and discharge, rainfall, temperature, evaporation, relative humidity records where collected for a period of ten years for both pre and post dam

CHAPTER TWO

THE STUDY AREA

2.1 BRIEF HISTORY OF SHIRORO DAM

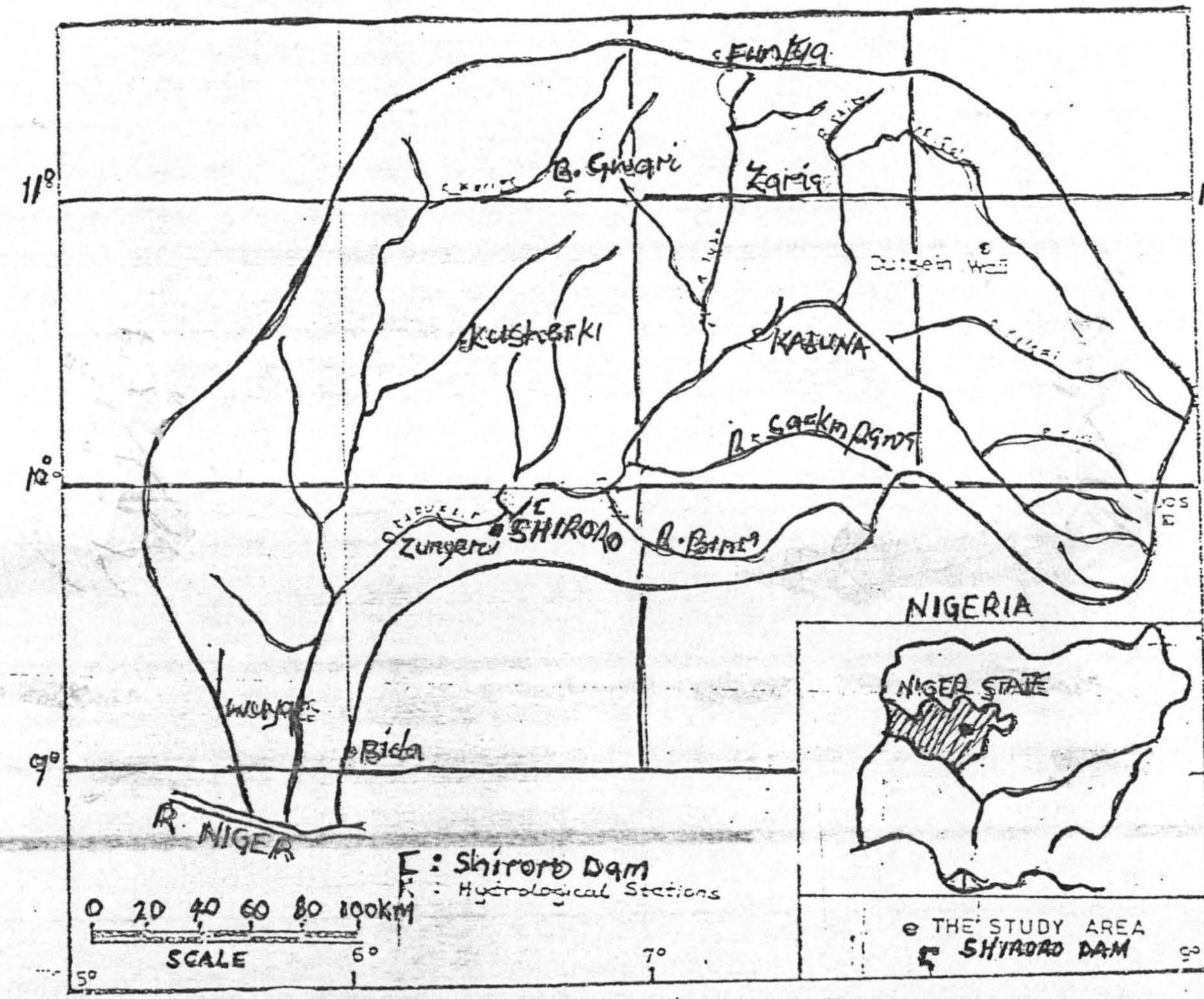
The Shiroro Hydroelectric Project was initiated by the defunct Northern Nigeria Government and the former Electricity Cooperation of Nigeria in 1957. It was originally conceived to meet the electricity requirement of Kaduna, Zaria and Kano areas. Work commenced in 1978 and by 1984 Shiroro Hydroelectric Dam Lake reservoir was successfully impounded while by 1990 the Power Station was commissioned; (Shiroro Annual report: 1994).

2.2 GEOGRAPHICAL LOCATION OF THE STUDY AREA

The Shiroro lake is situated on Kaduna River at the confluence of Kaduna river and River Dinya the lake is located on latitude 9°58'N and latitude 6^0 51'E. Kaduna river is the major river feeding the lake, the river takes its origin around the west and the northwest of Jos plateau, (Abubakar, 1997).

The river flows westward and southward from the plateau at an elevation of 1500 through Kaduna town at an elevation of 633m. The major left hand tributaries of the Kaduna river are the river Sarkin Pawa and Dinya; they rise from the hilly areas within the basement complex plains near Kaduna; while the major right hand tributary is River Tubo (Jimoh 1992, Abubakar, 1997).

Fig 2.0 LOCATION OF SHIRORO DAM AND MAIN RIVERS WITHIN ITS CATCHMENT



Adopted from Abubakar 1997

The dam has a catchment area covering about 20,300 square kilometers in Niger State alone and drains about 27% of the total landmass of the state. It has a total area of about 65,530 square kilometer from it headwaters to the gauging station at Wuya bridge (Shekwolo, 1990.)

2.3 CLIMATE

2.4 RAINFALL

The creation of Shiroro Lake has lead to a change of climate condition in and around the lake area. The monthly rainfall schedule for the year can be divided into (4) four periods. (Adefolalu, 1992, Shiroro Annual Report, 1994, Abubakar, 1997).

These are:

i. January to April, which record minimum rainfall ranging from about 5mm to a maximum of about 70mm in April.

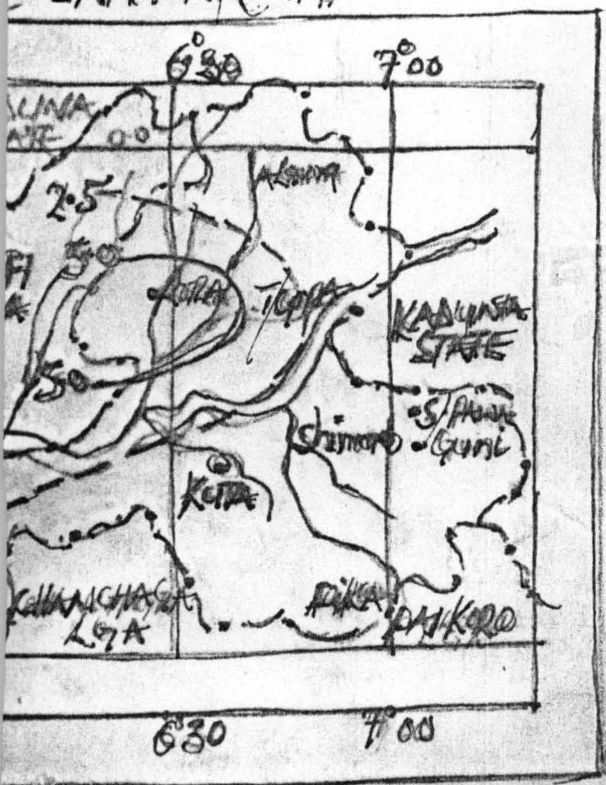
ii. May to July, rainfall within this period varies from 180mm to 200mm.

iii. August to October, rainfall about this period constitutes the peak of the rainy season with rainfall ranging from 250mm to 400mm.

iv. This period is similar to the first period of January to April and rainfall ranges between 5mm to 20mm. (Adefolalu, 1992, Shiroro Annual Report, 1994, Abubakar, 1997). See figure 2.1.

2.1

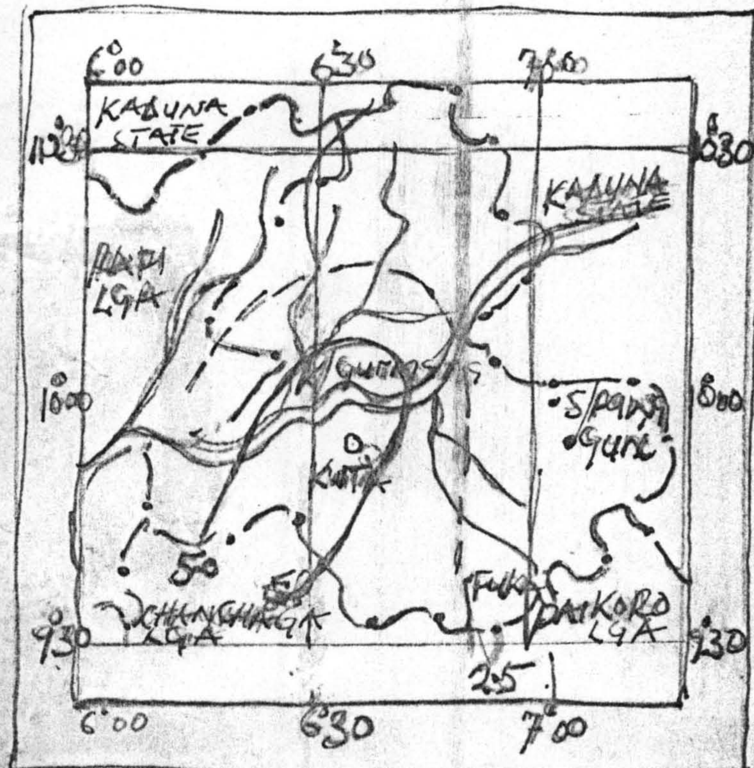
JANUARY (mm)



LEGEND
□ <10(mm)

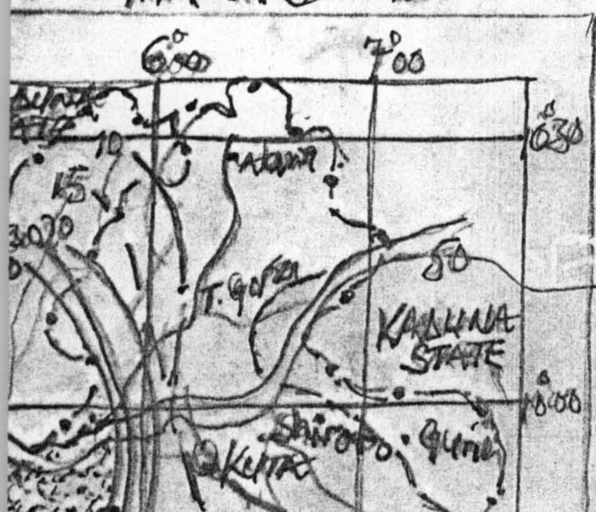
SCALE
1:500,000

FEBRUARY (mm)



LEGEND
□ ≤10mm

March (mm)



APRIL (mm)

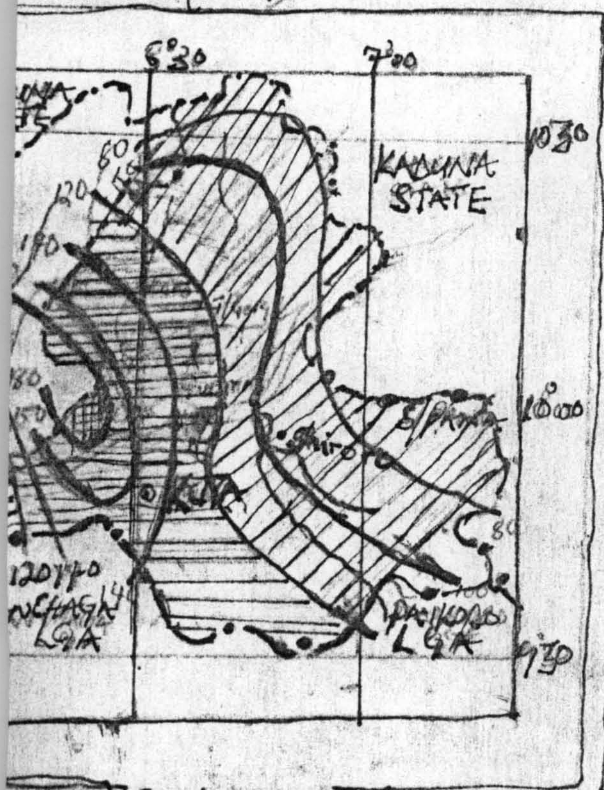
LEGEND
□ <20mm □ >20mm

SCALE
1:500,000

LEGEND □ <60mm ▨ >60mm

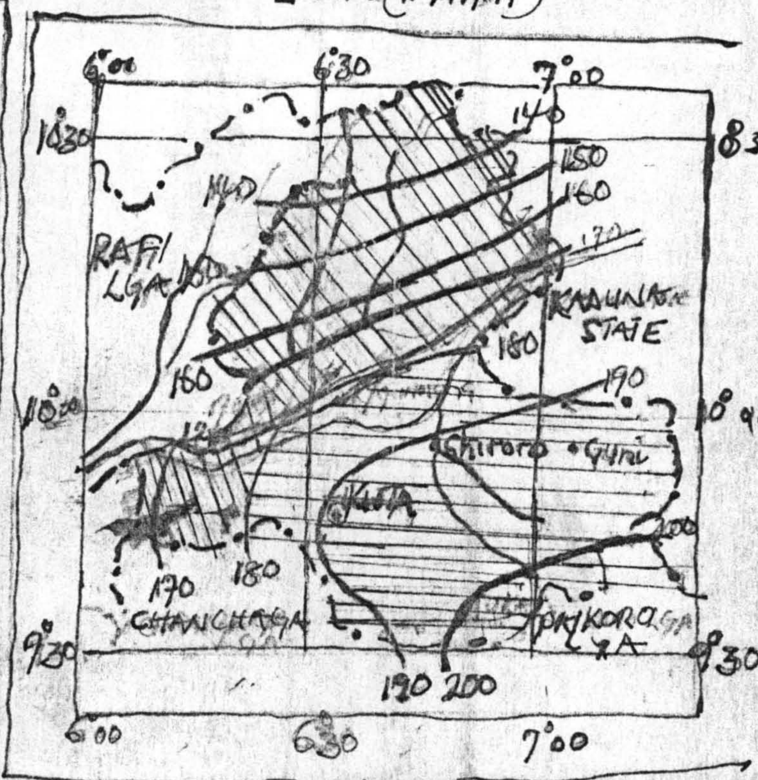
Abubakar (1997)

MAY (in mm)



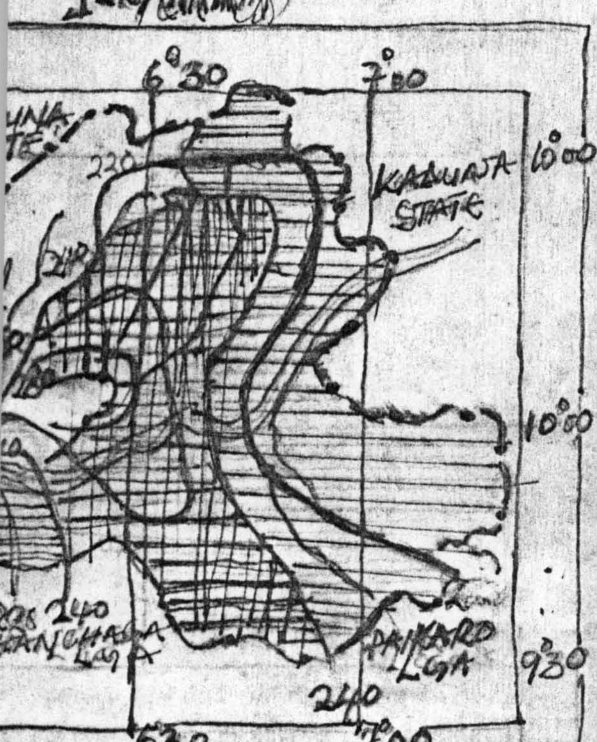
SCALE 1:500 000
LEGEND
-120mm 120-180mm >180mm

JUNE (in mm)



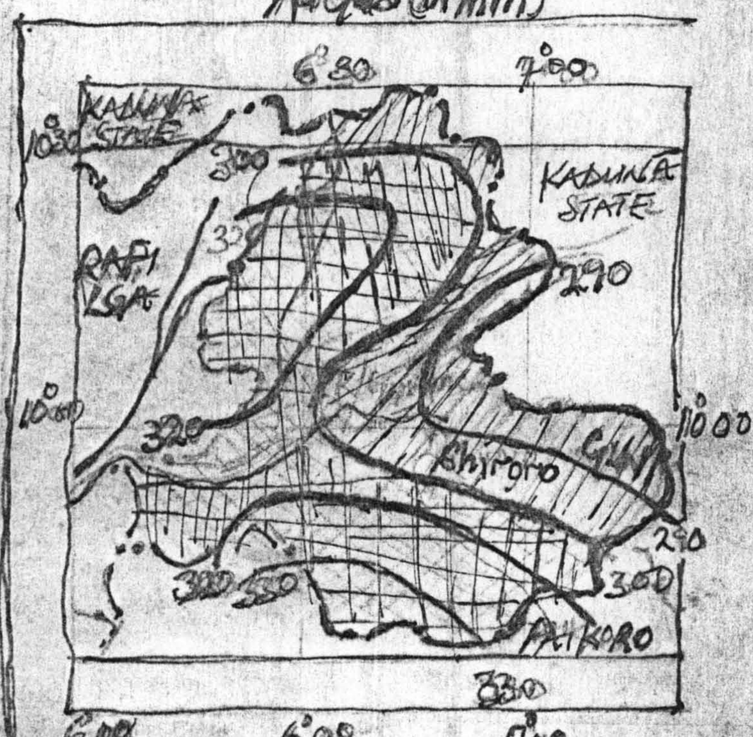
SCALE 1:500 000
120-180mm > 180mm

JULY (in mm)



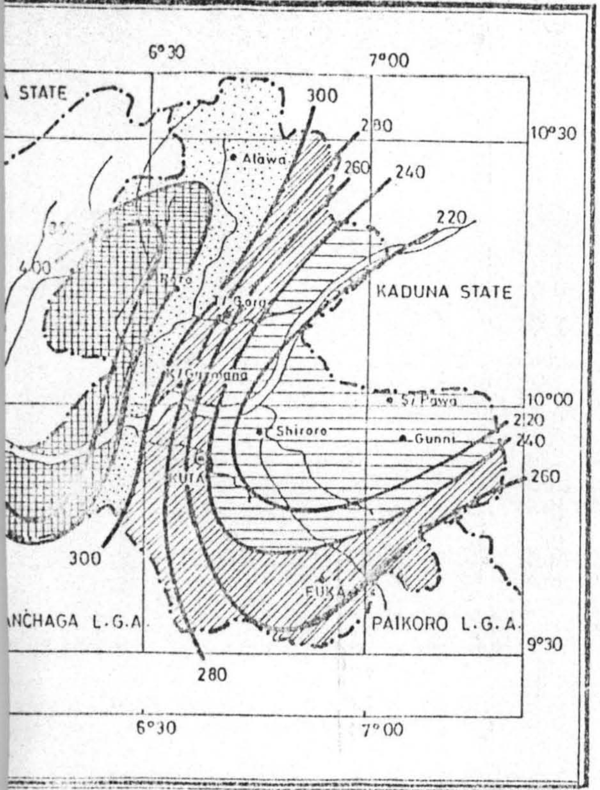
SCALE 1:500 000
LEGEND
120-240mm >240mm

AUGUST (in mm)



SCALE 1:500,000
LEGEND
240-300mm 300-360mm

SEPTEMBER (in mm)

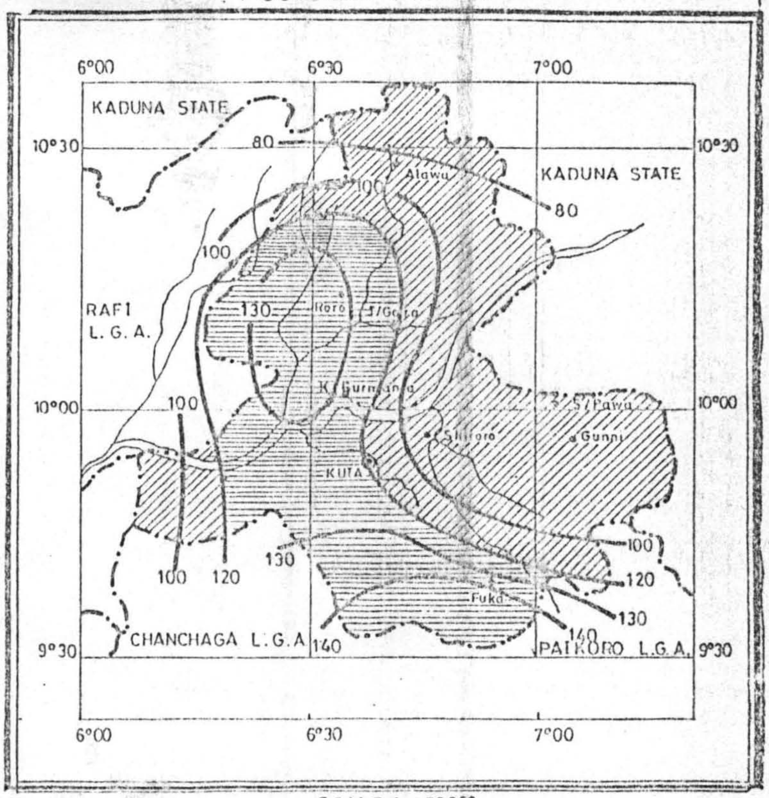


SCALE:-1:500,000

LEGEND

m | 240 - 300mm | 300 - 360mm | > 360mm

OCTOBER (in mm)

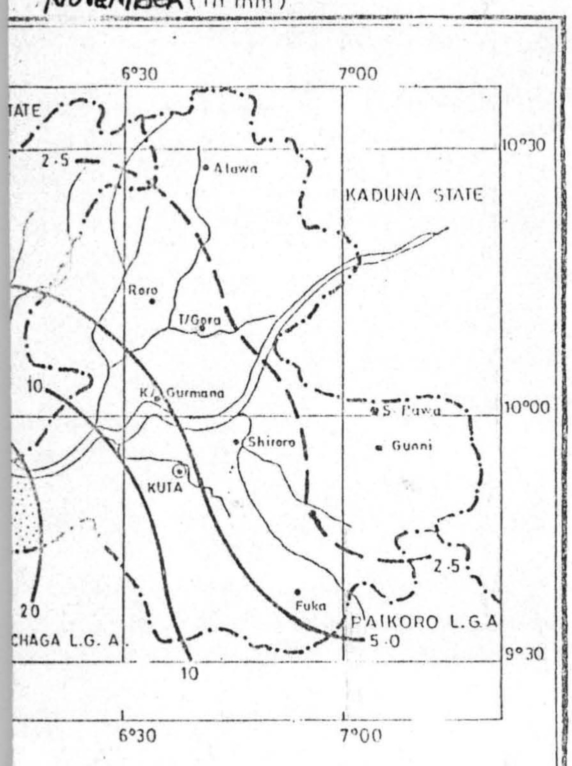


SCALE:-1 :500,000

LEGEND

< 120mm | > 120 mm

NOVEMBER (in mm)

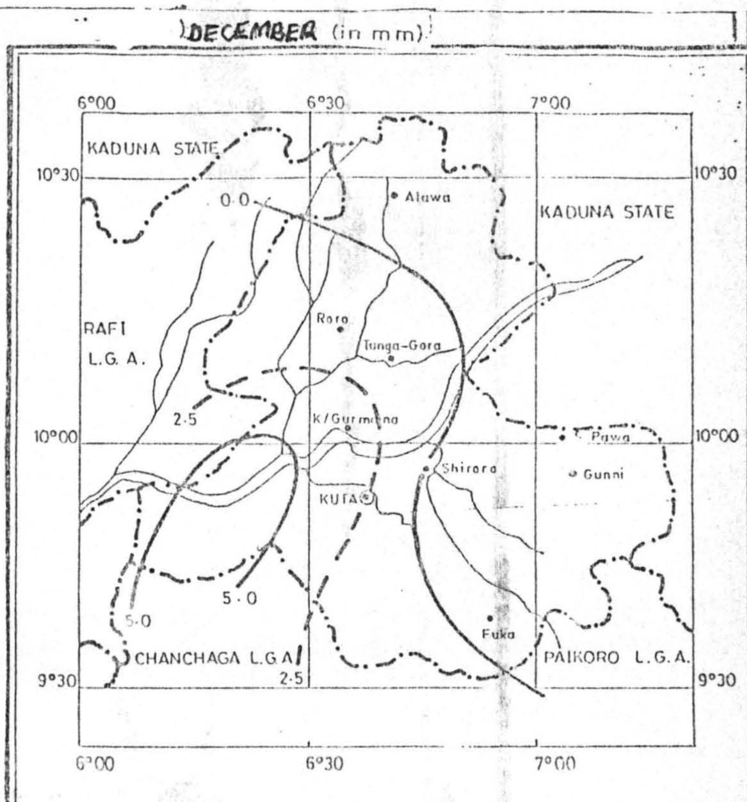


SCALE:-1 :500,000

LEGEND

≤ 20mm | > 20mm

DECEMBER (in mm)



SCALE:-1 :500,000

LEGEND

< 10 mm

(Adapted from Abubakar 1997

2.5 EFFECTIVE TEMPERATURE

The relative temperature of the study area result in cool/warm zone in the Shiroro Local Government Area, the Northern area where the lake is situated has a colder temperature than the southern part of the Local Government. (Shiroro Annual report; 1994).

2.6 RELATIVE HUMIDITY

The relative humidity for the water shed ranges between 32% to 78% for pre-dam condition. The values being higher between July to August. The values range between 40% to 88% for post dam condition. The highest values occur between July and August while the lowest values occur between December and February, (Abubakar, 1997.)

2.7 VEGETATION

The vegetation type of the watershed is guinea savanna, it is composed of montane forest of mainly trees with little shrubs and grasses, the grasses are between 1.5 to 3.5m high. The trees are short bold broad leaf trees of up to 16.5m in height; the grasses have durable roots which remain under ground after the tops have been burnt away after a dry season fire and they sprout again with the onset of the first rains the following year (Abubakar ; 1997.)

2.8 SOILS.

The soil type is primarily the result of the interaction between climate (Mostly rain fall and temperature) parent materials and geomorphic factors over varying periods of time.

The soils of the Shiroro catchment area are developed from the pre Cambrian complex rocks comprising granites, schist; gneiss and amphiboles; (Abubakar, 1997.).

CHAPTER THREE

3.1 LITERATURE REVIEW

Lohani et al (1978) asses all resources development projects as having social, economic and environmental consequences and water development is no exception whether such consequences are acceptable or not often matter of controversy and depend very much on the individual concerned, their personal interests, views, biases.

Hence it is not exactly uncommon to find a situation where a near water development project is unacceptable to certain segment of the society due to the unwarranted social environmental side effect while another side may be lobbying hard for the same development for different reasons to a certain extent such conflict can be explained by an analysis of the beneficiary which seldom conducted for most projects.

It is inevitable that all development project will benefit some citizens more than others and frequently some citizens may have to bear additional cost such as social and environmental cost.

This cost they further explained centers on three parameters which are:

- ✓ Physical
- ✓ Biological
- ✓ Human

The physical assessment involves the change in rivers and ecosystem regimes with the problem being that of silt being trapped in the reservoir resulting into clean water flowing downstream of the dam causing erosion to river beds and banks.

They further noted that lack of sediment down stream of the dam contribute to the significant reduction of plankton's and organic carbons, thus creating economic problem downstream to fishermen whose livelihood depends on fishing; other changes in terrestrial to aquatic system hydro meteorological effects and changes in social and water quality.

While the biological assessment has to do with water quality, which is of prime importance to health; the availability of portable water to much of man kind is literally a matter of life and death.

However, constant availability of large quantity of water in reservoir is conducive to the breeding of mosquitoes, which act as intermediate host for diseases like malaria. Similarly, plant growth around water bodies provides a suitable habitat for tsetse fly to transmit trapanosomiasis to human and domestic animals.

The human system was assessed and it was found out that as a result of releases from dams many local inhabitants are displaced.

Dube (1989) observed that information on environmental impact assessment is available from a number of studies which involves various methodologies and techniques and yielded data differing in levels of magnitude and accuracy; he further explained that remote sensing techniques are based on interaction of incidence radiation from the sun with the earth's features which in varying degrees reflect emit transmit or absorb electromagnetic radiation(EMR), variation in the EMR from different features provide information which s directly related to the properties of these feature such as quantity change in river and ecosystem requires change in soil quantity, hydro meteorological effects.

Okhimamhe A. A. (1993) carried out a survey using spot HRV acquired in 1986. The researcher combined the imageries with aerial photographs of 1974 to detect the changes in the land use/ land cover in Burun/Tiga area as a result of the construction of the Tiga dam over the period of 12 years. The study revealed that 38897 hectares of changes have taken place where crop/pastures land; wooded shrub land had increased by 104 percent. The study showed that the sandy area has increased which are indicators of desertification.

Ackermanetal (1973) indicate the range of effect of the dam construction to include loose of land through inundation and implication for water level sedimentation (silting) behind dams reduces down stream sediment load.

Toro (1994) has identified the negative effects of the Cameroonian Lagdo dam on the environment down stream to include siltation of river bed and water intake, in the Benue river lose of Fadama cultivation and navigation constraint; he also identified the positive effect of he Lagdo dam on down stream river Benue to include flood control and land reclamation and an increase dry flaws.

Jumoh (1992) has identified the sheet erosion from the catchment of river kaduna take place he further stressed that suspended sediment in river Kaduna is 0.4g/t and that of Sarkin Pawa 1.6g/1 he noted that there is high deposit of sand and clay loamy on the river course of river Sarkin Pawa during period of low flow.

Aviakyna et al (1977) have identified that the degree of a reservoirs impact on environment greatly depends on the magnitude of the measures aimed at ensuring that its construction does not have considerable consequences

Hafez and Shenouda (1977); in a study of the environment impact of the Aswan high dam attributed river bed erosion to sediment trapping, they observed that clean water flowing through the river causes erosion to the bed and banks and to some extent to installations along the Nile.

Abubakar (1997) analyses various meteorological variables at Shiroro dam in form of local micro-climate change which revealed that the damming of the river Kaduna at Shiroro has induced some micro-climate changes at the dam site; he noted rainfall shows an insignificant increase in the amount of rainfall from pre to post dam period, while temperature recorded a difference of 3.57°c between pre and post dam annually which indicates 9.6% decrease from the pre dam; and the relative humidity and evaporation between pre and post-dam as yearly high; he further explained the water deficit was

1,050mm for pre dam and 200m for post dam; Sam (2000) while assessing environmental impact and energy development in Nigeria opined that quantitative assessment of accuracy of the data already available was not attempted in the previous, reviews of project involving energy sector before 1992; hence Shiroro hydroelectric power projects dam was commissioned in 1990 without the due processes of any environmental impact assessment adhered to; he further noted that because of the considered primary and secondary environmental impacts of activities in the energy sector that the federal military government in Nigeria promulgated EIA decree 86 of 1992 which puts development in the energy sector such as that of the study area on the schedule of mandatory list of activities requiring an EIA that should lead to possible public bearing and final sound environmental management decision he further stress that water energy development projects, Hydro; pumped storage and tidal apart from ecological effect, Aesthetic effect and displacement of people during construction. Its usage is environment friendly.

3.2 SOME MAJOR IMPACTS OF HYDRO ELECTRIC DAM

The devastating impacts of the hydro electric power stations on the environment take many forms, these effects are felt upstream and downstream of the dams these negative effects can be classified into physical biological chemical (HYPPADEC; 2001).

The physical consequences includes the following:

i. sedimentation

ii. inundation of land

iii. modification of local/micro climate of the dam sites

iv. flood flow and collapse of dams. (HYPPADEC; 2001)

Biological consequences, the terrestrial ecosystem is turned into aquatic system and hence introduction of new flora and fauna.

Chemical consequences occurs when turbid water laden with fine sediment is allowed to settle down before being discharge downstream. The water storage has caused changes in the water quality; HYPPADEC; 2001.

CHAPTER FOUR

4.0 DATA AND COMPUTATIONAL TECHNIQUE

The environmental impact assessment of Shiroro dam on the environment will take the following procedure base on the earlier stated objectives.

A hydro-meteorological approach will involve the analysis of meteorological and hydrological data. These is to enable me determine to some extent the effects of Shiroro hydroelectric dam on the environment.

Description of Data

Class	Data	Station	Period	No of years
Meteorological			Pre dam Post dam	
	Rainfall	Shiroro	(1985-89) – (1995 –2000)	11 years
	Temperature	Shiroro	(1965-89) – (1995 –2000)	11 years
	Relative Humidity	Shiroro	(1985-89) – (1995-2000)	11 years
	Evaporation	Shiroro	(1985 –89) – (1995-2000)	11 years
Hydrological	Gauge height	Shiroro	1990-2000	11 years
	Discharge	Shiroro	1990-2000	11 years

The primary data sources which involves a reconnaissance survey of the study area during which field work notes, taking of major features such as vegetation, surface areas of the dam; excavated river flow channel, spill way maps and photograph of some features are documented.

The secondary sources includes mainly of information on climate data, discharge, gauge height or lake level which were gathered from ministries, departments, parastatal and other relevant organizations.

4.2 TECHNIQUES OF DATA ANALYSIS

Analysis Based On Mean Monthly variation of all meteorological and hydrological variables such as Rainfall, Temperature, Relative Humidity, evaporation the lake level and discharge will be computed in a tabular form on the study area for a period of 11years 1985-89 for pre dam and 1995-2000 for post dam periods except for discharge which will be 1990-2000, and were graphically plotted.

The formular 't' = $$\frac{\bar{y}D}{\sqrt{\left[\frac{N\sum D^2 - \left(\sum D\right)^2}{N}\right]\left[\frac{1}{N(N-1)}\right]}}$$

will be employed in order to find out if there exist any difference in the value between the pre-dam and post-dam periods, hence the students 't' test at 5% level of significance will be the basis for determining the extent of changes that have taken place as a result the dam construction and thus the effects of such changes on the environment.

The meaning of terms

i. $\bar{y}D$ => Sum of difference between the pairs of two groups under observations.

ii. N => The number of pairs under observation.

iii. ΣD^2 => Sum of square difference

iv. $(\Sigma D)^2$ => The square of sum of the difference.

v. N - 1 => The degree of freedom.

CHAPTER FIVE

5.0 DATA ANALYSIS AND DISCUSSION OF RESULT

5.1 MEAN MONTHLY RAINFALL AMOUNT

Mean Monthly Rainfall Amount. Table 5.1 indicate the mean monthly rainfall and their differences over the period of time; post dam value increased by 163mm over the pre dam value.

Figure 5.1 graphically shows that pre dam maximum amount of rainfall and that of post dam stood at 299.8mm and 298.2 respectively which occurred in the month August and pre dam has a difference of 1.06mm over the post dam periods. While the lowest rainfall amount occurring in November to February of the proceeding years for both pre and post dams, 0mm, however the highest difference occur in the month of June with the post dam having a difference of 52.02mm over the pre dam.

The onset and cessation of the rains as exhibited by fig 5.1 shows that post dam has the highest number of rain days starting from the month of march and terminating in early November while the lowest values stood at 0mm during the month of November for pre dam and 0mm for post dam periods see table 5.1 and figure 5.1

For mean annual rainfall post dam show a difference of 13.69mm over the pre dam periods, the Cal 't' = 2.394 thus sharing no much significant difference for mean annual rainfall at t tab = 2021

Table 5.1: Mean monthly variation in rainfall at Shiroro in (mm).

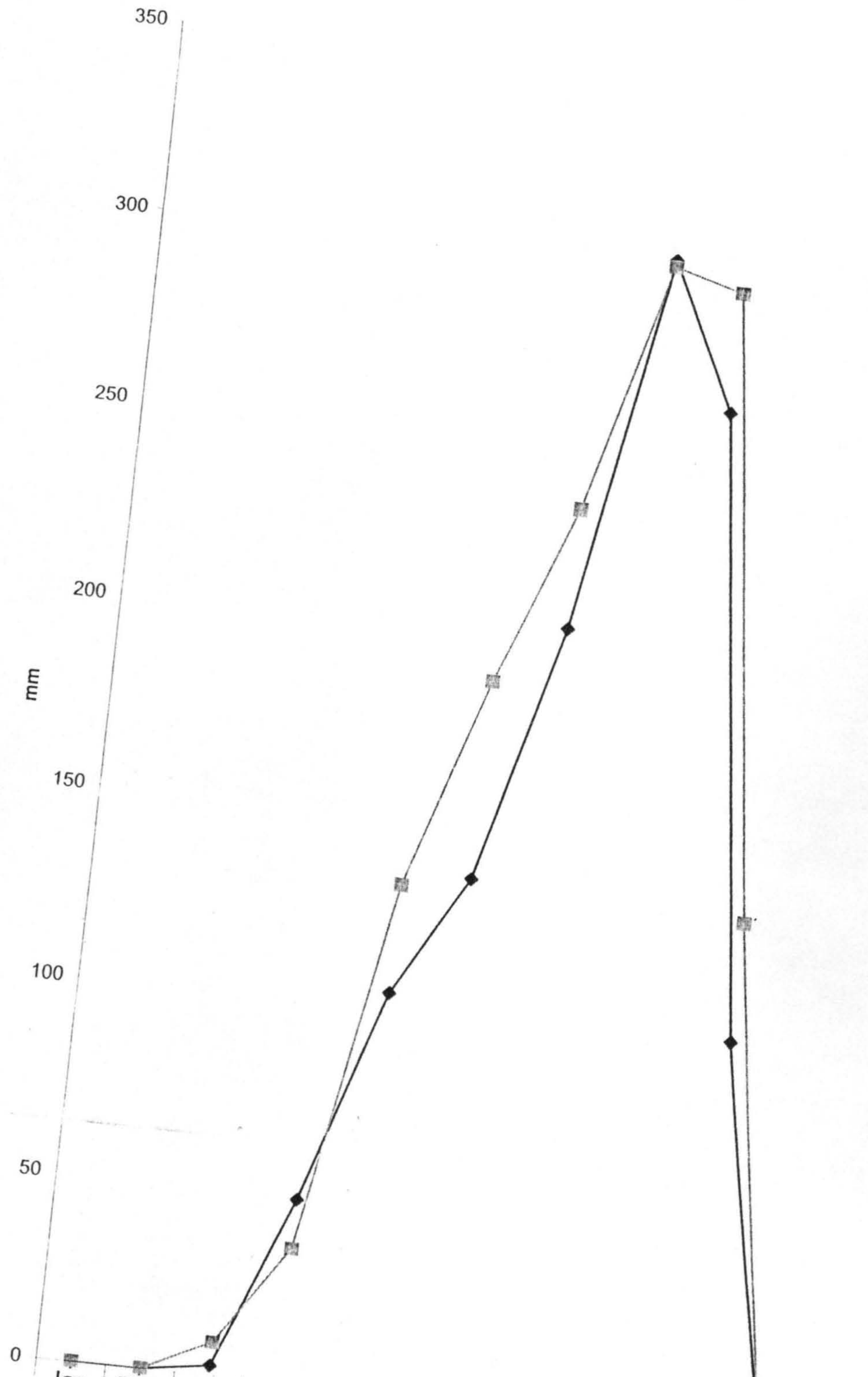
	Rainfall amount in (mm)		
Months	Pre-dam 1985-89	Post-dam 1995-2000	Difference
Jan	0	0	0.00
Feb	0	0	0.00
Mar	2.5	8.93	-6.43
Apr	49.1	36.01	13.09
May	104	131.9	-27.09
Jun	135.2	187.4	-52.02
Jul	202.8	233	-30.02
Aug	299.8	298.2	+1.06
Sep	261.4	292.9	-31.5
Oct	100.72	131.2	-30.48
Nov	0	0.2	-0.02
Dec.	0	0	0.00
Total	1155.52	1319.83	-164.22
Mean	96.29	109.98	13.69

Source: Compiled by the Author

Cal t' = -2.394

t = 2.201

Mean Monthly Rainfall Amount At Shiroro Dam



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
Pre-Dam	0	0	2.5	49.1	104	135	203	300	261	101	0	0
Post-Dam	0	0	8.93	36	132	187	233	298	293	131	0.2	0

Pre-Dam — Post-Dam

Source: Compiled by the Author

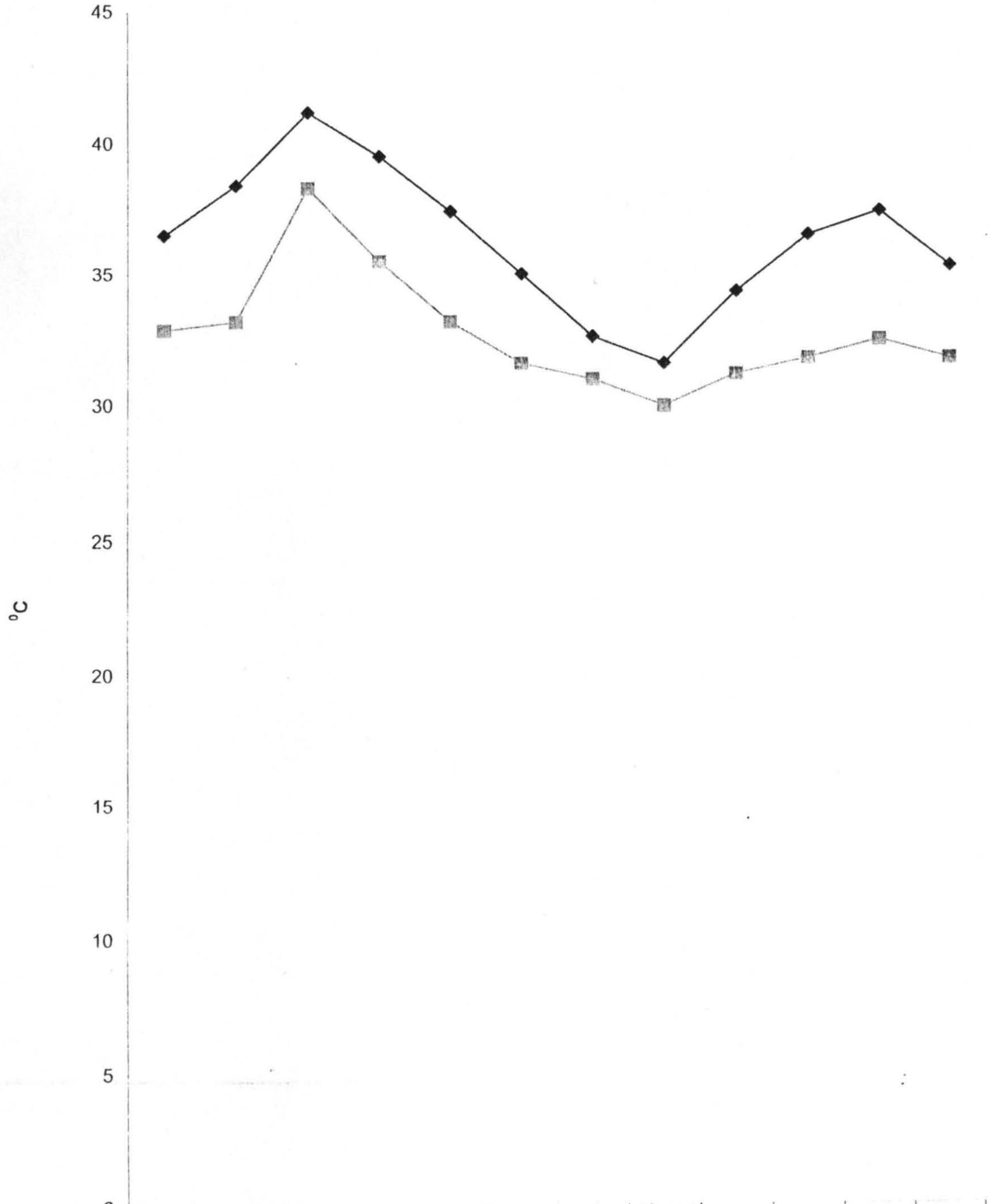
5.2 MEAN MONTHLY MAXIMUM VARIATION OF TEMPERATURE

Table 5.2 shows the lowest maximum temperature occurring in August for both pre and post dam periods, although that of pre dam is higher by an in significant difference of 1.6°c, the highest temperature occurs in the month of march when temperature rises to 41.17°c for pre dam and 38.30°c for post dam periods.

The most significant variations occur during the month of February when temperature difference nets 5.23°c over post dam value of 33.17°c

Fig 5.2 graphically typifies this relationship between the pre and post dam periods, however temperature seems to fall almost between December and January when the dry season and the onset of harmattan winds are blowing across the northern part of Nigeria. This is so for both pre and post dam periods. See figure 5.2 while the mean annual for pre dam is 36.31°c and post dam is 32.70°c. Showing a difference of 3.62°C thus a significant difference as Cal 't' = 11.42 higher than 't'.

Mean Maximum Tempurature at Shiroro dam



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
Pre-dam	36.5	38.4	41.17	39.5	37.4	35	32.6	31.6	34.33	36.5	37.4	35.3
Post-dam	32.86	33.17	38.3	35.5	33.17	31.6	31	30	31.2	31.8	32.5	31.8

Pre-dam   Post-dam

Source: Compiled by the Author

Table 5.2: Mean Maximum Temperature At Shiroro Dam

Months	Pre-Dam	Post-Dam	Difference (°C)
Jan	36.5	32.86	3.64
Feb	38.4	33.17	5.23
Mar	41.17	38.3	2.87
Apr	39.5	35.5	4
May	37.4	33.17	4.23
Jun	35	31.6	3.4
Jul	32.6	31	2.2
Aug	31.6	30	1.6
Sep	34.33	31.2	3.13
Oct	36.5	31.8	4.7
Nov	37.4	32.5	4.9
Dec.	35.3	31.8	3.5
Total	435.7	392.9	43.4
Mean	36.31	32.70	3.62

Source: Compiled by the Author

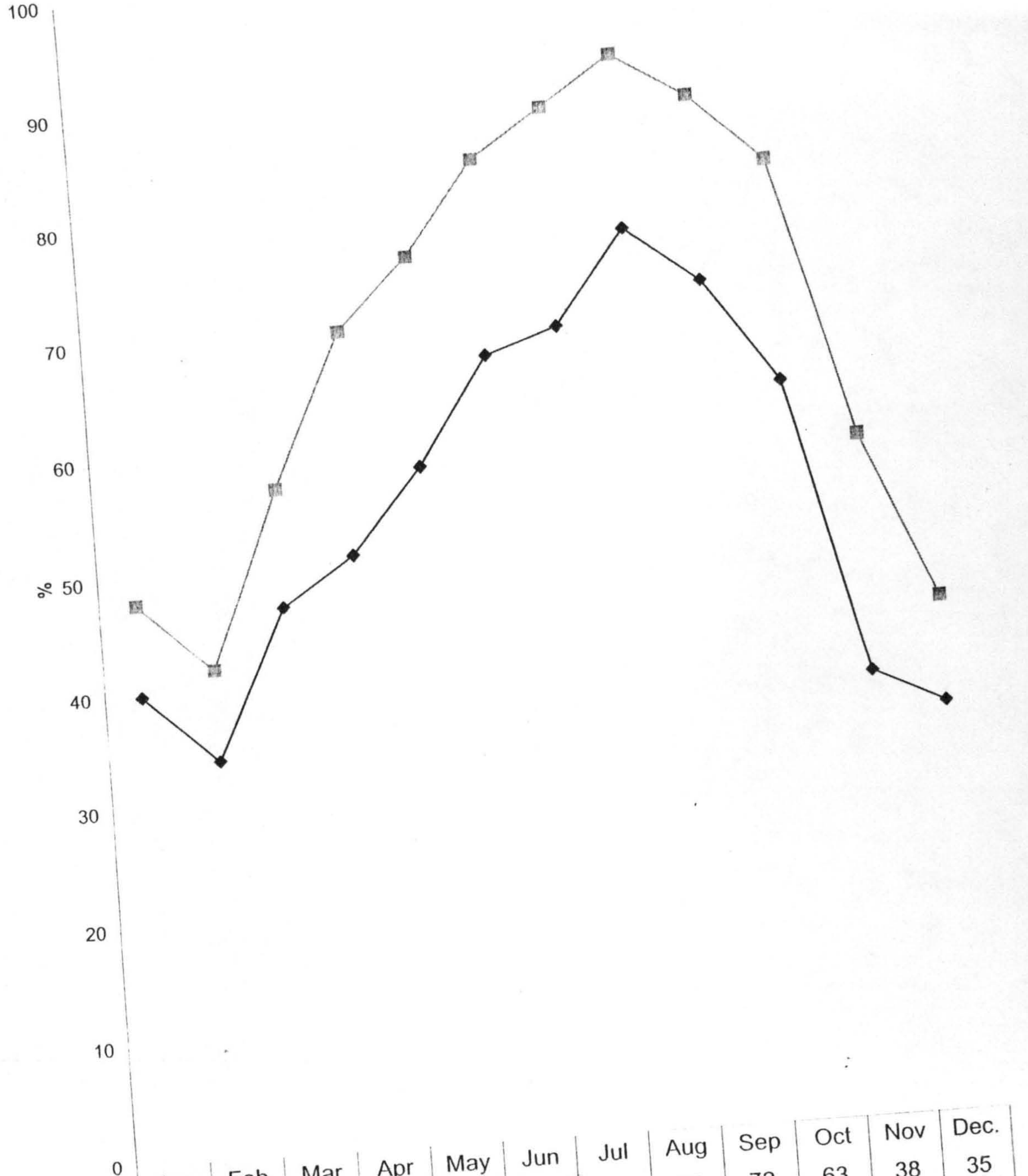
Cal 't' = 11.42

't' = 2.201

5.3 MEAN MONTHLY VARIATION OF RELATIVE HUMIDITY

Table 5.3 Shows the highest relative humidity occurring in August for both pre dam and post dam values of 77% and 92% respectively; it should be noted however, that the post dam periods has witnessed a rise in the percentage value, there is a significant

Mean Relative Humidity at Shiroro Dam



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
Predam	40	34	47	51	58	67	69	77	72	63	38	35
Post dam	48	42	57	70	76	84	88	92	88	82	58	44

Predam — Post dam

Source: Compiled by the Author

difference in the months of April, July and October that is, onset of rains, middle and cessation of dam fall periods while insignificant difference are recorded between December and January to February of the proceeding year, this is so because of the dry season; except for the month of November which has the greatest difference of 20% during the post dam over the pre dam value. Figure 5.3 describe the relationship. The mean annual for pre dam is 48.58 be post dam is 69.08 thus an increase of 20.5% during the post periods, thus Cal 't' is 14.96 showing a significant difference.

zSource: Compiled by the Author

Cal 't' = 14.96

t = 2.201

5.4 VARIATION IN MEAN MONTHLY EVAPORATION AT SHIRORO DAM

Table 5.4 shows the highest evaporation level of 425mm occurring in the month of March for both pre and post dam periods; while the highest difference is noticed in the month of April, where the post dam evaporation increase by 212mm.

The trend as exhibited by fig 5.4 shows that during season much greater water is lost especially in the months of February and March as against the trend of relative humidity in the same period.

Significant reduction occurs however in evaporation in the month of July especially during the post dam periods when the relative humidity is almost at its maximum and temperature has inversely reduced while rainfall has substantially been recorded. The mean annual show a significant difference of 145.75 over the pre-dam period; at Cal 't' is +13.06.

Table 5.4: Mean monthly Evaporation (mm)

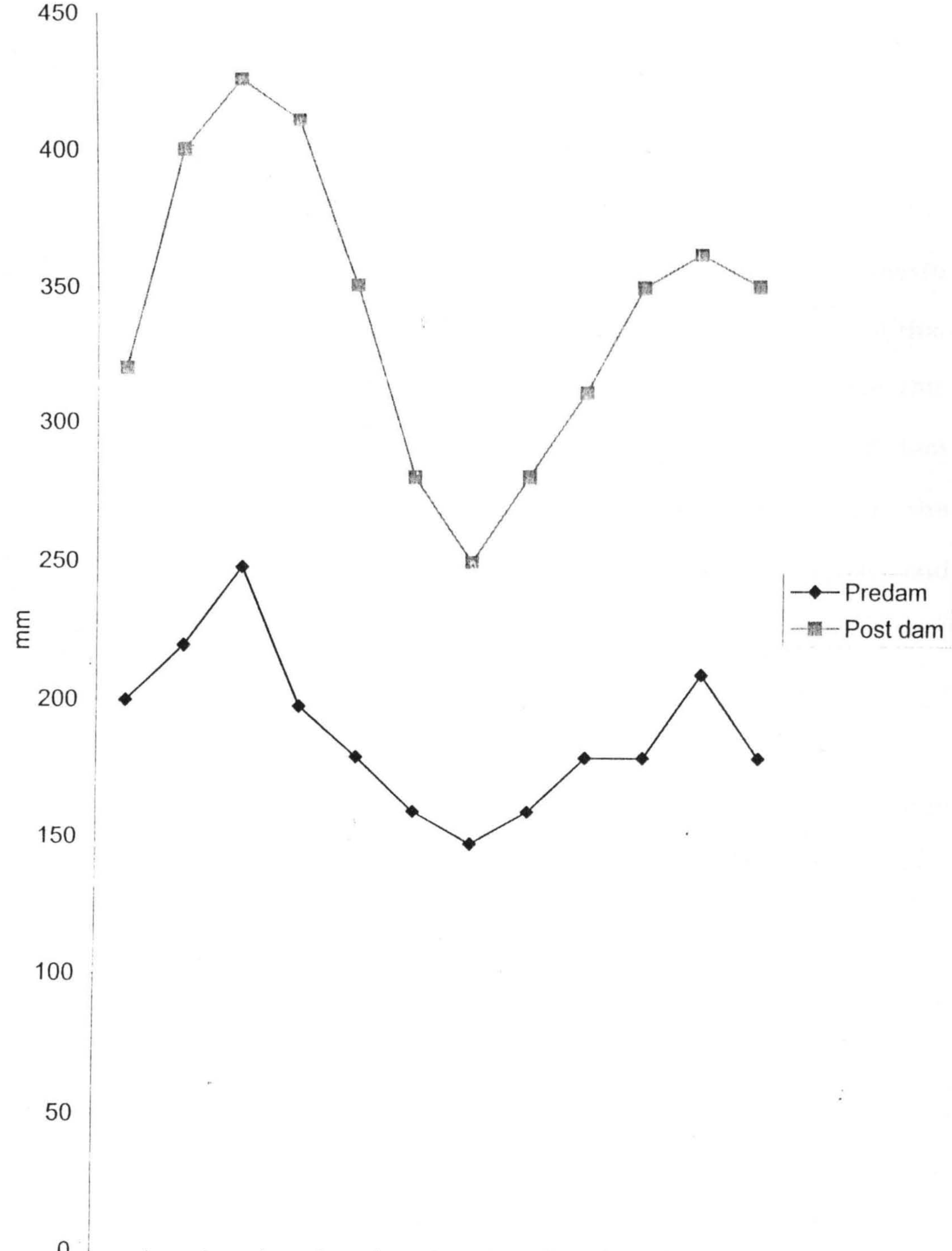
Month	Pre-Dam	Post-Dam	Difference
Jan	200	320	- 120
Feb	220	400	- 180
Mar	248	425	- 177
Apr	198	410	- 212
May	180	350	- 170
Jun	160	280	- 120
Jul	148	250	- 102
Aug	160	280	- 120
Sep	180	310	- 130
Oct	180	348	- 168
Nov	210	360	- 150
Dec.	180	348	- 100
Total	2444	4013	- 1749
Mean	203.67	334.42	- 145.75

Source: Compiled by the Author

Cal 't' = 13.06

't' = 2.201

Mean monthly Evaporation



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
Predam	200	220	248	198	180	160	148	160	180	180	210	180
Post dam	320	400	425	410	350	280	250	280	310	348	360	348

Source: Compiled by the Author

The mean monthly evaporation exhibits an increase progressively a head during the post dam when compared with the pre dam values of 203.6mm while that of post dam rose to 334.4mm a total of 145.75mm remain as difference between pre and post dam periods. The dry season periods during the month of December show a minimum value of difference of 100mm and during the months of July when rainfall is relatively high and the relative humidity is high, however temperature is remain low at this month hence little water is lost. See figure 5.4

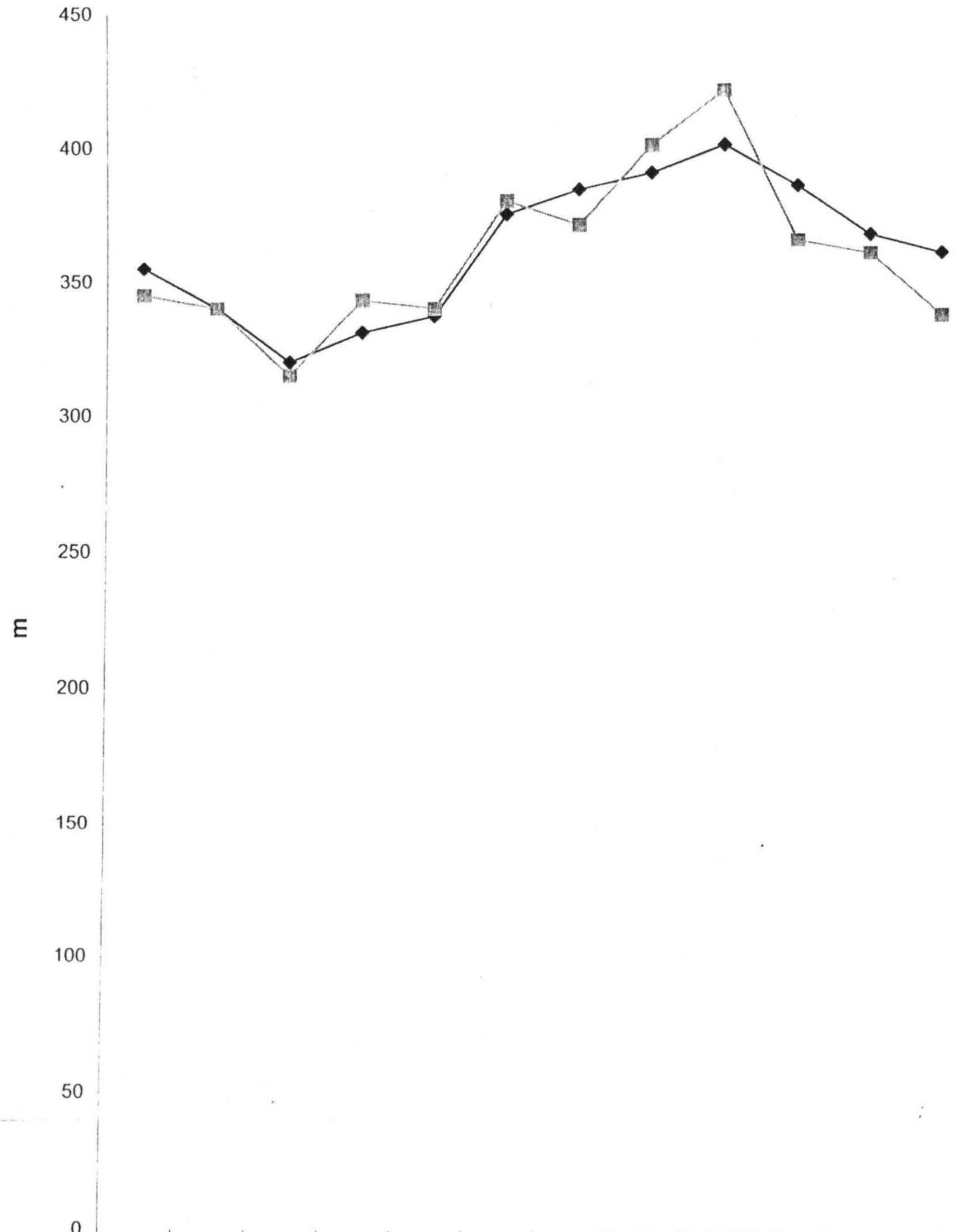
5.6 HYDROLOGICAL ANALYSIS

The hydrological variable at Shiroro dam site were analyse and the result shows that for gauge height either wise referred to as lake level show some rising and falling of the lake level fig. 5.5 exhibits this relationship between pre and post dam gauges.

In January when rain has ceased the lake level stood at low values for pre dam and post dam while higher values was recorded in the pre dam period in the month of September with a value of 420 meters as mean monthly value while the month of March witness a decrease in the lake level for both pre and post dam periods. The rise in September can be attributed to the high rainfall in the year of August and hence all tributaries empty into Shiroro Gorge whereby increasing the water level in the reservoir.

The gauge height decreases in the month of November and December and finally reached its lowest level in the month of March due largely to dry season. The mean annual difference was only 2.33m which when compared to pre-dam was insignificant hence t = 2.201 and the Cal 't' = 0.587.

Mean monthly lake level in (m)

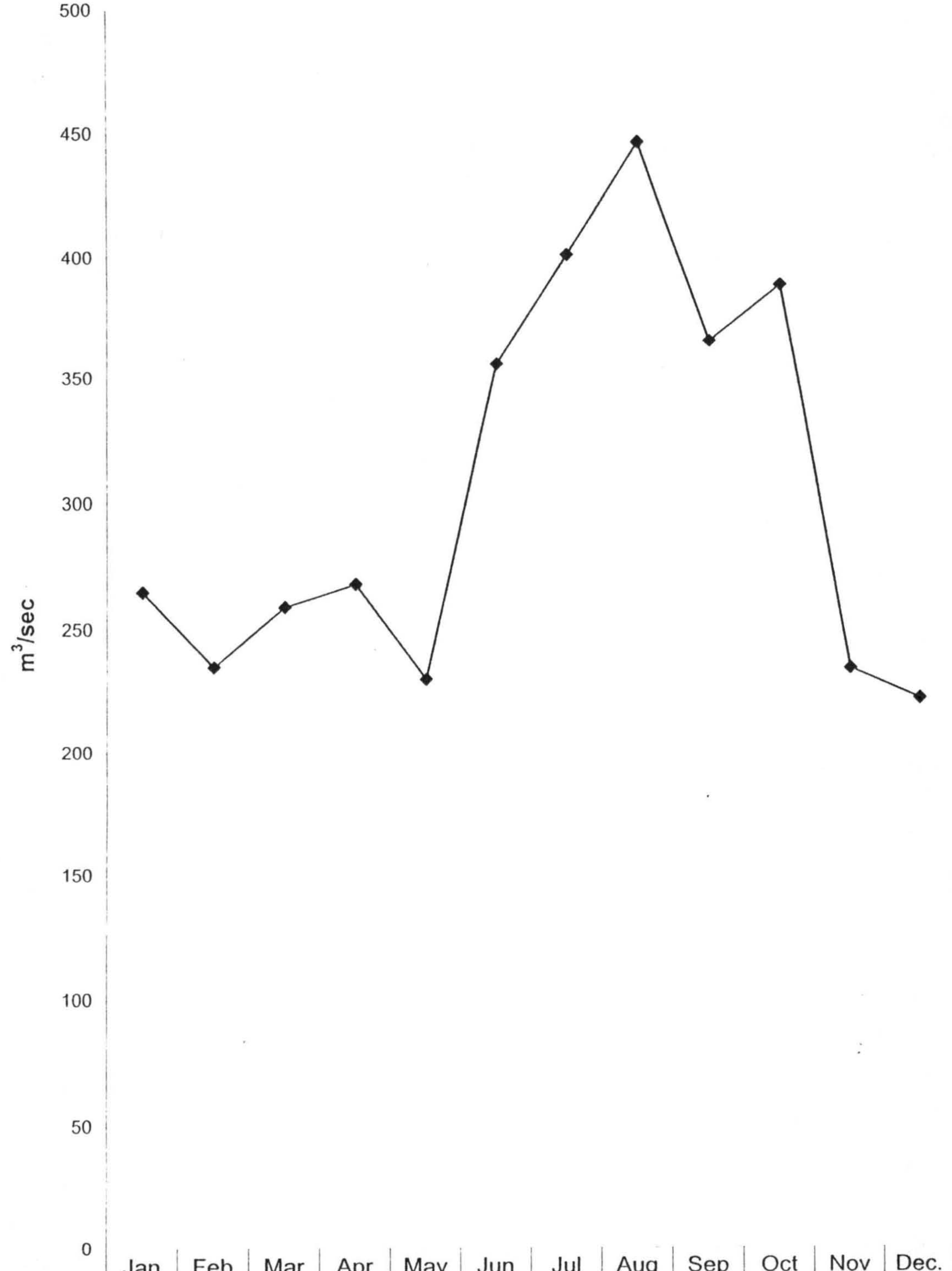


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
Post dam	355	340	320	331	337	375	384	390	400	385	367	360
Predam	345	340	315	343	340	380	371	400	420	365	360	337

Post dam — Predam

Source: Compiled by the Author

Mean monthly discharge at dam site 1990 - 2000



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
Series1	265	235	259	268	230	355	400	445	364	387	234	222

Source: Compiled by the Author

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