IMPACT ASSESSMENT OF SOIL EROSION IN BIDA TOWN

BY

IBRAHIM L.A.MOHAMMED

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DEDICATION

This project is dedicated to Almighty Allah. It is also dedicated to my parent Alhaji Mohammed Gborigi and Hajiya Fatimatu Mohammed, and to my every reliable and hard working wives madina and lami Ibrahim.

ACKONWLEDGEMEN

I would like to express my thanks and appreciation to Almighty God who granted me the grace and strength and guided and sustained me throughout the period on my academic programme.

I am greatly indebted to Dr. P. S. Akinyeye my supervision for taking time to read through any project work, making correction and offering expert suggestions and criterion.

I want to thank all the staff of geography department for their unrelenting encouragement and guidance in the course of my study, professor A.A Adefolalu, professor J. M. Baba, Dr. G.N. Nsofor, Dr. A.A. sadauki, Dr M.T. Usman, Dr. P. S. Akinyeye, Dr. A.A. Okhimamhe and Mrs. A.E. Odafen.

My sincere application goes to my friends and course mates for their support.

DECLATRATION

I here by declare that this thesis was wholly and solely written by me under the supervision of DR .P. S. Akinyeye. No part of this work had either been wholly or practically presented before for any degree elsewhere.

Information hereby obtained from published works and unpublished work of other have been referenced and acknowledged accordingly

Ibrahim L.A Mohammed

2/4/2002

Date.

CERTIFICATION

This is to certify that this project report being submitted by Ibrahim L.A Mohammed to the Department of Geography, Federal University of Technology Minna, Niger State is considered Adeguate and worthy of presentation for the post graduate Project.

_____	2/4/2002.
Ibrahim L.A.Mohammed	Date
_____	_____
DR. P. S. Akinyeye	Date
_____	_____
Dr. M. T. Usman	Date
H. O. D.	
_____	_____
Deam of Graduate School.	Date
_____	_____
External Examination	Date

ABSTRACT.

Soil erosion occurrences have become very common with increasing frequencies both locally and globally and equally increasing losses of lives and properties

Damages include those to crops, livestock, buildings and socio-economic infrastructure

Today, large segments of the global human family living along low-lying coastline and along river and streams course are under constant threat of erosions. This under covers the need for this study.

Discharge and guage height for river lanzun were colleted and analyzed and monthly rainfall record of Bida, 1980-1995 aware also collected and analyzed.

The analysis work gives a statically picture of the variation of the rainfall pattern, flow hydrograph flood erosion, occurrences percentage, flow hydrograph as well as the magnetic of flood erosion frequency on a climatologically basis over Bida in Niger State.

The flow hydrograph shows a general patters of tropical rivers, characterized by a gradual rise towards July and reached its summer peak in August, but with a gradual fall in September indicating rain fall cessation.

The frequency shows no variation in both existence interval and return period respectively but with little variation in re-occurrence- interval of the flood.

TABLE OF CONTENTS

CHAPTER THREE (METHRDOLOGY)

Data and Computation method.

CHAPTER FOUR (RESULTS & DISCUSSION).

CHAPTER FIVE SUMMARY& CONCLUSION)

LIST OF TABLES

Pages

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 BASIC GROUND

Erosion is on of the greatest man-made environmental hazards that threat Nigeria and this affect nearly all parts of the country. Over 8% (percents) of the land in Nigeria is ravaged by erosion (NEST) 1991, wind, sheet, gully and beach erosion affect different parts of the country in varying intensities.

Show lines erosion constitutes a serious hazard to Nigeria coastal Agricultural and recreational land and annually same 13m to 30m of Nigeria coastal land is lost to beach erosion caused by both natural and human agents

Soil erosion is a process whereby surface layer of (weathered rock is loosened and carried away by running water, wind, ice, or natural agents and lower horizon is the soil is exposed. Soil erosion occurs is server parts of Nigeria under different geological, climate and soil condition but the degree of occurrence varies considerably from one part of the country to other.

According to the current National policy on soil erosion and flood control "soil erosion involves a general removal of the soil by the action of wind and water. This has however, been accelerated by certain human activities (Agriculture, construction, deforestation, bush burning ete). In the

past problems of soil erosion were peculiar to certain Nigerian ecological zones. Today, problem has been spatially distributed across the various ecological belts of our country. Features of soil erosion, especially gully development are now a common land mark in all parts of Nigeria. From the above analysis erosion is caused by different agent but man largely aggravates it. However, soil erosion is one of the most important physical and socio-economic problems that affect our development in this part of the globe. Apart from the fact that it constitutes a menace to the environment and its destruction of infrastructures and high ways etc it creates a major problem on Agriculture soil, thereby interfering tremendously with the mass food production campaign.

The foregoing reason prompted me to study make an impact assessments of soil erosion in Bida is as a result of continues destruction of farm plots, buildings and properties.

The channels water stage during and after a heavy rainfall is alarmingly high. At the peak of the rains, the stage reaches a maximum. It overflows its banks submerging farmlands nearly and threatens the structure along it path. There are evident marks of high stage noticeable after rains on shrubs, trees and even on the side wall of the structure. At such periods the velocity of flow is high.

As earlier discussed, large discharge is collected into drains are run off due to the considerable large radius of catchments. This is further

helped by the sharp gradient of the terrain ensuring that rain water collect flows at high velocity into the unlined drains.

1.2 PROMBLE STATEMENT.

It is crucial to education the citizens about the dictation environmental impact of erosion in Nigeria of over 100 million people with population growth of 3.3% crammed with landmass of 128, 768m^2. Due to population explosion, shifting cultivation & bush falling, traditional system that were very suitable for ecological conditions with mammal risk of erosion, are no larger satisfactory. This is because too much exposure of the land cultivating triggers soil nutrient depletion and erosion as well as deforestation, which in turn cause streams to silt up and eventually disappear.

Erosion has caused a lot of damages to Agricultural lands facilities, including service road, Villagers and semi-township besides, it also cause damage to main highways, cause of relatively important public facilities lost of life, properties serious damage to homes and commercial buildings.

1.3 JUSTIFICATION

Realizing the enormity of the problem created by soil erosions disaster in Niger State especially in Bida environs in previous years which rendered many people homeless especially those living in IYA- RUWA, MASAGA, salawu-Etsu areas all in Bida, while settlements and farm plots were destroyed.

It is the light of this that this project intend to look into this problem of soil erosion or surface run-off in Bida. Niger State and hope that the framework will provide base line information on the following.

(i) Causes of soil erosion in BIDA.

(ii) Its variable frequency and intensity or magnitude

(iii) Preventive measure to avoid future damage from erosion.

1.4 AIM AND OBJECTIVES

The aim of this study is to Assess the impact of soil erosion in Bida environment within this broad aim, the specific objective are:

(a) To Determine the causes of erosion in Bida

(b) To Access the consequences of erosion.

(c) To Provide basic information about the variation in erosion in the study area.

(d) To proffer solution to erosion.

1.5 SCOPES AND LIMITATION

Bida has only a single River (lanzun River) that passes the center of the city; other smaller Rivers are faw kilometers from the town. These Rivers are Mussa River in the west and UMARU River is the East. These rivers form the tributaries to Lanzun River.

The data for erosion flow characteristics are insufficient, the work in gathering all required date analyzing countless alternatives in order to come up with an accurate and satisfactory result will be extremely difficult, if not in possible.

1.6 CAUSES OF EROSION.

Soil erosion is caused by physical or human factors or combination of both.

Physical factors that leads to soil erosion include the following, Nature composition of soil, climate and topography.

Nature and composition of the soil, soil is the top layer of the earth crust that is capable of supporting plant growth. As soil science has developed, however, it has become known the soil is a dynamic layer is which many complex chemical, physical and biological are going on constantly. Far from being static, lifeless zone, it is a changing and developing body.

Composition of soil has been derived from the underlying rock no matter how long a soil has been in process of formation, the original "raw material most therefore have some effect on its ultimate nature". The process by which the parent-rock material is broken into smaller fragments are known collectively as weathering.

Weathering initiates the erosion of rock, causing alterations in the surface layers. In dry climate, the top layer of rock may expand from the heat of the sun and crack off from the lower layers. If the rock consists of several minerals, the minerals may expand at different rates and break up the rock. In cold climate, frost breaks up rock because rainwater, which seeps into cracks and pore in the rock, expands when it freezes. Rain in damp climates acts chemically as well as mechanical in the weathering of rocks. As rain passes through the atmosphere it absorbs carbon dioxide, forming carbonic acid, which dissolves some minerals and decomposes others. Feldspar, a common family of minerals in granite is change into clays, and certain minerals in basalt combine with oxygen and water to form lron oxides, such as limonite. Plants play a role in weathering as roots can split rock and extract soluble nutrients (Lecture notes).

Soil becomes adjusted to condition of climate, land form and vegetation and will change internally when this controlling conditions changes.

Soil formation is a function of several variables which can be stated in an equation:-

S = (D, O ,R ,P.T)

S = Soil property.

F = function (which is dependant following)

d = Cimate

O = organism (biological activity)

R = Relief.

P = Parent material.

T = Time.

CLAMATE:- Climate exerts a dominant influence on soil formation. It determines the intensity of weathering leaching and rate of organic decomposition on fact specific soil forming processes one characteristic of each major climate zone. In the hot or warm humid one in general where there is excess precipitation over evaporation the predominate movement of water in the profile is down wards.

1.6.2

TOPOGRAPHY(RELIEF).

.Topography and altitude affect the formation and nature of soil in passive way.

The major relief influences are steepness of slope and position whether high or low. Soil characteristic change from hill to top to valley bottom.

It also affects soil properties by influencing slope angles. The greater the slope, all things beings equal the greater the amount of material removed. gentle slope are characterized by thicker soil layer. In this project the slope is moderate or gentle.

1.6.3

HUMAN IMPACTS ON EROSION

Without human activities losses of soil through erosion would in most areas probably be balanced by the forms this of new soil. On virgin land a mantle of vegetation protects the soil. When rain falls on the surface of grass or on the cause, some of the moisture evaporates before it can reach the ground. Trees and grass serve as windbreaks, and a network of helps to hold the soil in place against the action of both rain and wind. Agriculture and lumbering, as well as housing, industrial development and highway construction, however, partially or wholly destroy the protective canopy of vegetation and greatly speed up erosion of certain kinds of soil. Other human activates include inappropriate cropping techniques, deforestation, clearing for construction of road, settlements, mining activities, bush burning, overgrazing, and excessive farming.

In Niger state, in addition to soil erosion, splash/runoff/ stream) degradation of soil also takes the farm of loss of fertility. The later is currently serious and is worsening. The worry have relates to server socio-economic disruption suffered by rural people whose livelihood depend entirely on the productivity of their soil. Many rural communities in Bida and Gbako local Government are as typify this problem, which is a statewide. Farmers of these communities now migrate every year in search of fertile land into other local Government.

These trends are not all-inclusive, but are meant to high light the current danger man is exposing himself to as result of inappropriate development strategies. The point of note is that this erosion of vital, life support system is likely to continue until human aspiration come into line with relatives of earth capacity and process and civilization thereby becomes sustainable over long term.

Deforestation from over cutting of wood vegetation for fuel wood and timber increased wind speed at ground level facilitating wind erosion and invasion of sand dues, as is characteristic in Northern Nigeria.

CHAPRER TWO

LITERATURE "REVIEW"

2.1 EROSION DISASTER

One of the major environmental problems in the world today is Erosion. Nigeria too is affected by this problem since erosion has become a global issue. Several world conferences on these critical environmental issues have been held in various parts of the world. During the earth summit in 1992 at Riode Janerro in Brazil, most countries including Nigeria took an obligation under agenda 21 to reduce the cross of soil, hold back deserts, save arable land rationally use forest and biological recourse and to use their water resources properly.

Erosion by water is particularly prevalent in the humid, high rainfall areas,. Heavy rainfall results in rapid water run-off. Gully erosion is the more obvious form of soil erosion because of its remarkable visible effects on the landscape. They develop easily in areas of soft bedrock and often rapidly grow into enormous gullies. Areas of spectacular gully erosion in Nigeria is one Anambra, Akwa Ibom, Cross. River, Imo, Plateau, Bauchi, Abia, and Sokoto States. In the Agulu-Nanka areas of Anambra State for instance, over 1000 Hectares of land have been lost to gullies estimated to be expanding at 1% per annum for the least (Ofomata 1991), other consequences associated with gully erosion are the loss of residential houses, farm corps, changes in topography and hydrology of affected areas, disruption of communities lines and loss of sum of money.

The world development report in 1992, indicates that soil erosion may harm productivity by depositing silts in the Dams, irrigation systems and river transport in channels, there by damaging fisheries.

In Africa, according to United Nation Environmental Programme UNEP 1984), in Solau (1993), 6,900 million hectares covering approximately 80% of regions cropland have lost between 25% and 100% of their productive capacity.

Global assessment of soil degradation by United Nation Environmental Programme (UNEP) reveals that 1.2 billion Hactares, about 11% of earth's vegetation surface, have undergone moderate or severe soil degradation as a result of erosion. The problem is significantly greater for developing countries in the tropics than for temperate countries in that rainfall and Agricultural practices naturally promote soil erosion (World Development Report 1992).

Certain forms of environmental problems, although highly localized are associated with high way construction . This phenomenon has been reported by Petters (1993) and include mostly accelerated gully erosion which offten occurs in the course of highway construction wherever drainage is diverted into adjoining lands often with no outlet for water, or where culverts cross the road.

The above forms of land degradation are ambiguities along Nigeria highways, for example the Calabar-Itu highway linking both cross River and Akwa Ibom States.

The world watch institute estimate yearly top soil loss at 25 billion tones roughly the amount that cover Australia's wetlands. In the Nigeria Punch News paper February 2000, a Corps member in minna, Umoh (2000) identifies cause

of environment hazards in the country has been attributed to the negligence and intransitivity of people toward issues that affect their environment. Umoh (2000) therefore, charge Nigerians to imbibe the culture of planting trees and beautifying their environment against hazards and degradation.

In Niger State, around kainji Dam and some parts of River Niger, Silting Occurs and reduces the efficiency of the hydroelectric power supply system by the reduction in quantify for available water for the turbine engines. Silting rises the level of river beds and beds of water reservoirs resulting in use of ground water level, there by resulting to flooding, cases of this occurrence are in Sokoto Rima basin 1996 and also Victoria Island Lagos, during the rainy season of 1995 and 1996 respectively.

In minna, one cannot forget the great flood of 1986 which rendered many people homeless especially those living around keteren Gwari, Angwan kaje and new markets areas of the town while various plots of farm and cattle were destroyed.

On Sunday 18th September, 1999, Nigeria Television Authority (NTA) Minna featured in its "News cope 'flood erosion disaster in Niger State with special reference to Minna and its environment. The NTA Stated that the heavy down poor of rains that lasted for five and seven hours on the 11th and 17th of September 1986 respectively. Among the areas affected mostly are Kpakungu and its environs, Bosso, Tunga and Chanchaga all in Minna. It stated that River Suka bridge was over flooded along Minna western bye pass, residential houses were submerged, farm and properties worth of Millions of Naira destroyed and

lived were lost. It further stated that other areas badly flooded was Tunga, where a body of a three years old girl was recovered from the flood.

In Nigerian Punch Newspaper of January, 2000, the Minister of environment, Alhaji Hassan Adamu described Jalingo, the Traba State capital as a disaster zone because of the menace of gully erosion in the town. He said that the problem of the area is beyond what the State government could handle,. That the gullies in the land orient drainage basin and grown in length from about 25,000 to about 100,000m . lack of urban drainage, un controlled urban use and development and other forms of human inferences cause flood erosion annually of life in most Southern Nigeria cities (Petters 1993). It can be concluded that most flood erosion disaster in Nigeria are man – made. The most notorious cases are the Ogunpa urban flood disaster in Ibadan in 1980 which claimed over 300 lives, and the Bagauda dam burst in 1988 which killed 146 People (NEST 1991).

Another headline on This day 6th March, 2000, flood devastated Mozambique. Mozambique face a new on slaughter of flood water as rain which fell in South Africa high land over flow its banks and flooded Mozambique making most of them homeless, properties worth of millions of dollars destroyed and many lives were lost, also destructive of economic activities and infrastructure.

CHAPTER THREE

DATA AND COMPUTATIONAL METHOD.

3.1 METHOD OF DATA COLLECTION

Streams, Rivers, stream discharge and velocity record with meteorological data consisting of rainfall and evaporation were supplied by Niger State water Board, Bida.

The topography map of Bida was obtained from Niger State Ministry of land and Survey Minna.

Datas colleted from Niger State Water Board Bida include the follwing:-

1. Water gauge height of Lanzun River at Bida from (1973 – 1984)
2. Discharge measurement of Lanzun River at Bida from (1973 – 1984)
3. Monthly rainfall record of Bida from (1980 – 1995)

3.2 METHOD OF DATA ANALYSIS.

There are several methods of synthesis, but the following have been used in this work.

Histogram: This method have been used for both water gauge height and monthly rainfall date colleted, histogram is aimed at depicting the mean annual distribution of water gauge height for the period of twelve years (1973-1984) as well as the means annual distribution of rainfall for the period of fifteen years (1980-1995).

3.3 WATER SURFACE RUN-OFF ESTIMATE.

The run-off of surface water depends on many factors-

1 Duration rainfall and its intensity

2 Storm frequency

3 Amount and type of vegetation cover

4 Probable changes in land use etc.

Having identified the catchments (watershed) areas, terrain and land use, the rational formula is well suited for solving problem of surface run-off of drainage and roads.

The formula is

$Q = 0.278\ C.I.A$

Q = Critical rate of run-off from such unguarded catchments in cubic metre per second ($m^{3+}/5$)

C = Run off coefficient (run-off / rain fall)

I = Average rain fall intensity mm/hr

A = Catchments area (sq/cm) contributing to the run-off.

In view of the assumptive deficiencies of the rational formula, the time concentration of the watershed (catchments areas) has been made at least equal to the duration of rain fall. Since the catchments area is considered small, this formula can be used directly. The time combination of over land flow time and conduits flow time which exist any where is the basin.

3.4 RUN-OFF COEFFICIENT

This is the ration of run-off to that of the rain fall and it is dependent on the following factors.

Rainfall intensity:

The area under study is relatively uniform in character regarding terrain, vegetation and land use.

Table 3.1 Value for urban areas.

Item	Description	C
1.	Flat, residential with 30% of Area impervious	0.40
2	Moderately steep, residential with About 50% of areas impervious.	0.65
3	Moderately steep, built up with about 705 of area impervious	0.80
Since	The description of the site goes with item 2, then C value is 0.66	
	Source : Niger State Ministry of Work and Housing	

3.5 RAIN FALL INTENSITY:

This is the rate of precipitation and is expressed in m/hr.

Generally, it is given as

$$1 = \frac{kn}{(t + a)^{b.}} \text{ mm/hr}$$

where t = the duration ie time elaspsed from the beginning to the end of a period of rainfall of given intensity.

Also $t = 0.019^{L.77} S^{0385mm.}$

L = longest length of water shed (m)

S = slop of the catchments Areas

K = 2.54 (A + B log 10n) A & B are constants for stations with similar rainfall regions

However, autographic rain quage records for Niger State has provided a synthesized peak value of Bida monthly rainfall as

I = 38 2mm/hr.

3.6 DETERMINATION OF VELOCITY OF FLOW (V)

Some of the known methods of determining the velocity of flow includes:

(i) Tracers method.

(ii) Current meter method.

(iii) Manning empirical formula.

The tracer (flat) was adopted because if its simplicity and very practical approach. It involves placing a very light unsoakable material called "flat at a

marked point A, along the flow of storm water. This was done during the rain. The float was observed to travel over a distance AB of 10m. There are two observers and a clock man to start, stop and record time lapsed from the top watch. The following readings were taken flow direction

A----------B

10m

float travel time A to B is

T1 = 12 seconds.

T2 = 11.6 seconds

T3 = 11.70 seconds

T means = 11.77 sconds

V = = L/t = 10/11.77m/hr.

0.85m/s

3.7 WATER GAUGE HEIGHT OF LANZUN RIVER (1973-1984).

River gauge stage in the elevation above some arbitrary zero datum of the water surface at a station (Linsley), Kohiler, Palhus 1982). The datum is some times taken as mean level but more often is slightly behold the point of zero flow in the stream. The simplest way to measure river stage is by means of a staff gauge, as calibrated so that a portion of it immersed in the water at all times. The recording or automatic gauge include the punch type, gauge float type, bubbler gauges crest stage gauge, and water or mercury filled manometer.

Abubakar (1999) estimated the highest value of mean monthly low gauge hights at Minna to be between the month of July and October. The value range between 2 to 3.5m .the lowest value between 0.4-1.2m occur between the month of December and April. This contrast with values of mean monthly gauge height, the highest value occurring between the month of July and September with value ranging between 3.2-5.8. Then lowest values occurs between the months of December to April with records ranging between 1.0 – 1.2m. The Peak occurs between August and September every year. Low flows occur mostly in March and April. This observation equally applicable to Bida since the two towns lay under the same climatic zone, though the observation and conforms with the rainfall pattern.

CHAPTER FOUR

METHOD OF DATA ANALYSIS AND DISCUSION OF RESULT

There are several methods of Data synthesis but the following have been used in this work.

4.1 ESTIMATE BY THE USE OF DURATION CURVE:

Discharge measurement value of Lanzun river at Bida were used, this is to depict the percentage of occurrence of flood erosion within the year of study (1973-1984)

4.2 ESTIMATE OF WATER BALANCING RIVER BASIN USING THE RELATION.

$R = P - PET.$

Where R = runoff into river

P =precipitation

PET = potential evapo transpiration

In order to determine the amount of water balance in any particular river basin, the amount of run off into the river basin have to be estimated or computed for us to achieve this relation simply given by

$R = P - PET$ as indicated

The mean monthy values for both P and PET as computed by Aremu for Minna for the period of ten years (1980-1990) will be used.

Mean monthly rain fall with corresponding mean monthly potential everpotranspiration of Bida (1980-1995)mm.

FLOW DURATION CURVE OF LANZUN RIVER AT BIDA.

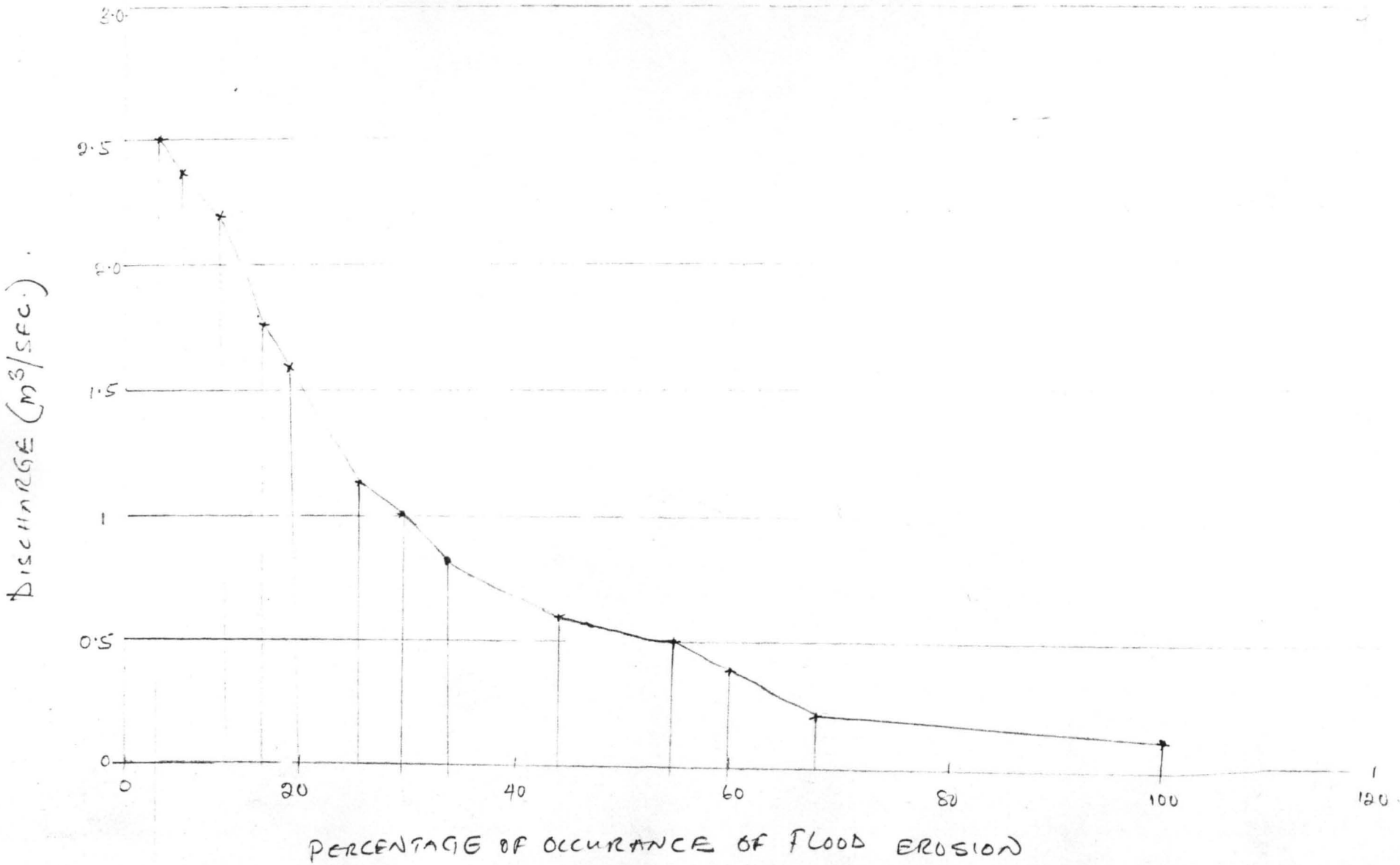


Fig. 4.2

YEAR RAIN-FALL	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1980-90	1.2	0.0	14.5	39.9	109.2	157.1	204.0	266.2	195.9	86.1	27.3	0.0	1104.4
PET 1980-'90	153.0	155.1	159.9	153.9	144.5	108.7	101.8	99.93	102.11	117.44	110.88	95.40	1502.75

SOURCE: Niger State Water Board.

4.3 ESTIMATE OF FLOW INDEX (K) USING THE RELATION.

$Km = \frac{Qm}{Qy}$ = monthly flow Co-efficient of flow index

Qm = mean monthly discharge

Qy = mean annual discharge.

The final result have been use to

1. Plot the flow hydrography
2. To determine the like hood

$K = {}^{1}/m = Km$

Where m = 12 (month of the year).

4.4 ESTIMATE ON RIVER STEADINESS

The average flow velocity (v) using the relation

$V = C\sqrt{RS^2}$ m^{sec-1}

Where V = average velocity flow

R = Hydraulic radius

$\frac{\text{Width}}{2}$ & $\frac{\text{depth}}{2}$ 2

S = gradient $\frac{(Q_2 - Q_1}{D_2 - d_1}$

$C = {}^1/n,$ $R = {}^1/6$

N = roughness factor (we assumed this to be one (1) for Lanzun River there is no catarachs.

In the Estimating the river steadiness of Lanzun river one has to determine the average flow velocity (v) using the relation given.

$V = \sqrt{CRS}$ m^{sec-1}

Where R = 2.49m

C = 1.16m

S = 27 Computed from the available data.

In substituting the variable in the above formula

$V = 9.51\ m^{sec-1}$

4.5 MOVING AVERAGE CURVE.

Fig . 3.1 shows the moving average curve for Bida.

The monthly rainfall records (mm) in the Appendix (1)

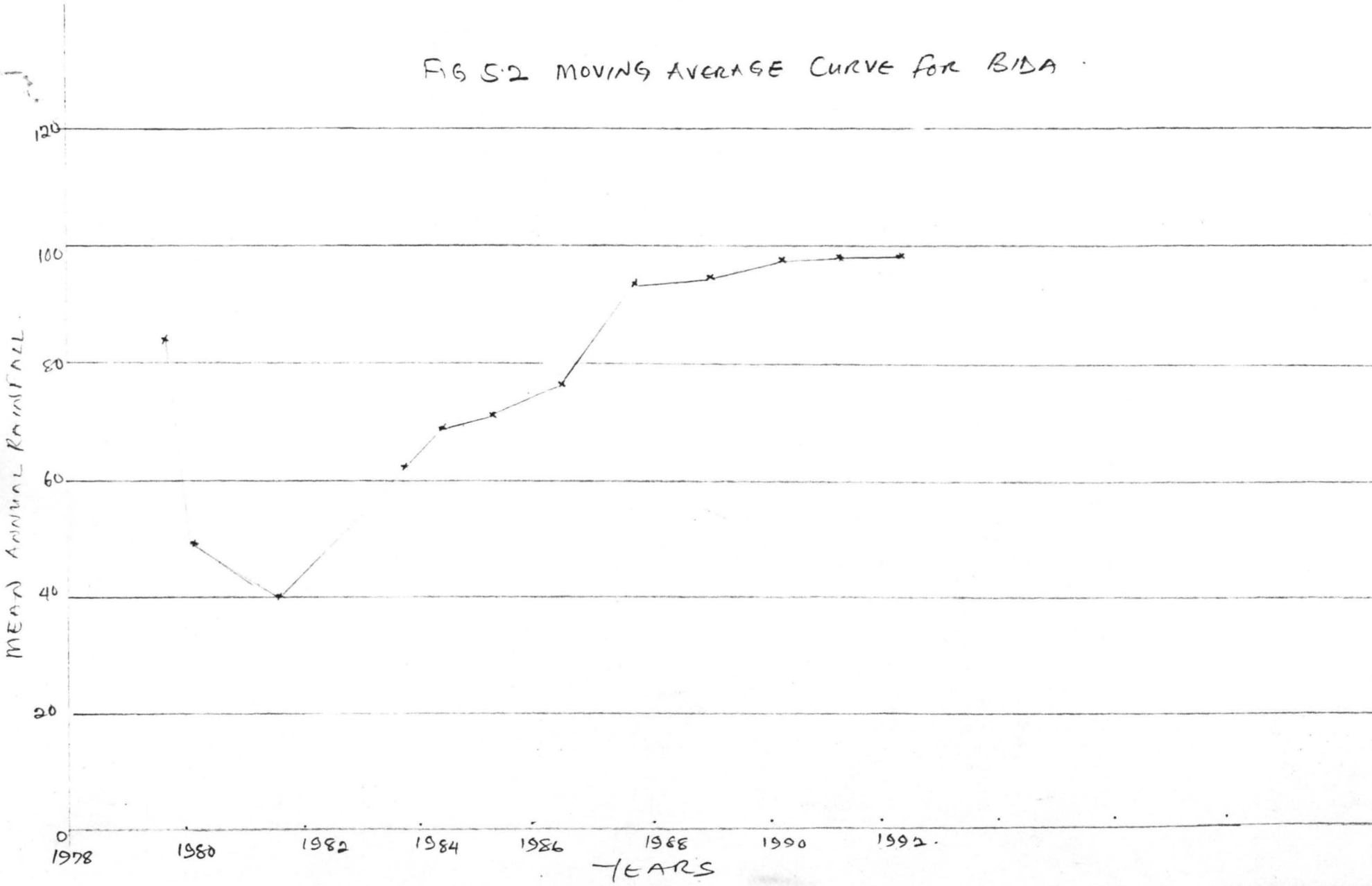
Were used for the moving average or moving mean curve. In the process the yearly average rainfall of Bida was plotted in bar graph fashion as shown in fig. 5.2. Such a bar graph does not indicate clearly any trends or cyclic patterns in the rainfall due to abrupt variations in individual years . In order to suppress these and in order to bring forth the general trend of the rainfall, the averages of three consecutive years were found out progressively and then plotted as shown in the figure.

4.6 FLOW HYDROGRAPH.

The results which detail computation as shown in Appendix (v) were used in plotting the flow hydrograph (fig. 5.2.). The flow hydrograph has values of flow index (k) plotted against months. An inspection of the flow hydrograph shows that it may be considered to consist of three parts, the concentration curve, or rising limb, the crest segment and the recession or falling limb.

The concentration curve is a function of the time area histogram of the basin and of the duration and uniformity of the rain. The rising limb is seen to be concave upward rising slowly in the early stage of the flow event and more rapidly towards the end of the rise. This tendency could be strengthened by the fact that the portion of the rainfall which is taken up by infiltration, interception

FIG 5.2 MOVING AVERAGE CURVE FOR BIDA.



and surface detention is greater in early stage of a storm, hence uniform rates of rainfall generally mean steadily increasing rate of flow.

The peak is the highest instantaneous value of the flow hydrograph but the peak extend from the point on the falling side. The peak summer as observed in the flow hydrograph was in the month of August, it occurs when the aggregate contribution is at maximum.

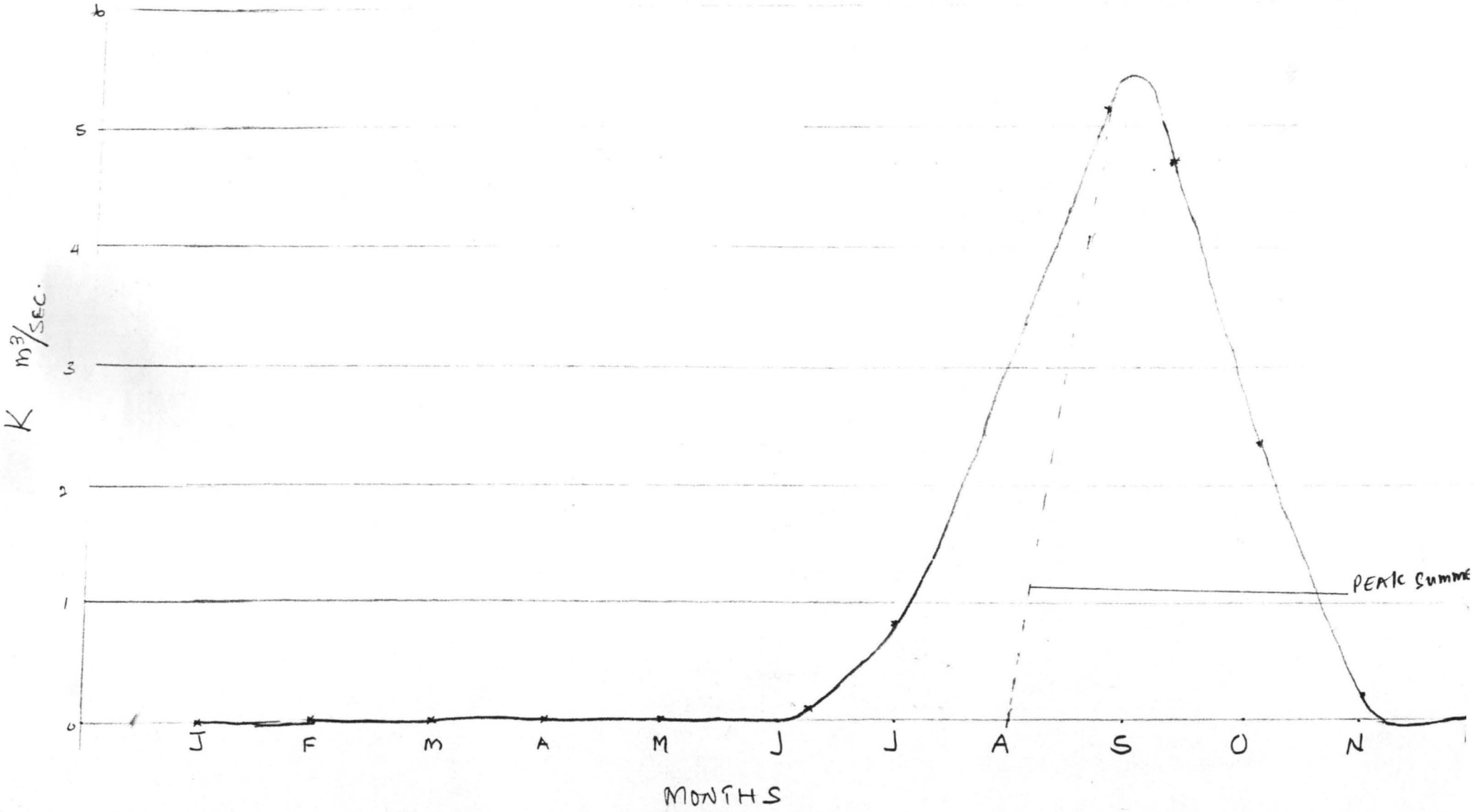
The recession curve or falling side in the figure represent withdrawal of flow, the limb is independent of time variations in rainfall or infiltration and is occasionally dependent on the physical features of the channel alone.

The flow hydrograph, however, gives a general pattern of tropical river with peak summer in August. The final result obtained in Appendix (v) was to determine the likelihood of flood erosion occurrence, and from the calculation the value of Km > K which imply that flood is likely, for say ten or more years.

In considering the force of the flowing water alone its exerting impact and a dragging action upon the bed, can erode poorly consolidated alluvial materials such as gravels, sand, silt, and clay. A river with flow velocity of 9.51 m/sec. In 1970 was therefore expected to be turbid with suspended load boulders of great size may be moving over the river bed since the river gradient was steep.The hydraulic water on unconsolidated material in a short time which could result into channel deepening and undermining of the banks causes huge masses of alluvian to slump.

If these process could take place in 1970, then must expect the bed to have been built up by large amounts of bed –loaded supplied to the river during

FIG 5:3 FLOW HYDROGRAPH FOR LANZUN RIVER AT BIDA



the first phased of heavy run-off, hence, the hydraulic radius R might have been reduced to less than 2 metres in 1986.

The graph (fig.5.5) shows the average gauge height for Lanzun River at Bida for each month. The graph reveals the variation in the regime of the river between the summer high level and the winter low level.

CHAPTER FIVE

5.1 SUMMARY

The analysis of this work gives a statistical picture of the variation of the rainfall pattern flow hydrograph as well as the magnitude of flood erosion frequency, on a climatological basin over Bida, Niger State. These parameters were calculated from meteorological records of rainfall as well as the discharge measurements and gauge height level supplied by the Niger State water board, area office Bida. A strong correlation were found between the seasonal variations of rain fall pattern for one year and the next.

The flow hydrograph shows a general pattern of tropical rivers characterized by a gradual rise towards July and reached its peak summary in August but with a gradual fall in September dictating rainfall cessation. The frequency analysis shows no variation in both excedence interval and return period respectively but with little variation in reoccurrence interval of the flood.

5.2 CONCLUSION

This work was to investigate the possible ways of providing a solution to the destruction to effects of erosion in Bida Niger State by looking into the causes of erosion, its variable frequency and the preventive measure to be taken as to avoid damages from erosion.

Generally, soil erosion is been caused due to hydraulic forces of water and human activities (interference). But one have to be wondered that in spite

the fact that Bida has only a single River (langun) that passes through the town yet erosion is pronounced in some part of the town. Actually, the data of erosion flood characteristics are insufficient therefore the work in gathering all the required data and analyzing countless alternative in order to come up with an accurate and satisfactory results of the causes magnitude of the frequencies of erosion in Bida were extremely difficult, hence the results of the analysis were not hundred percent accurate.

5.3 RECOMMENDATION

The need to arrest the wasteful trend in soil erosion loss has been widely recognized and various soil conservation measures have to be take at various levels to deal with the problems.

In order to reduce the frequency and magnitude of erosion in Bida, Niger State with particular study of Masaga environs with Lanzun River, erosion control measures would be recommended. However, this measure strive to reduce the frequency and the magnitude of erosion damages, but cannot eliminate the residual hazard from rare events. The following recomendations become handy to avoid menacing effect of erosion in Bida.

Two broad measure of controls: curative and preventive measures. On the curative side the lines of action depends mostly on the type of erosion involved and the attempt has always been to prevent as much as possible from reaching the areas e.g gullies, wind, sheet and rill erosion.

5.4 CHANNEL IMPROVEMENT.

This method improves or increase the capacity of waterway. The erosion of channel improvement is to increase the conveyance capacity so that high discharges are passed without the level of water surface being raised to dangerous height. The increased capacity brought by clearing, snags, trash, accumulated materials, needs from the channel has a relatively low first cost, but high maintenance cost because it must be periodically repeated for a more permanent improvement is replacing the natural channel with larger pris-matic channel on straighter alignment.

5.5 CONCRETE STRNCTURES AND DRANAGES

These structures can be culverts, bridges, concrete line drains, dykes. The line drain should be open drain for easy access of water passage and clearing of sediments.

The purpose of the structures is to collect, discharge and control the movement of storm water during the raining season to the basin of the study area.

The provision of this facilities should be adequately design non-audible roadway drainage channel on the pattern of flow of runoff during the raining season and the design should be deep enough to accommodate the velocity flood and covert, and Bridges should be wide enough with head room to allow easy passage.

Provision of the open line drain will be=

(i) Prevent erosion-flood damage

(ii) Provide access to residents at more locating along its lengths.

(iii) Improve sanitation and accentuate the aesthetic of the area

(iv) Increase hydraulic capacity.

5.6 PROVISION OF STONE PITCHING AND EDGE KERBING

5.6.1 STONE PITCHING

As apart of the permanent work to support the bridge embankment of high fill. This becomes necessary so as to prevent erosion reoccurrence of the sides.

Stone-pitching proves a hard non-erodible and non permeable surface for water to be taken right into the drain as well as ensuring that the soil is protected from cracking and shearing under its own weight.

5.6.2 EDGE KERBING

During the rains, cambered surface of the carriageway ensures that water is drained from the pavement to the shoulders. If not confined the water would drain at any available section of the shoulders. The function of the kerbs is to properly direct the run-off towards the drain at specific points called the off-shoot drain.

5.7 ENGINEEING METHODS OF LAND USE TREATMENT.

These measures will attempt to decrease run-off by increasing infiltration and could be achieved by contour cultivation or ploughing, land leveling and corps residue use on crops land : bush control, range seeding and farm pond on pastureland and tree management, afforest ration and fire control of forest land.

In addition to reduce erosion peak, land treatment will also reduce erosion damage by reducing the sediment content of the water. Land treatment functions by increasing soil moisture storage capacity and delaying over land flow to reduce direct run-off while increasing inter flow and base flow.

5.7.1 BIOLOGICAL METHOD

Biological method which is the use of organisms primarily rather than tools and mechanical equipments by the manipulation of domesticated plants. Only sloping grounds, strip cropping the (alternative of grain in other crops that give little soil protection with strip of close ground leaf or grass sod) is used. This method can be combined with terracing or contour cultivation. Shelterbelts are useful where wind erosion is serious. This consist of planting of shrubs and trees in wind breaking barriers along wind ward edge of crop lands.

The use of natural vegetation and ground litter to break the force of rain and reduce impact on bare soil is vital. Crop litter residue on ground surfaces can be kept instead of turning under plunghing. Mulching can be done to cover soil and manure and other organic waste can be used to reduce soil erosion by improving the structure of the soil.

5.7.2 GRASSING

Grass, apart from its pleasant appearance, is necessary on verges and embankment to prevent erosion. Thick carpet of grass binds the earth together and its being washed away. It also absolve moisture from the earth and helps to stabilize it.

To be suitable for their purpose, roadside grasses must be deep-rooted and must spread rapidly for a closely-knit carpet most not grow too tall and must resist several months of drought. The ideal types, which can be answerable to this requirement in Nigeria today, are the dhub and bahama grasses. They grow on virtually any type of soil but preferably top soil and are batter grown at the beginning of the rain.

5.8 PREVENTIVE MEASTURES.

Where the incidence of erosion is either not known or not serious a number of measures are taken in addition to the above simple curative measures to check the inception of soil erosion. These measures include limitation of the extent of forest degradation by evolving system of cultivation, which will always ensure that the ground is under effective cover of vegetation. Controlling the and timing of bush burning, adaptation of contour ploughing.

Introduction of inter and multiple cropping and effective use of cover crops, zoning and controlling the use of pasture. Other control measures are enlightenment programme and environmental education.

The provision of grazing reserves for animals as well as water supply and control is also important for soil conservation.

The use of available energy source can be controlled by reforestation through the use of solar energy and wind energy, biogas and energy conservation (by way of establishing law on the exploitation of forest and on the use of woody plants valued of firewood or charcoal.

Generally, all these suggested controls are all very vital and they are in some ways inter-related. For instance, the cultivation of and their management would reduce evaporation losses, prevent or minimize soil erosion by wind and water and provide alternative sources of energy e.g. biogas.

The problem created at the river Lanzun has been traced to human activities and hydraulic forces of water. Hence the problem is not of the engineering alone but of the environment. Furthermore, before any such construction is embark upon the environmental impact assessment and monitoring team should be informed for assessment before the project take off.

It is hoped that the recommendation or suggestion would be enforced to make or better the environment for our generation and for generation to come.

APPENDIX 1

MONTHLY RAINFALL RECORD (mm)

STATION - MUBIA

LAT - $9^{0}.37^{1}$

LONG - $6^{0}.32^{1}$

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL	MEAN
1978				4·7	122·6	138·6	282·4	310·3	393·4	94·7			1356·4	113·03
1979			17·4	180·6	218·2	69·3	201·7	367·5	196·6	78·7			1317·0	109·75
1980						118·3		127·8	18·6	78·1			419·8	34·56
1981				7·8		137·2							145	12·08
1982													968·4	75·67
1983				171·1	21·32	132·0	241·7	152·9	231·2	152·9			1044·9	87·52
1984					70·4	73·47	140·7	213·9	178·0	37·2			713·67	59·47
1985			3·0	54·6	81·2	114·8	24·8	185·6	148·1	73·3			884·1	72·71
1986			61·2	17·3	141·7	250·6	233·3	298·7	176·6	61·0			1320·4	99·28
1987			39·6	15·4	86·0	183·8	121·7	243·0	315·8	83·8	17·6		1106·7	100·68
1988			13·50	111·0	101·30	83·90	143·70	238·5	94·60	100·10			885·4	72·78
1989	8·0		38·0	121·0	81·50	132·0	218·3	350·1	103·6	33·10			1115·5	119·63
1990			5·0	19·5	165·5	316·0	193·7	248·7	202·0	79·0			1257·9	104·75

APPENDIX 3a

RIVER NAME LANZUN — STATION NAME M

CODE NO — CATCHMENT AREA 58

AGENCY NIGER STATE UNDER BOARD — STATE NIGER

LATITUDE - - - - - - — LONGITUDE - - - -

GAUGE HEIGHT LEVEL 1986

Date	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1	15·61	15·61	15·03	14·53	14·07	13·73	13·92	15·52	16·17	16·29		16·03
2	15·60	15·60	15·03	14·52	14·03	13·72	13·92	15·67	16·24	16·29		16·04
3	15·66	15·60	15·01	14·51	14·01	13·71	13·9[illegible]	[illegible]·75	16·23	16·28		16·05
4	15·65	15·59	15·00	14·50	13·99	13·70	13·95	15·88	16·21	16·28		16·06
5	15·64	15·59	14·98	14·49	13·98	13·71	13·97	15·95	16·27	16·27	16·00	16·06
6	15·61	15·58	14·96	14·48	13·96	13·70	13·99	16·04	16·28	16·24	15·98	16·05
7	15·64	15·58	14·95	14·47	13·94	13·71	13·02	16·08	16·27	16·25	15·95	16·04
8	15·65	15·57	14·93	14·46	13·95	13·72	14·03	16·10	16·29	16·24	15·92	16·03
9	15·65	15·56	14·92	14·45	13·94	13·73	14·04	16·09	16·29	16·22	15·90	16·02
10	15·65	15·55	14·91	14·44	13·93	13·74	14·05	16·08	16·29	16·22	15·87	16·01
11		15·53	14·81	14·43	13·9[illegible]	13·75	14·08	16·07	16·28	16·21	15·85	16·01
12	15·66	15·52	14·89	14·42	13·91	13·76	14·10	16·06	16·[illegible]	[illegible]	15·83	16·01
13	15·66	15·51	14·87	14·41	13·90	13·77	14·12	16·07	16·25	16·19	15·81	16·01
14	15·66	15·49	14·86	[illegible]	13·89	13·76	14·15	16·06	16·24	16·18	15·78	16·01
15	15·66	15·45	14·85	[illegible]	13·88	13·77	14·17	16·06	16·23	16·15	15·77	16·01
16	16·65	15·48	14·84	14·38	13·87	13·80	14·19	16·06	16·22	16·14	15·76	16·01
17	15·65	15·47	14·83	14·37	13·86	13·81	14·21	16·05	16·21	16·13	15·76	16·01
18	15·66	15·46	14·82	14·36	13·85	13·80	14·23	16·04	16·20	16·12	15·74	16·01
19	15·01	15·45	14·81	14·35	13·84	13·77	14·27	16·06	16·21	16·11	15·73	16·01
20	15·64	15·44	14·80	14·32	13·82	13·77	14·30	16·06	16·20	16·10	15·[illegible]	16·01
21	15·64	15·43	14·79	14·31	13·83	13·81	14·32	16·07	16·19	16·09	15·71	16·01
22	15·63	15·40	14·78	14·30	13·82	13·82	14·34	16·06	16·18	16·08	15·80	16·01
23	15·63	15·38	14·77	14·28	13·81	13·84	14·38	16·06	16·17	16·08	15·79	16·01
24	15·64	15·37	14·76	14·23	13·80	13·84	14·40	16·06	16·19	16·07	15·73	16·01
25	15·63	15·35	14·75	14·21	13·79	13·85	14·42	16·07	16·24	16·07	15·72	16·01
26	15·63	15·32	14·74	14·19	13·78	13·81	14·41	16·08	16·28	16·05	15·72	16·01
27	15·62	15·30	14·73	14·15	13·79	13·83	14·41	16·08	16·25	16·04	15·71	15·99
28	15·62	15·30	14·72	14·13	13·78	13·89	14·45	16·07	16·27	16·04	15·70	15·99
29	15·61	15·29	14·71	14·11	13·76	13·90	14·45	16·10	16·29	16·03	15·70	15·98
30	15·61		14·70	14·09	13·75	13·91	14·50	16·13	16·30	16·02	15·70	15·98
31	15·60		14·69		13·74		14·53	16·13		16·02		15·97
MAXIMUM	15·66	15·48	14·92	14·30	13·88	13·90	14·16	16·02	16·03	16·15	15·78	16·01
MEAN	15·67	15·61	15·05	14·53	14·07	13·91	14·53	16·13	16·3	16·29	16·00	16·06
MINIMUM	15·60	15·37	14·69	14·09	13·74	13·70	13·92	15·52	16·17	16·02	15·57	15·97

ANNUAL STATISTIC

MEAN 15·98 MAX 16·89 MIN 13·70

APPENDIX 3C

AGENCY WATER BOARD STATE NIGER

LATITUDE - - - - - - LONGITUDE - - - - - -

GAUGE HEIGHT LEVEL 1998

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	13·35	12·85	12·40	11·98	11·82	11·55	11·99	12·95	15·01	15·15	14·91	14·43
2	13·33	12·83	12·39	11·93	11·79	11·59	11·98	12·95	15·09	15·13	14·91	14·38
3	13·22	12·81	12·37	11·90	11·77	11·66	11·97	12·95	15·10	15·11	14·90	14·31
4	13·31	12·79	12·35	11·88	11·73	11·70	11·96	12·96	15·11	15·09	14·89	14·27
5	13·29	12·78	12·34	11·86	11·70	-	11·94	12·96	15·10	15·07	14·88	14·21
6	13·28	12·76	12·32	11·83	11·66	-	11·94	12·95	15·11	15·04	14·88	14·16
7	13·26	12·75	12·31	11·81	11·63	12·12	11·94	12·95	15·16	15·00	14·87	14·11
8	13·25	12·72	12·30	11·79	11·60	12·13	11·93	12·95	15·16	14·97	14·87	14·05
9	13·24	12·72	12·29	11·77	11·66	12·12	11·93	13·01	15·18	14·94	14·87	14·00
10	13·23	12·71	12·28	11·74	11·53	12·12	11·94	13·04	15·20	14·91	14·86	13·94
11	13·22	12·69	12·27	11·72	11·30	12·11	12·01	13·10	15·22	14·94	14·85	13·90
12	13·22	12·68	12·26	11·70	11·48	12·11	12·05	13·12	15·25	14·94	14·84	13·87
13	13·21	12·65	12·26	11·68	11·46	12·10	12·26	13·17	15·25	14·94	14·83	13·81
14	13·21	12·64	12·25	11·66	11·42	12·10	12·27	13·24	15·25	14·94	14·81	13·78
15	13·20	12·62	12·23	11·64	11·37	12·10	12·27	13·21	15·26	14·94	14·79	13·76
16	13·18	12·60	12·21	11·62	11·32	12·08	12·51	13·22	15·29	14·95	14·78	13·73
17	13·16	12·59	12·20	12·01	12·30	12·06	12·66	13·26	15·25	14·95	14·77	13·69
18	13·14	12·57	12·19	11·91	11·23	12·04	12·59	13·26	15·20	14·96	14·75	13·65
19	13·11	12·56	12·18	11·96	11·31	12·04	12·64	13·28	15·20	14·96	14·74	13·63
20	13·06	12·53	12·17	11·96	11·28	12·04	12·64	13·91	15·22	14·96	14·73	13·59
21	12·16	12·51	12·16	11·92	11·26	12·03	13·63	13·96	15·21	14·97	14·72	13·57
22	13·07	12·49	12·15	11·89	11·24	12·01	12·61	13·97	16·19	14·95	14·70	13·54
23	12·95	12·47	12·15	11·87	11·26	12·01	12·61	14·01	15·21	14·93	14·68	13·52
24	12·91	12·45	12·15	11·84	11·21	11·99	12·65	14·08	15·23	14·93	14·64	13·51
25	12·93	12·44	12·14	11·82	11·19	11·98	12·76	14·22	15·25	14·93	14·64	13·48
26	12·92	12·43	12·13	11·20	11·18	11·97	12·76	14·27	15·23	14·93	14·61	13·46
27	12·90	12·42	12·12	11·68	11·15	11·95	12·77	14·42	15·20	14·93	14·57	13·42
28	12·89	12·74	12·11	11·86	11·14	12·00	12·78	14·50	15·18	14·93	14·54	13·41
29	12·88	-	12·09	11·85	11·15	12·02	12·82	14·56	15·17	14·93	14·51	13·39
30	12·87	-	12·05	11·84	11·51	12·03	12·86	14·63	15·16	14·93	14·47	13·37
31	12·86	-	12·01	-	11·52	-	12·86	14·75	-	14·93	-	13·36
MEAN	13·11	12·63	12·21	11·85	11·44	11·19	12·37	13·62	15·19	14·93	14·76	13·79
MAX	13·36	12·85	12·40	12·08	11·82	12·13	12·86	14·75	16·22	15·15	14·91	14·61
MIN	12·86	12·42	12·01	11·62	11·14	11·55	11·93	12·95	15·01	14·92	14·47	13·36

ANNUAL STATISTIC

MEAN 13·09 MAX 15·29 MIN 11·14

Appendix 3e(

RIVER NAME LANZUN — STATION NAME _ M' INNIA.

CODE NO — CATCHMENT AREA 58.04 KM²

AGENCY NIGER STATE NIGER BASIN BOARD — STATE _ NIGER _.

LATITUDE _ _ _ _ _ — LONGITUDE _ _ _ _ _.

GAUGE HEIGHT LEVEL 1988

Date	JAN	FEB	MAR	APR.	MAY	JUN	JUL.	AUG	SEPT	OCT	NOV	DEC
1	15·67	15·61	15·09	14·53	14·07	13·73	13·92	15·52	16·17	16·29		16·03
2	15·66	15·60	15·03	14·50	14·03	13·72	13·90	15·67	16·24	16·29		16·04
3	15·66	15·60	15·01	14·51	14·01	13·71	13·92	·75	16·23	16·28		16·05
4	15·65	15·59	15·00	14·50	13·99	13·70	13·95	15·88	16·21	16·29		16·06
5	15·64	15·59	14·98	14·49	13·98	13·71	13·97	15·95	16·27	16·27	16·00	16·06
6	15·64	15·58	14·96	14·48	13·96	13·70	13·99	16·04	16·28	16·26	15·98	16·05
7	15·64	15·58	14·95	14·47	13·94	13·71	14·02	16·08	16·27	16·25	15·95	16·04
8	15·65	15·57	14·93	14·46	13·95	13·73	14·03	16·10	16·29	16·24	15·93	16·03
9	15·65	15·56	14·92	14·45	13·94	13·73	14·04	16·09	16·29	16·22	15·90	16·02
10	15·65	15·55	14·91	14·44	13·93	13·74	14·05	16·08	16·27	16·22	15·87	16·01
11		15·53	14·89	14·42	13·9	·75	14·06	16·07	16·28	16·21	15·85	16·0
12	15·60	15·52	14·88	14·42	13·91	13·76	14·10	16·06	16·2	·1	15·80	16·01
13	15·66	15·51	14·87	14·41	13·90	13·77	14·13	16·07	16·25	16·19	15·81	16·01
14	15·66	15·49	14·86	14·3	13·89	13·78	14·16	16·06	16·24	16·18	15·78	16·01
15	15·66	15·48	14·8	·29	13·88	13·77	14·17	16·06	16·23	16·15	15·77	16·01
16	16·65	15·48	14·84	14·28	13·87	13·80	14·19	16·05	16·22	16·14	15·76	16·01
17	15·65	15·47	14·83	14·27	13·86	13·81	14·21	16·05	16·21	16·13	15·76	16·01
18	15·66	15·46	14·82	14·26	13·85	13·80	14·22	16·03	16·20	16·13	15·74	16·01
19	15·64	15·45	14·81	14·25	13·84	13·77	14·27	16·00	16·24	16·11	15·73	16·01
20	15·64	15·44	14·80	14·32	13·82	13·79	14·30	16·06	16·20	16·10	15··	16·01
21	15·64	15·43	14·79	14·31	13·83	13·81	14·32	16·07	16·19	16·09	15·71	16·01
22	15·63	15·40	14·78	14·30	13·82	13·82	14·31	16·06	16·18	16·08	15·80	16·01
23	15·63	15·38	14·77	14·29	13·81	13·81	14·38	16·06	16·17	16·08	15·79	16·01
24	15·64	15·37	14·76	14·28	13·80	13·69	14·40	16·06	16·19	16·07	15·73	16·01
25	15·63	15·25	14·75	14·21	13·79	13·85	14·42	16·07	16·24	16·07	15·77	16·01
26	15·63	15·32	14·74	14·19	13·78	13·84	14·41	16·09	16·23	16·05	15·72	16·01
27	15·62	15·31	14·73	14·15	13·79	13·83	14·41	16·08	16·25	16·04	15·71	15·99
28	15·62	15·30	14·72	14·13	13·78	13·89	14·45	16·09	16·27	·04	15·70	15·99
29	15·61	15·29	14·71	14·11	13·76	13·90	14·40	16·10	16·29	16·03	15·70	15·98
30	15·61		14·70	14·09	13·75	13·91	14·50	16·12	16·20	16·02	15·70	15·98
31	15·60		14·69		13·74		14·53	16·13		·02		15·97
MAXIMUM	15·14	15·48	14·92	14·30	13·88	13·70	13·16	16·02	17·03	16·13	13·75	16·01
MEAN	15·67	15·61	15·05	14·53	14·07	13·91	14·53	16·13	16·3	16·29	16·00	16·06
MIN	15·65	15·37	14·69	14·09	13·74	13·70	13·92	15·52	16·17	16·02	15·57	16·02

ANNUAL STATISTIC

MEAN 15·88 MAX 16·29 MIN 13·70

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APPENDIX 3b

AGENCY NIGER BASIN STATE NIGER

LATITUDE ---------- LONGITUDE ----------

GAUGE HEIGHT LEVEL 1987

Date	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	13·62	13·19	13·76	14·69	14·25	13·82	14·52	14·65	15·12	14·18	14·37	14·14
2	13·61	13·17	13·74	14·68	14·24	13·81	14·51	14·67	16·10	14·17	14·37	14·12
3	13·60	13·16	13·74	14·67	14·23	13·80	14·51	14·77	15·08	14·16	14·31	14·10
4	13·59	13·14	13·73	14·66	14·22	13·79	14·50	14·76	16·07	14·15	14·36	14·08
5	13·58	13·13	13·72	14·65	14·21	13·78	14·50	14·75	16·06	14·14	14·34	14·07
6	13·57	13·11	13·66	14·63	14·19	14·04	14·52	14·85	15·01	14·14	14·39	14·04
7	12·56	13·10	13·17	14·69	14·17	14·10	14·54	14·84	15·03	14·15	14·33	14·01
8	13·55	13·09	13·66	14·62	14·16	14·15	14·54	14·87	15·01	14·16	14·03	13·08
9	13·51	13·08	13·65	14·61	14·14	14·19	14·52	14·91	15·01	14·25	14·32	13·98
10	13·53	13·07	13·59	14·51	14·14	14·25	14·50	14·91	15·00	14·38	14·32	13·96
11	13·51	13·07	13·55	14·58	14·10	14·28	14·48	14·90	14·78	14·32	14·31	13·94
12	13·47	13·06	13·51	14·57	14·09	14·31	14·66	14·90	14·95	14·36	14·31	13·94
13	13·47	13·06	13·47	14·56	14·07	14·35	14·45	14·90	14·92	14·37	14·30	13·88
14	13·45	13·05	13·43	14·55	14·04	14·32	14·45	14·91	14·89	14·37	14·30	13·87
15	13·43	13·05	13·31	14·51	14·04	14·31	14·46	14·91	14·87	14·37	14·29	13·86
16	13·40	13·02	13·37	14·53	14·02	14·40	14·45	14·92	14·81	14·38	14·28	13·84
17	13·38	13·01	13·35	14·52	13·99	14·42	14·43	14·92	14·79	14·38	14·27	13·82
18	13·36	12·98	13·33	14·51	13·98	14·44	14·42	14·96	14·71	14·39	14·26	13·81
19	13·35	12·95	13·32	14·50	13·96	14·47	14·40	14·97	14·70	14·39	14·25	13·79
20	13·34	12·92	13·31	14·49	13·93	14·49	14·40	15·04	14·61	14·39	14·24	13·78
21	13·33	12·91	13·30	14·48	13·89	14·50	14·40	15·15	14·51	14·40	14·23	13·76
22	13·32	12·90	13·28	14·47	13·86	14·51	14·41	15·26	14·50	14·40	14·22	13·74
23	13·31	12·89	13·27	14·46	13·84	14·53	14·42	15·31	14·47	14·40	14·20	13·72
24	13·30	12·87	13·25	14·43	13·82	14·53	14·44	15·47	14·44	14·40	14·19	13·70
25	13·29	12·86	13·23	14·41	13·80	14·54	14·44	15·59	14·41	14·40	14·18	13·68
26	13·26	12·86	13·21	14·38	13·86	14·57	14·51	15·75	14·36	14·39	14·17	13·66
27	13·27	12·83	13·19	14·36	13·79	14·55	14·50	15·92	14·30	14·39	14·17	13·66
28	13·21	12·81	13·17	14·33	13·79	14·54	14·60	15·99	14·25	14·38	14·16	13·64
29	13·24	12·79	13·15	14·31	13·79	14·53	14·60	16·04	14·21	14·37	14·15	13·63
30	13·22		13·13	14·28	13·78	14·52	14·63	16·10	14·18	14·37	14·15	13·62
31												

MEAN 13·97 MAX 16·10 MIN 12·06