ENVIRONMENTAL EVALUATION ASSESSMENT OF RIVER GURARA (AT IZOM) FOR IRRIGATION PURPOSES

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CERTIFICATION

I hereby certify that this project was carried out by Bashir Ahmad Abdul PGD/AGRIC/70/98/99 and has been prepared in accordance with the regulations governing the preparation and presentation of project in the Federal University of Technology, Minna..

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DEDICATION

This project work is dedicated to my parents, wife, children, brother, sisters and friends.

ACKNOWLEDGMENT

The preparation of this work hd depended largely on the good will and untiring effort of a large number of people. To all of them, many of whom I cannot for reasons of time and space be singled out. I wish to express my very sincere appreciation. In particular, I have to register my profound gratitude to my versatile supervisor, for his untiring effort and guidance to me during the period of writing this dissertation until its completion, his willingness to offer good advice and assitance at these times is greatly appreciated, as well as all the staff of Department of Agricultural Enginering Federal University of Technology, Minna for their constructive criticism, advice and sophisticated knowledge they imparted in me. In addition, I wish to acknowledge the support received from (HOD) Dr. M.G. Yisa, Dr. D. Adgidzi a senior lecturer in the department, Engr. Ayodeji, Engr. Chukwu, Mr. Alabadan, Mrs. Osunde, and all my departmental colleagues who have offered useful suggestion and ideas. The Co-operation received from Kaduna Polytechnic staff particularly Agricultural Department and government functionaries at the local, state and federal level who sparred time for their busy schedule to discuss with me on various aspects is also acknowledge.

I wish to mention the hospitality received during the cause of this project from the family of Late Alhaji Suleiman Liman, may his gentle soul rest in perfect peace amen. I will not fail to mention my brothers, sisters, friends and uncles who took the ressponsibility of guiding me both financially and morally.

The patient, tolerance and moral advice received from my wife and children, as well as my parents who through constant advice, prayer, financial and moral back are also acknowledge.

Above all, thank be to ALLAH, with whom I always seek protection and WHO has always been my guidance throughout my life. And may HE continue to guide us into a straight path (Amen).

ABSTRACT

This study was carried to assess the quality of River Gurara for dry season farming at Izom Niger State. The river water and soil along the bank were analysed and found to be of good quality for irrigation. The classification was found to be C1S1 salinity hazard to be very low, SAR = 0.03, Exchangable Sodium Percentage (ESP), and Residual Sodium Carbonate (RSC), was negligible, pH = 6.5, Na = 0.04 (soil), Na=0.3 (River) and, Cl-$^{-1}$1=11mg/l]. However, application of calcium (Ca) and Nitrogen (n) fertilizer are required to improve the structure. Sources of the river water pollution where also identified and it is recommended that the NNPC be mandated to treat their pollutants before being discharged to the river.

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CHAPTER ONE

1.0 INTRODUCTION

There is no doubt that water is an important natural resource of any country. The role of water in agriculture, industries and domestic activities cannot be over emphasised. It is little wonder then that water is regarded as life and no water no life. A sustainable use of the natural resources calls for appropriate methods to collect base line information to assess environmental problem associated with the natural resources.

Nigeria which is the biggest and fastest developing country in Africa show that more problems have been created through a myriads of development project because Environmental Evaluation Assessment (EEA) appraisal were not made while poor programme may be associated with inadequate data input, which could have been given to Environmental International Agency (EIA) report if it had been available for forward planning at the time of independent. In order to minimize pollution and environmental problem associated with the presence of the industries and other activities that the federal government of Nigeria enacted a decree establishing Federal Government Protection Agency (FEPA) under decree 50 of 1988 and amended under decree 59 OF 1989.

Musa (1998) specified the following as the function of FEPA.

1. Monitoring of environmental condition by identifying problems which would decrease environmental degradation though assisting the local government develop capacity for effective monitoring and assessment of local situation.

2. Monitoring and enforcing industrial regulation and standards set by FEPA. These may be supported by fines, licensing fees, bonding and insurance requirements, which are likely to serve as revenue source for the government.

3. Ensuring that all project with potential environmental impacts assessment process before they are allowed to be developed.

4. Developing a state environmental actions plan in urine with the radical guideline at the same time identifying priority areas for action.

5. Collection analysing and distributing data relevance to Environment International Agency (EIA) policy analysis and environment monitoring within the state.

It is with this in mind that this study area River Gurara (fig 1) and parameter are being considered for assesses the Environmental

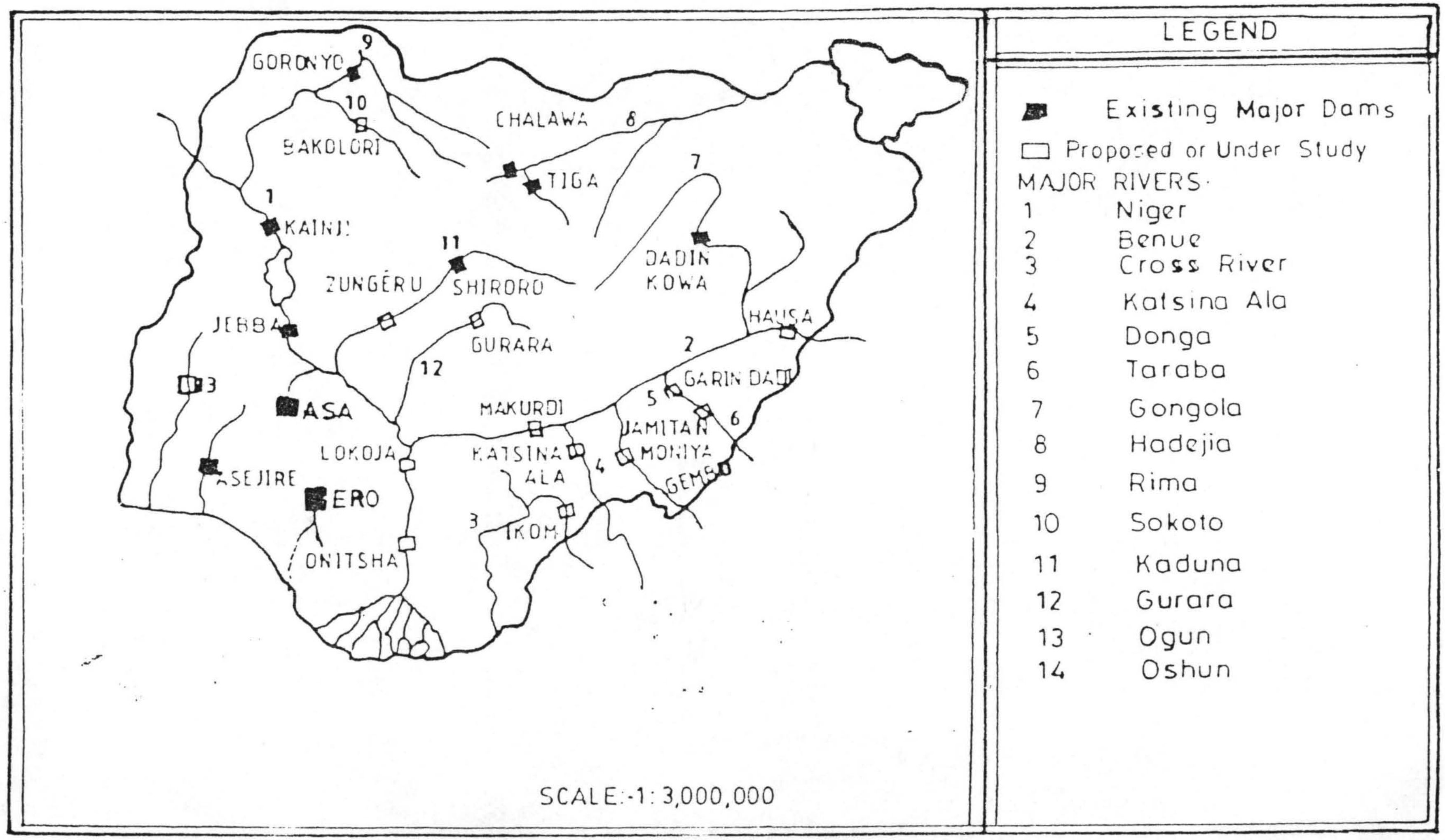

Fig 1: SOME MAJOR DAMS AND RIVERS IN NIGERIA

Source: Olademehin (1999)

Evaluation of river Gurara (Izom) and possible monitoring in order to establish basis for advising both local government, state and federal government of Nigeria especially as regard food production.

The environmental evaluation of the river bank is necessary when one consider the truth that as it is hard to squeeze water out of stone, so is it to find absolute pure water along river bank for irrigation. The only possible pure water is rain water, but still contains dissolved gases absorbed during its route through atmosphere. In order to evaluate the river bank the concentration level of some elements must be known.

1.1 AIMS AND OBJECTIVES

The objectives of this study includes:

i.) To determine the quality of river Gurara at Izom for irrigation purpose

ii.) To examine the socio-economic, cultural and probable health implication of the river on the people within the environment.

1.2 JUSTIFICATION

A sustainable use of the natural resources calls for appropriate methods to collect base line information, to assess environmental impacts and to monitor environmental change. In an ideal situation, all surface and sub-surface water should be monitored and analysed before they are allowed to de developed.

A good example is the Kaduna Polytechnic Farm (Nariya), in this case lack of monitoring the pollution and environmental problems associated with the presence of the industries at the upstream of the river Kaduna (i.e. Kakuri, Kaduna South) resulted to poor water quality for irrigation.

The source of the problem can be attributed to the industries discharge of effluents into the river. To avoid this therefore, there is urgent need for assessment of rivers/streams before using same as irrigation water.

1.3 SCOPE AND LIMITATION OF THE PROJECT

This study is limited to the assessment evaluation of river Gurara (at Izom town) for the purpose of dry season farming. It also looked into the type of agriculture practiced in the area wether subsistence or commercial and its viability. Furthermore, the impact of the river on public health will also be considered.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 THE ENVIRONMENTAL MOVEMENT

By definition, Environmental Evaluation Assessment (EEA) is a process based on current scientific knowledge used to determine the environmental consequences of a proposed action, project or programme and to provide decision makers with systematic information presented in such a way that the impacts, as well as mitigating needs can be assessed in temporal and spatial perspective (UNEP, 1988) Stromquist and Talham (1992) and Glass et'al (1994).

Without doubt historians of the future will regard the late 1960s' and early 1970's as a period when most industrially developed countries became deeply concerned about environmental problems. Already, numerous studies have described this increase in public concern which has been variously called 'the ecology movement', 'the new conservation movement or just the environmental movement'. More recent studies have shown that certain aspects of this movement have begin to wane. It is probably safe to concur with Bowmem (1975) who writing said; "Few would disagree that we are witnessing a gradual decline of intense interest in the environment'

Sandbach (1980).

The rise and fall of the environment as practical issue may be charted by examining a variety of indicators and resources, for example, News media and literature, public opinion and social survey data; environmental pressure group involvement; the induction of new political institution and environmentalism itself. The collection of evidence about changes in the intensity or the objective of public concern is fraught with methodological problems and interpretation of the results has given rise to much controversy. Sandbach (1980).

2.2 RESOURCES AND DEVELOPMENT

2.2.1 POPULATION STRUCTURE AND DISTRIBUTION

The greatest resources of Niger State are its people who apply their skills, labour and training to transform components of the natural environment in goods and services. The structure and distribution of this populaion is presented below Baba (1994)

According to the 1991 National Head Count, Niger State had a total population of 2,482,367 people. Of this total 1,290,729 (or 52%) are male while 1,191,647 (48%) are female. Table 2.1 further shows the spatial distribution of this population on local government basis.

The average density of pouplation in the state may be put at about 33 persons per square kilometre, which must be among the lowest in the country. In deed falling even below this low average density would be the densities in such territorially large LGA's like Borgu, Wushishi, Mariga and Shiroro.

These statistics suggest is the presence in Niger State of large expanses of land resources waiting to be developed either through carefully guided policy of induced population redistribution or technological improvement for more efficient resource utilisation, or a combination of all these Baba (1994).

Through, the study area recorded second to the last lowest population area in the state. But the world's population, have been predicted to increase and reach an alarming rate of over 6.1 billion by 2000, there is a predicted sharp increase in the demand for water for domestic uses, in industry and in agriculture. In order to meet this ever-increasing demand, various developmental efforts have been geared toward water resources management and development. Hence. a number of water resources development projects have taken place and had been implemented Olademehin (1999).

Table 2.1: DISTRIBUTION OF POPULATION IN STATE BY LOCAL GOVERNMENT AREA

S/N	LGA	MALES	FEMALS	TOTAL
1	Lavun	23.647	114.665	238,312
2	Mariga	126,220	111,790	238,010
3	Shiroro	108,542	104,297	212,839
4	Wushishi	102,871	92,549	195,420
5	Bida	87,908	82,817	170,725
6	Chanchaga	82,568	74,591	157,159
7	Magama	67,737	66,653	134,390
8	Suleja	70,635	54,624	125,259
9	Rijau	63,922	60,939	124,861
10	Borgu	56,596	53,308	109,904
11	Paikoro	55,025	52,606	107,691
12	Rafi	55,127	51,033	106,160
13	Gbako	54,066	50,381	104,447
14	Mokkwa	56,277	47,608	103,085
15	Bosso/ Maikunkele	48,925	43,338	92,263
16	Lapai	44,044	40,128	88,172
17	Agaie	43,128	42,152	85,280
18	Gurara	22,746	23,192	45,938
19	Agwara	20,736	20,916	41,652
TOTAL		1,290,720	1,191,647	2,482,367

Source: Niger State (1993).

In achieving this lofty objectives, the following types of projects are petinent and more importantly, can be distinguished.

1) Irigation and drainage.

2) Urban and rural water supply.

3) Controlling waste discharge by the industries and individual.

4. Other water related developments.

Whatever the type of project, certain changes are imminent in the environment, to this end environment impact assessment is therefore, necessary to be carried out in-order to identify and evaluate the magnitude of impacts of these changes in the biological, bio-geophysical, economic and usefulness to the community and the entire nation.

2.3 ENVIRONMENTAL EVALUATION

In Kaduna, the industries downstream contribbutes immensely in the discharge of into water receiving bodies. Such pollutants are not objectionable in water but threats to irrigation agricultural propose.

Analysis of water and soil along the river bank had shown great variation in the concentration of micro-element. The variation observed Table 2.2 for the area depends on the time from which the wastewater is discharged into the river.

Industries in the Sothern part of the city discharge their effluents mostly early in the morning, making the river to show low concentration of some substances in its water later in the day, as a result of the dilution effect of her river, this usually makes the farmers along the bank to feel that the water is completely safe for irrigation s shown in Table 2.2. earler complained by the farmers.

The soil of the River bank have shown low concentration of sodium (Na) upstream when compared to the soil down stream as shown in Table 2.3. The pH of river water along the banks requires moderation through reclamation measures in order to reduce the effects to high or low values by use of acid where waste water is alkaline and use of alkalis where waste water is acidic by Chara and Musa (1998).

The mean concentration of sodium for the Kaduna South water is 47mg/l standard deviation of 3.9 and variance of 3.8 (Beecorf, 1976) for River Kaduna, the low concentration of sodium (Na) could have been due to the dillution of waste water of the drains with water of the River Kaduna, which has relatively very low concentration of Na. The high concentration of sodium in waste water of the drains may result in the accumulation of Na ions in the soil, which will result in the displacement of calcium and magnesium, causing soil dispersion and reduces infiltration, which in turn will result in reduced permeability and low crop production.

Table 2.2: CHEMICAL PROPERTIES OF RIVER KADUNA AT KABALA

S/N	Date	Location	pH	Na ppm	Zn mg/l	(B) Boron mgl	BOD mg/l
1	25-11-97	Upstream	6.7	23	0.8	0.05	2.8
2		Downstream	6.8	85	T.aces	1.4	12
1	23-02-98	Upstream	6.1	4.2	1.0	0.3	3.0
2		Downstream	10.1	70	0.2	0.8	12.2 8
1	04-05-98	Upstream	6.1	3.6	0.5	0.2	
2		Downstream	6.9	5.1	1.0	0.0	

Source: Chara (1998)

Table 2.3 CHEMICAL PROPERTIES OF THE SOIL BANK ALONG RIVER KADUNA AT KABALA

S/N	Date	Location	Depth (cm)	pH		Na mg/100g	Zn mg/l
				H_2O	$CaCl_2$		
1	25-11-97	Upstream	0 - 10	6.7	6.4	1.5	17.2
2			10 - 60	5.8	5.0	2.5	16.8
3			0 - 10	5.6	5.1	3.3	5.2
4		Downstream	10 - 60	5.8	5.2	1.1	8.8
1	23-02-98	Upstream	0 - 10	8.0	7.0	1.4	18.8
2			10 - 60	7.5	6.5	1.5	16.2
3			0 - 10	4.0	3.5	1.3	6.1
4		Downstream	10 - 60	4.5	3.4	2.9	7.2
1	04-05-98	Upstream	0 - 10	7.2	6.7	2.4	14.6
2			10 - 60	6.9	6.3	2.1	22.0
3			0 - 10	6.5	6.0	4.2	17.3
4		Downstream	10 - 60	6.0	5.6	3.6	30.6

Source: Chara (1998)

Another similar work has been carried out by Kolong (1998) on the evaluation of Kaduna River for irrigation purpose from the period of this study (Dec-April, 1998) is presented in Table 2.4. The average value is used to evaluate the quality of the water for irrigation purposes for the period of the study. The classification of the water falls in C_2S_2 according to USDA classification. This implies that during this period the water salinity is medium. It is acceptable for irrigation, but moderate amounts of leading are necessary to control salt accumulation in the soil. The water has also medium amounts of Na. It is therefore of permissible quality for the soils of the farm, but precaution should be taken so that excess exchangeable Na does not develop.

Another serious problem that need proper monitoring is the impact of crude oil spills range from barely tolerable to the utterly disastrous on both land and water bodies. Farmers often complain bitterly about oil spills and the resultant damage of food crop. A case study of crude oil spill at 197km Izom/Sarkin-Pawa axis (NNPC), occurs as result of pipe line corrosion when the pipe is corroded, it can no longer withstand the pressure of the product passing through the weaker area that has corroded will eventually start with either leaking or bursting. At kilometer 197 the crude oil pipe cracked and within a short period of time the crack expanded to above two metres along the pipe due to high pressure and vibration. A major spill was recorded because it involves over 3,500 barrels of crude oil floating on land by Eromosele (1996)

in a nutshell, with the foregoing studies background from literature that uses both conventional and non-conventional method in carrying out the environmental evaluation of River and their implication on the eco-system, it is very clear that there is need for carrying out the environmental evaluation assessment of River Gurara (at Izom).

Table 2.4: <u>CHEMICAL PROPERTIES OF RIVER KADUNA AT NARIYA</u>

Months	Na%	SAR	Ec/M/cm	USDA Classification	Salinity Hazard
December	52	6.35	150	C_1 S_1	Low
January	54	9.72	440	C_2 S_2	Medium
February	56	11.11	567	C_2 S_2	Medium
March	62	14.14	1210	C_3 S_3	High
April	65	11.92	129	CS_2	High
Average	57.8	10.65	499.2	C_2 S_2	Medium

Source: Kotong (1998).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

Environmental Evaluation Assessment (EEA) is a useful tool for quality management and cost effectiveness in relation to maintenance of eco-system balance. The aim of any EEA is to ensure that beneficial effects of a project do not 'over-ride' the negative impact if sustanable development is to be maintained.

To achieve the above aims and objectives of this study. three opproaches have been adopted to the study as the ways and means of obtaining the relevant information required. These are:

i) Finding out sources of published and unpublished information relevant to the study area river Gurara (Izom) The information obtained include those on climate, hydro-geology, geology, vegetation maps and existing infrastructure facilities by location and type, the source of these information were acknowledged.

ii) Determination and identification of environmental evaluation assessment consideration area through analysis of the river bank soil and water. The analysis was carryout to give a useful information on the condition of the soil and water.

iii) Establishment and identification of environmental evaluation assessment consideration area through the administration of "structure or coded" questionnaires were designed to provide detailed information on the socio-economic characteristics of the people and the environmental evaluation assessment of the river on agriculture (irrigation) as well as on the general development.

In conducting the research, the materials used are discussed below. The methodologies of data extraction and computation procedures for analysis are also discussed in this chapter.

3.2 DATA COLLECTION

The materials collected for identification and assessment of the river are 1985 - 2000 mean daily gauge heights (m) and the maps of Nigeria and Niger State showing location, political boundaries, mean annual rainfall (in mm), mean onset dates of the rains, mean cessation dates of the rains, length of the rainy season (in days), the vegetal pattern and geology of the study area.

3.3 LOCATION OF THE STUDY AREA

River Gurara takes it source from Kachia - hills and flows for several kilometer before reaching Izom town and finally discharge to River Niger. Izom is about 22km away from Suleja along Minna road (to Minna town, state capital) and about 77km from Izom to Minna

Izom (figure 2) is between latitude 9°.00'S and 9°.15'N and longitude 6°.56'E and 7°.00'E in Gawu Local Government Area of Niger State.

However, in relation to the political boundaries (fig 3), the state is bounded on the east by the Federal Capital Territory (Abuja) and Kaduna State, on the West by the Republic of Benin, on the North by Kebbi and Zamfara State and on the south by Kwara and Kogi States.

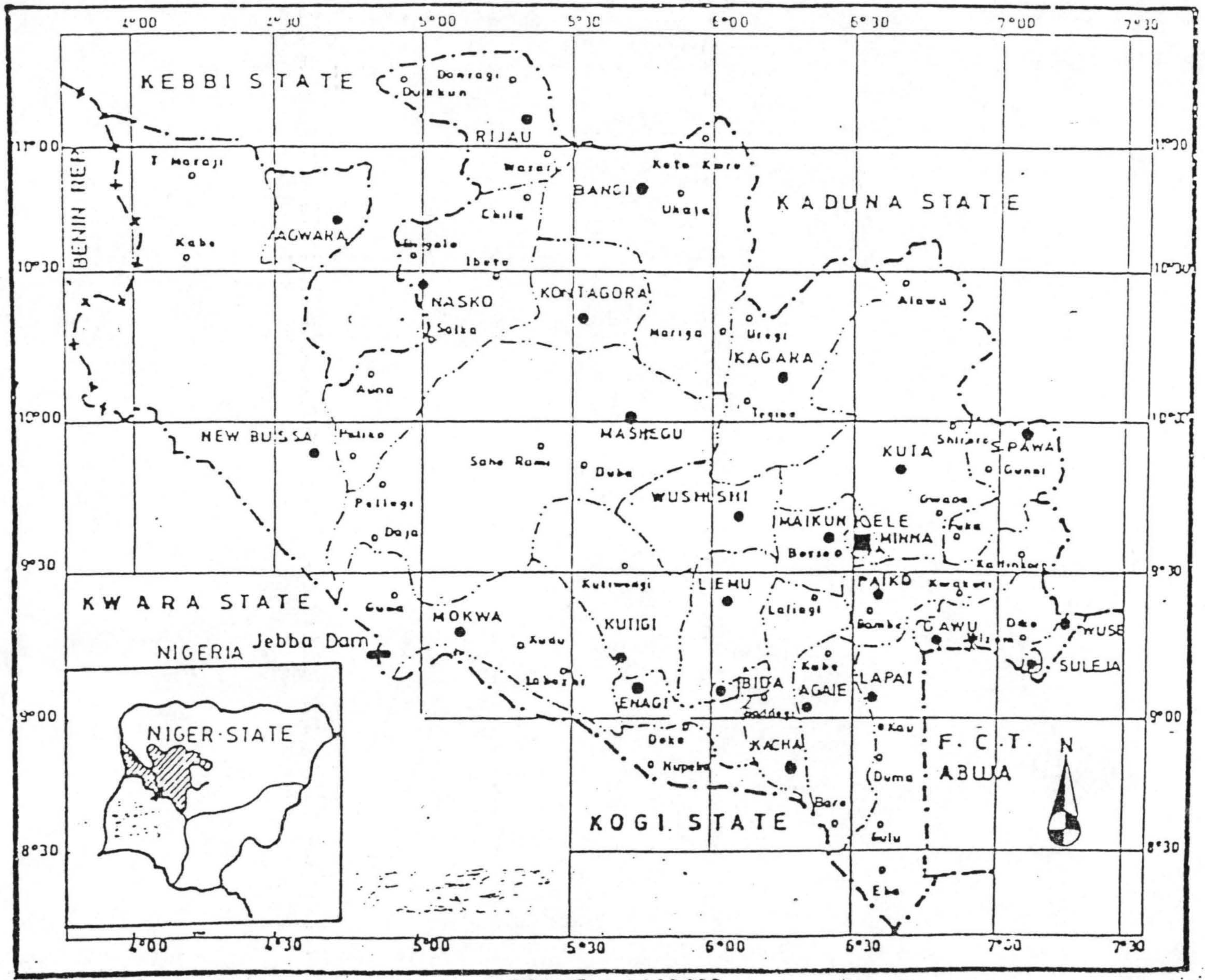

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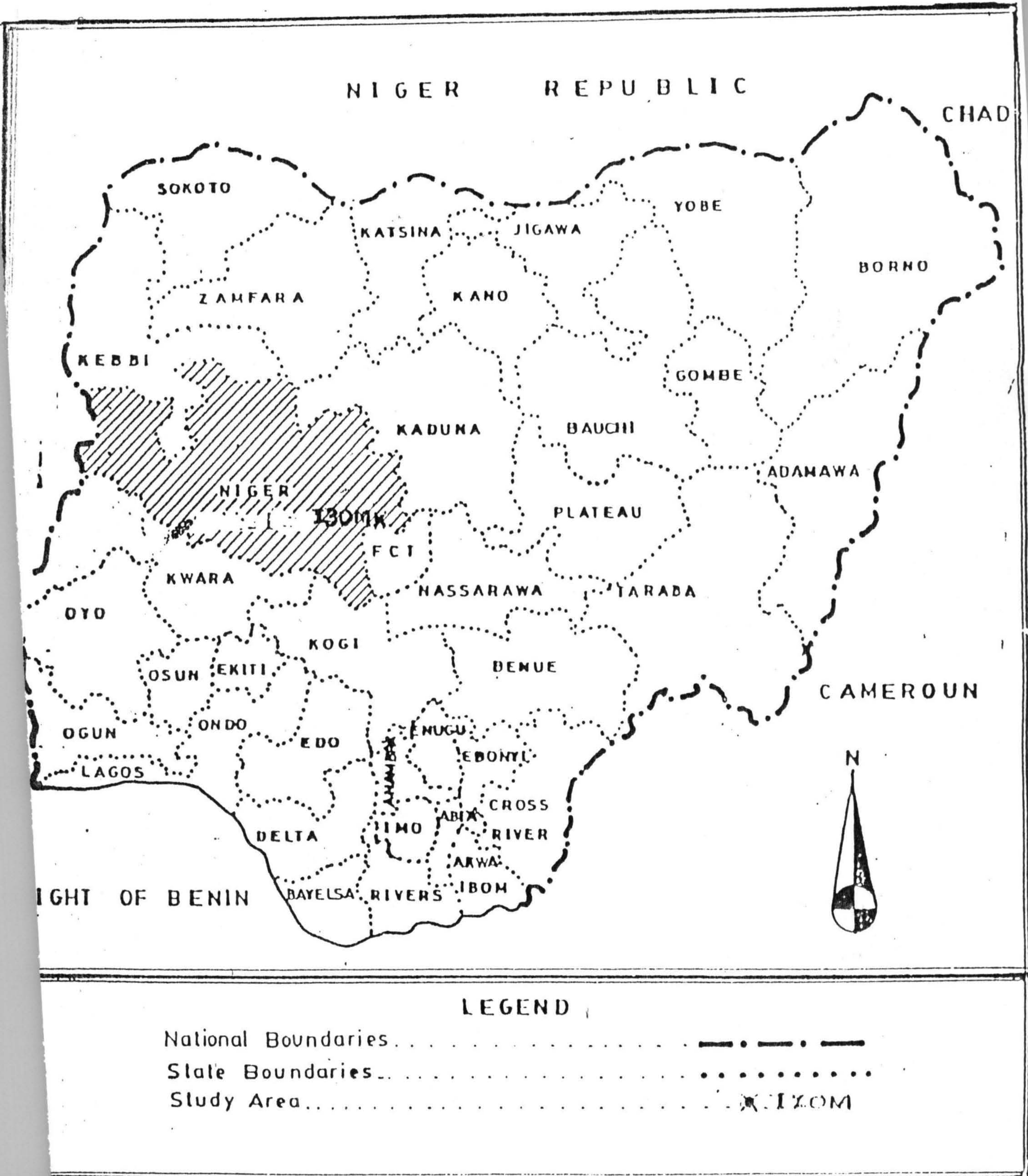
Fig 2 MAP OF NIGER STATE SHOWING THE LOCATION OF THE STUDY AREA



3.1: MAP OF NIGERIA SHOWING THE STUDY AREA AND RELATION TO THE POLITICAL BOUNDARIES.

Source:- Geography Department Federal University of Tech. Minna Cartography Section (1998)

3.4 GEO-PHYSIOGRAPHIC AND HYDROLOGY

3.4.1 RELIEF AND CLIMATE

Generally, the land rises from the south with the associtaed highlands towards from Futajalon Highlands in Sierra Leone and flows southwards down to meet river Benue at Lokoja Olademehin (1999).

Five major land units have been identified in the area, hill slopes, colluvial foot slopes, ground water woodland riparion zone and Niger river, each land unit has its own geological and ecological characteristic.

Step hill slopes represent steep bedrock, often covered by thin infertile soils. Colluvial foot-scopes (including pediments and small hills), trades to the steep hills-slopes having potential visual impacts. Accumulation of materials from the upper hill-slopes has created coarse texture colluvial deposits Olademehin (1999).

'Ground water, bush land/woodland surrounds the seasoned tributaries to the river Niger. The seasoned streams flow in direct response to precipitation. The climate condition of the project site/study area is mild and of the tropical type with Sudan Savanah type vegetation, Olademehin (1999).

3.4.2 RAINFALL

The rainy season span between March and November. Main annual rainfall in within the range of 1.200mm to 1.4mm see figure 4.

Phrenologically, it is not the amount of rainfall that matters, it is how much of it that is available to dissolve soil nutrient (minerals which yield protein, sugar, fat and carbohydrates as end-products) that plants require from the soil. A soil which is very rich in nutrients can only release them to plants if they are in solution. But when plants have no access to these nutrients, there is bound to be failure.

Such a situation may arise when precipitation distribution (in time and space) is abnormal. For example, late onset, (i.e. the beginning) of the rains may result in problems even when the total rainfall received during the entire season is normal or above average. One to this abnormal situation, irrigation schemes were integrated into dams project as an alternative means to rain fed agriculture along rivers basin.

Similarly, premature cessation (i.e the rains stop before the normal period) constitutes a major problem. To this end, the "precipitation effectiveness" is very important. The means onset dates of the rains in the study area is before April 10, while the means cessation dates of the rains is between October 27-November 16 as shown in fig 5 and 6. The length or rainy season is between 150days to 200days, as shown in fig 7. These suggest that:

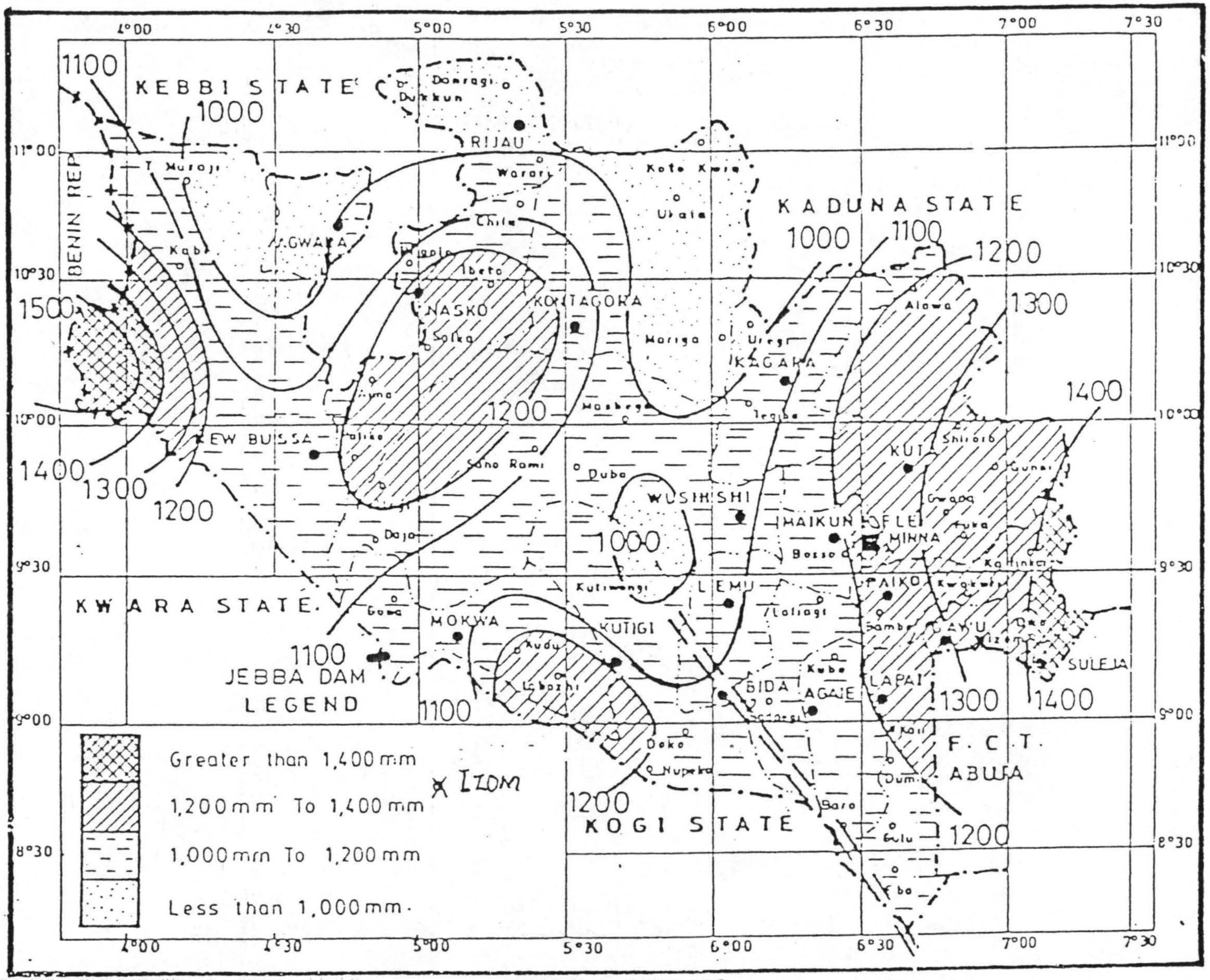


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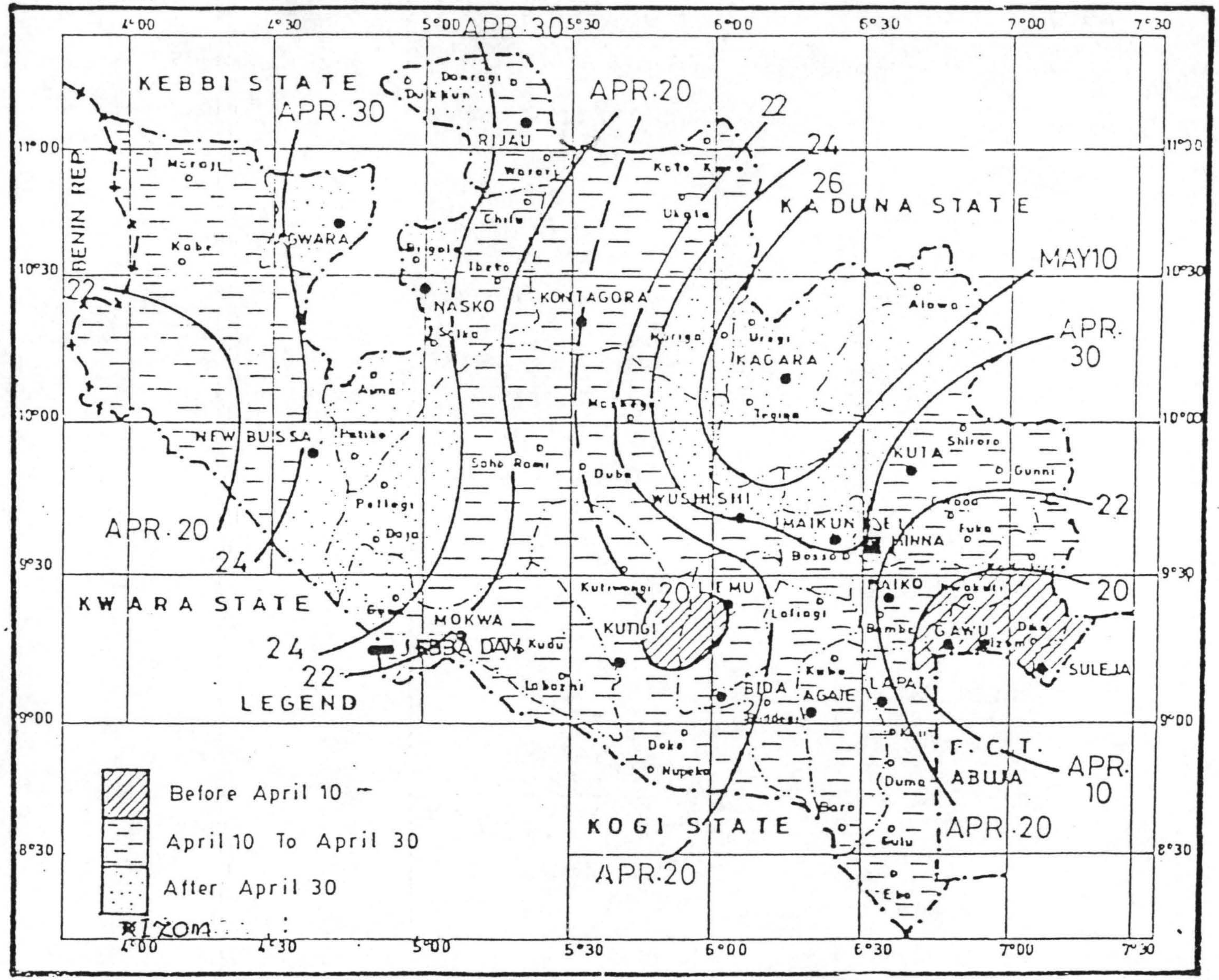
FIGURE 4 MEAN ANNUAL RAINFALL (IN MM) IN NIGER STATE

Source: Olademehin (1999)



SCALE:-1: 2,000,000 Source:-. Olademehin (1999)

FIGURE 5 MEAN ONSET DATES OF THE RAINS NIGER STATE

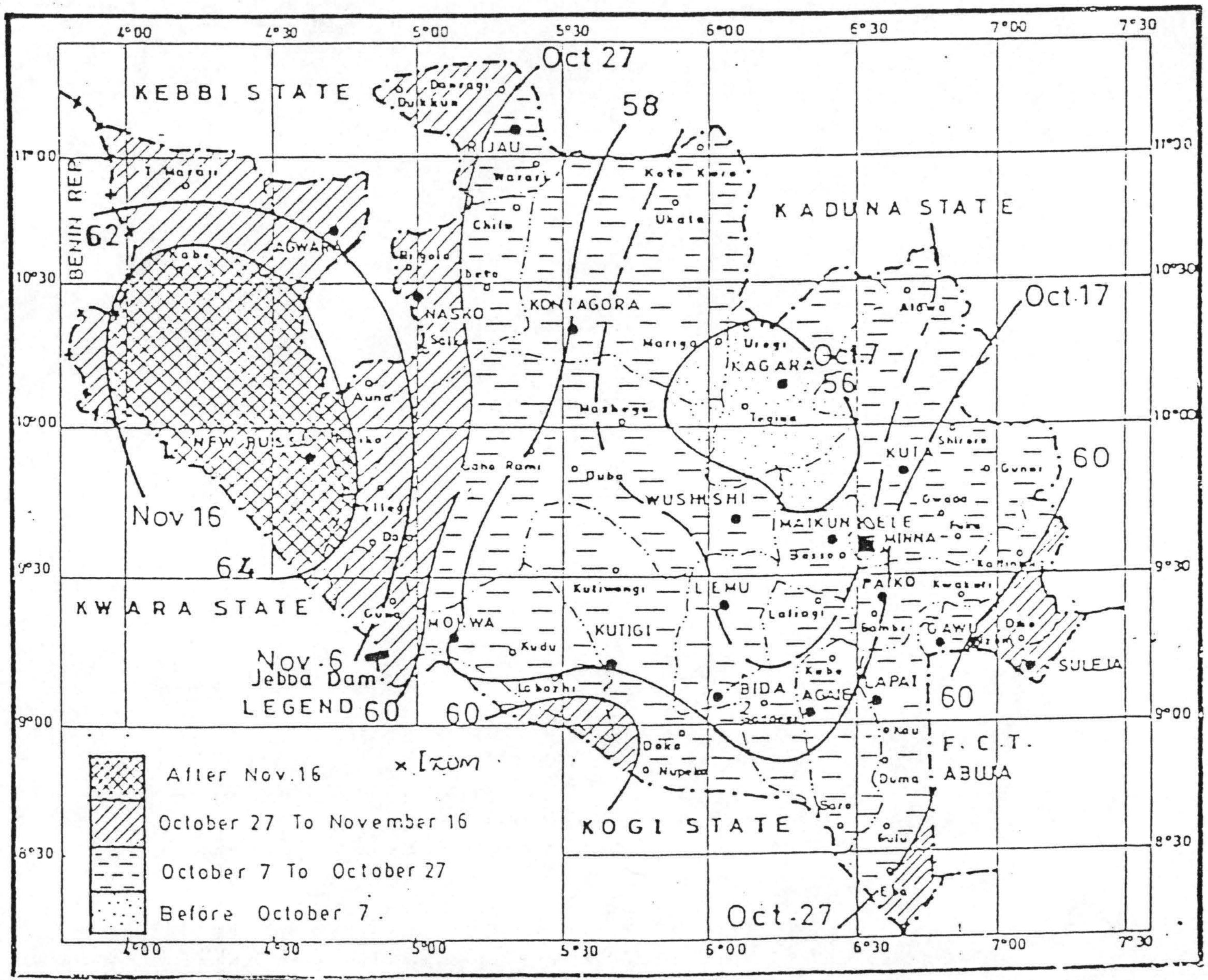


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FIGURE 6 MEAN CESSATION DATES OF THE RAINS IN NIGER STATE

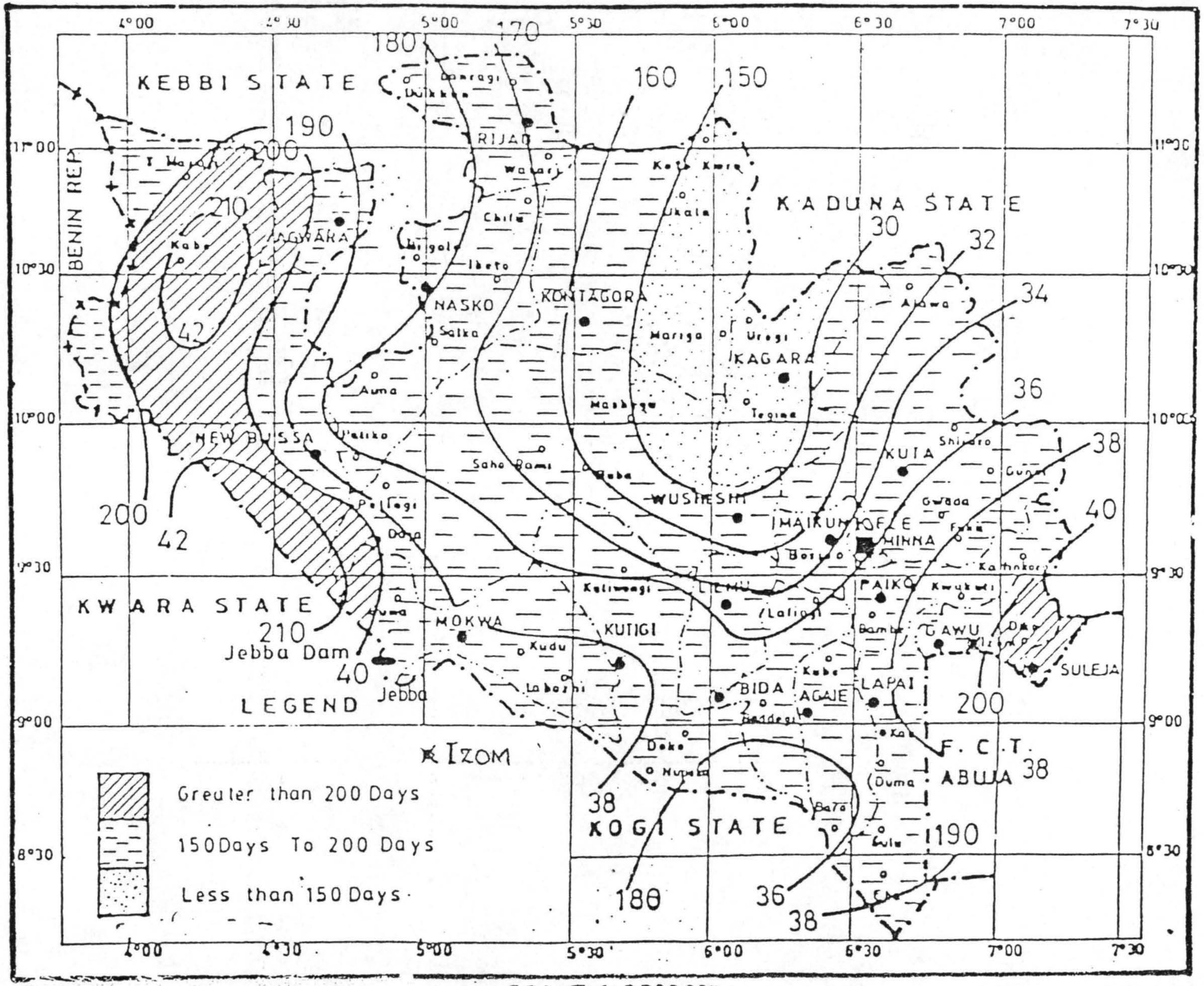

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FIGURE 7 LENGTH OF THE RAINY SEASON (L.R.S.) IN DAYS NIGER STATE

Source: Olademehin (1999)

i) Rain fed agricultural cannot be embarked upon before April 10.

ii) Plant that cannot normally mature on or before October 27 to November 16 should not be introduced without adequate test and in depth studies.

iii) Dry season farming can be embarked upon between the ending month of November to December depending on the type of crops to be plant.

iv) Flooding/Erosion should be expected in the month of maximum rainfall (August and September).

The south westerly winds blow mostly throughout the year. During the month of November to March, the cooler continental winds from the interior of the continent prevails.

The hottest months in the year are March and April, that is just before the onst of the first rains. The main daily maximum temperature remains high throughout the year at above 32°C for most of the year. There is a marked drop in temperature during the peak of the rainy season from July to earily September Baba (1995).

3.4.3 VEGETATION

The vegetation of the study area can generally described as a typical guinea savanah as show in fig 8 with a mixture of trees, shrubs and tall grasses. The remaining forest patches within the belt which is similar to that of that of the tropical rainforest due to its nearness to River Niger while the North East section of the area is purely savanah with its associated bare ground in some pocket by Baba (1995).

Plant such as 'Dongo-yaro'. Acacia and Comfilora (shea butter) families are common.

3.4.4 GEOLOGY OF THE STUDY AREA:

About 60 - 70% of the total landmass of Niger State is underlain by 'hard' rocks of the crystalline basement complex which are believed to the Precambrian in age Shekwollo (1989). The remaining 30 - 40% of the state is covered by sedimentary rock of cretaceous to recent age. The basement complex rocks occurs in the Izom area as shown in fig 9. However, with adequate supply of water the soil support grasses which can be used for grazing of particular interest are the fadamas, which occur in parts of the basement complex aged around the river down stream in the sedimentary areas.

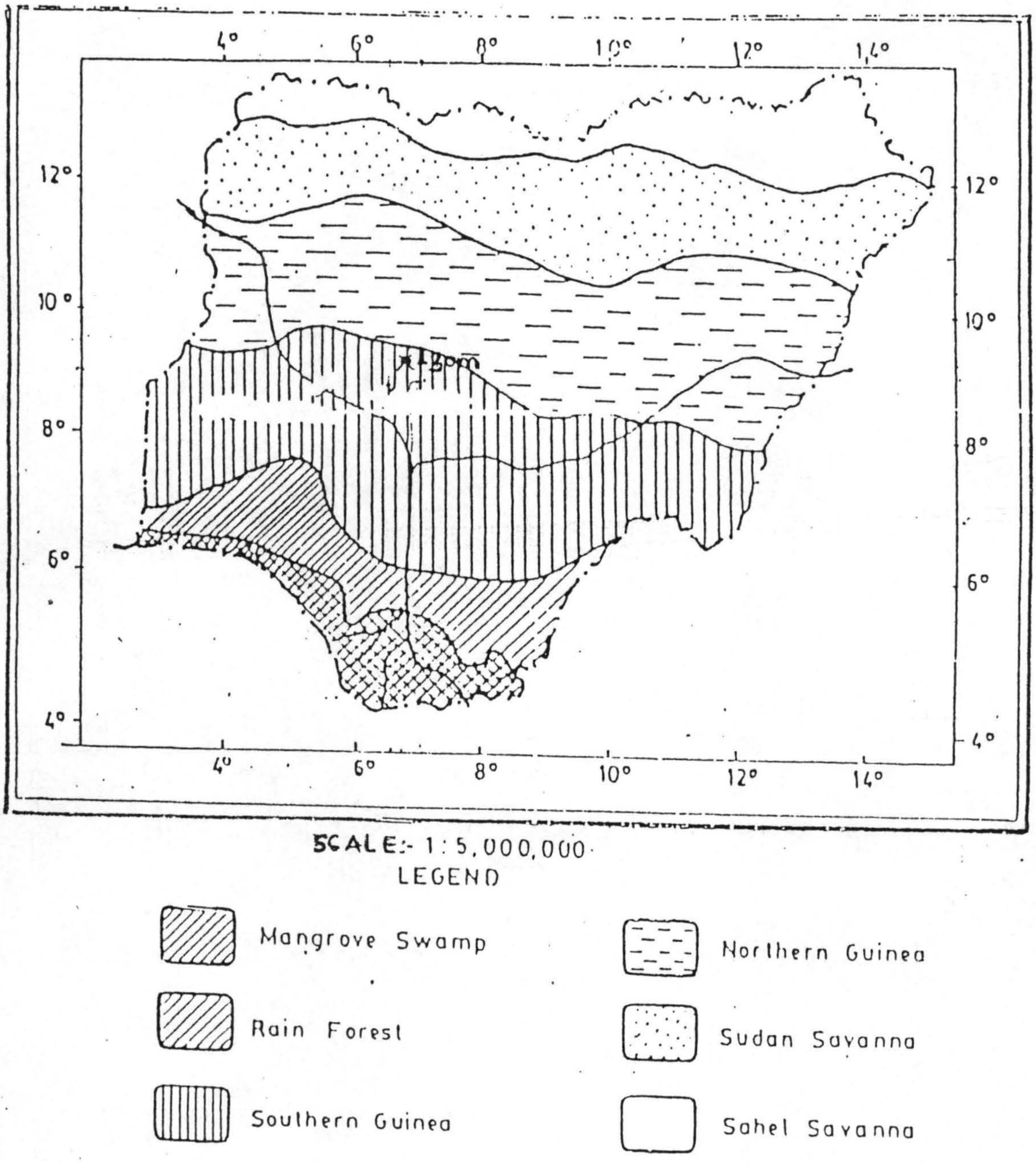

Fig: 8, MAP OF NIGERIA SHOWING THE VEGETAL PATTERN OF THE STUDY AREA

Source: Olademehin (1999)

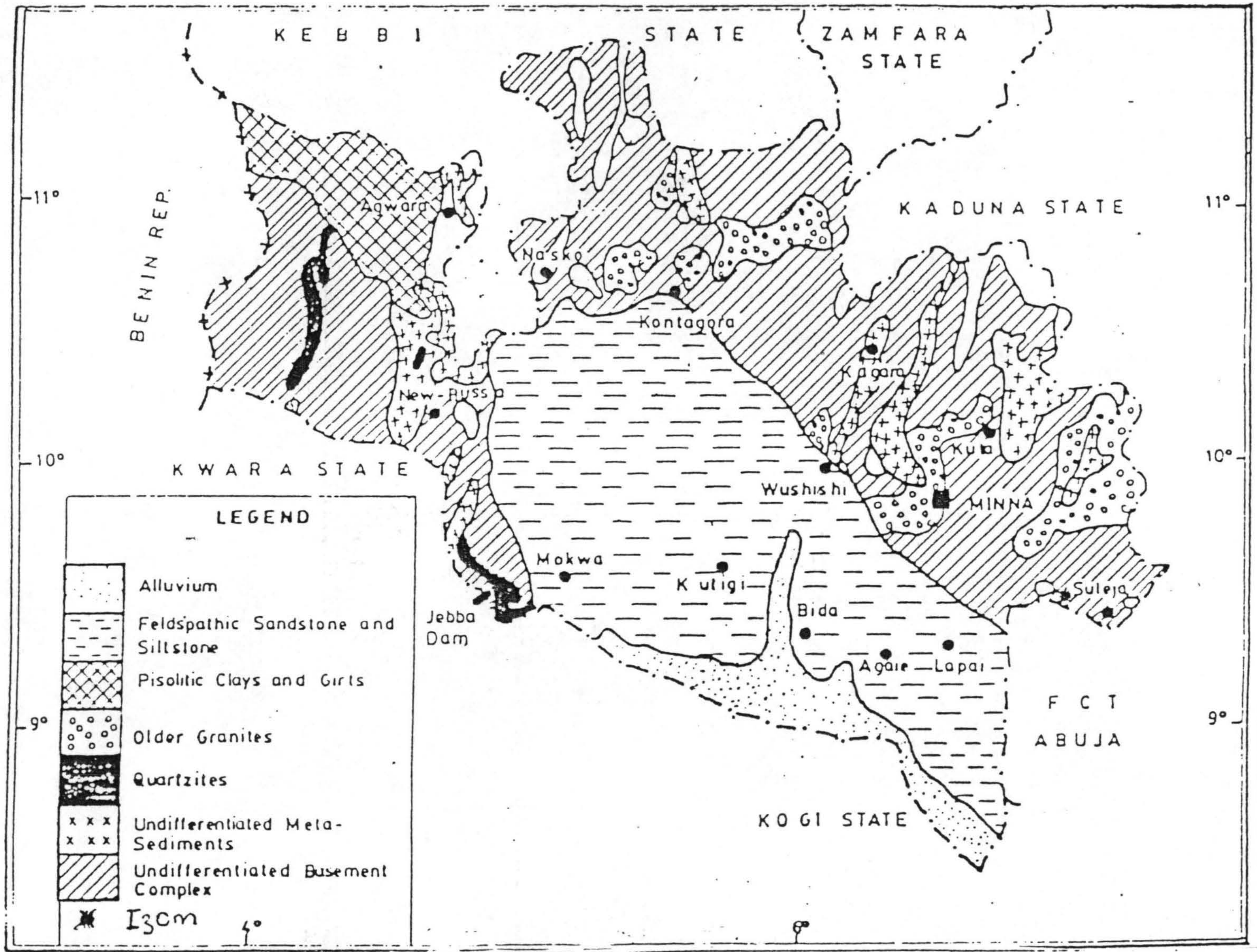

Fig 9 GEOLOGY OF THE STUDY AREA

Source: Olademehin(1999)

3.4.5 HYDRO-GEOLOGY

The provision of water supplies is the major concern of engineering hydrologist and hydro-geologist. Hydrology embraces the study of the movement of water both upon and beneath the ground, their chemistry and physics.

The hydrological cycle in a region is highly influenced by the climatic condition and the underlying geology, precipitation, interception of rain water by vegetation; evaporation and transpirate transpiration and infiltration. This will depends on the porosity and permeability of the underlying rocks in the sedimentary areas such as Izom.

3.4.6 SURFACE WATER

Water occurring naturally and of good quality suitable for main's use is a precious resource and mankind through ages, has been faced with the problem of providing suitable water in sufficient quantity for his use.

Water is most readily available to man in the flow of streams and rivers. These flows, show very wide variation both in time and place. It is therefore necessary for rational development and utilization of water that the quantities available from such stream (stream runoffs) and their variability are known. The runoffs of stream and rivers are determined on the basis of counting measurement of rivers stages and dischrges (see appendix for more details of Izom river stages and calculated discharge).

3.5 SAMPLE COLLECTION (SOIL)

A hole was dug about 1x1 meter, on a spot on the feild, with shovel. Samples were collected at different depths (that is 0-10cm, 10-30cm £ 30cm to 60cm), placed in a polythene bags labeled and then taken to the laboratory for analysis.

3.5.1 SAMPLE PREPARATION (SOIL)

The soil samples were spread in the laboratory for air drying. After drying, a mortar and pestle and sieved with 2mm sieve.

3.6 WATER SAMPLE COLLECTION

Water samples were collected using 1.5 litres plastic bottles. The bottles were submerge to about 6-7cm below the water surface and inclined against the direction of flow. Caps were screwed on which the filled bottle remained submerged. They are labeled and immediately conveyed to the laboratory for refrigeration and subsequent analysis were carried out.

3.7 SOIL ANALYSIS

PH DETERMINATION

Apparatus:

Glass electrode pH meter, beakers, stirring rod, thermometer, weighing balance and measuring cylinder.

Reagents:

Distilled water, 0.01m cacl2 .and Buffer solution (pH 4, 7 and 9.2).

Procedures:

20g of air-dry 2mm sieved soil was weighed in duplicates into 50ml beaker. Into one, 20ml of distilled water was added and into the duplicate, 20ml of 0.01 $CaCl_2$ was added. They were allowed to stand for 30 minutes and stirring was done occasionally with a glass rod.

The pH meter was standardised with buffer solutions of pH4, 7 and 9.2.

The pH of the soil in water and $CaCl_2$ and water samples were then read on the pH meter.

3.7.2 SOIL TEXTURE DETERMINATION

APPARATUS:

Mechanical stirrer, thermometer, Boryorcers Hydrometer, measuring cylinder, stirring rod, Flask, stop watch.

Reagents:

Sodium Hexa-meta-phosphate (calgon) Na (PO3)6), Distilled water, sodium carbonate (NaCO3).

Procedures:

50g of air-dry 2mm-sieved soil was weighed into a flask nd 100ml of solution of calgon and sodium carbonate was added and allowed to stnd for 30mins. stirring was done with the mechanical stirrer for 15 minutes after which the suspension was transferred into the measuring cylinder and distilled water added to 1000ml mark. The rod was used to bring back all the particles into suspension and at 40secs, the hydrometer reading was taken and the temperature determined. The cylinder was then left.on a stablle surface undisturbed and after two hours the hydrometer and temperature readings were taken. A blank was prepared without the soil and its readings were also taken at 40sec and 2 hours.

The percentages of the soil particles got from the above determination were then plotted on the textural triangle and the name of the texture read-off.

3.7.3 DETERMINATION OF ORGANIC MATTER:

APPARATUS:

Burettes, Pipette, flasks, measuring cylinder.

Reagents:

Potassium Dichromate ($K_2Cr_2O_7$), Cone Sulphuric Acid (H_2SO_4), O-Phosphoric acid (H_3Po_4), Ferrous - Ammonium Sulphate, O-Phenanthroline - ferrous complex, Distilled water, Sodium Floride (NaF).

Procedure:

1g of air-dry 0.5mm sieved soil was weighed and 10ml of $K_2Cr_2O_7$ was added and swirling was done gently to disperse the soil. 20ml conc. H_2SO_4 was added and the flask swirled gently to mix the soil and reagents. 100ml of distilled water was then added afer standing for 30mins. 10ml of orthophosphoric acid and about 0.1gm of sodium floride were then added. 3 - 4 drops of the O-Phenanthroline indicator was added and then titrated with ammonium ferrous sulphate. A blank was prepared following the same steps without the soil.

The organic matter content was determined by multiplying the organic carbon percentage by a factor of 1.72.

3.7.4 DETERMINATION OF TOTAL NITROGEN

APPARATUS:

Macro-k jeldahl digestion - distillation apparatus, macro-kjeldahl flasks.

Reagents:

Mercury catalyst tablets, Boric acid, Methyl rod, Bromocresel green, ethanol, sodium hydroxide, sulphuric acid (conc), Hydrochloric acid.

Procedure:

5g of air-dried 0.5mm sieved soil was weighted and 20ml of distilled water added. swirling was done for a few minutes and then allowed to stand for 30 minutes. One tablet of mercury catalyst was added and then 30ml of conc. H_2SO_4 was also added. The mixture was boiled for 5 hours after which it was allowed to cool and 100ml of distilled water slowly added. The digest was transferred to another-flask without the sand particles. The sand particles was thoroughly washed with about 50ml of distilled water four times and the Ahquot transferred to the digest. 50ml of H_3BO_3 indicate solution was added and then placed under the condenser of the distillation apparatus and distilled. Distillate was collected into 150ml of sodium hydroxide. The nitrogen content in the distillate was then determined by titrating with 0.01N hydrochloric acid.

3.7.5 DETERMINATION OF AVAILABLE PHOSPHORUS

(BRAY NO. 1 METHOD)

APPARATUS:

Centrifuge, Mechanical Shaker, test-tube, Spectrophotometer, flasks, pipette, measuring cylinder.

Reagents:

Ammonium Floride (NH4F), Hydrochloric Acid (HCl), stannous chloride ($SnCl_2 . 2H_2O$), Ammonium Molybdate ($(NH_4)_6 M0_7 O_4$), Distilled water, Potassium hydrogen Sulphate ($KH_2 . PO_4$).

Procedure:

1g of air dried 2mm sieved soil was weighted into a centrifuge tube and 7ml of the extracting solution (NH_4F plus HCl) added. It was shaken for one minute on a mechanical shaker and then centrifuged at 2,000rpm for 15mins. 2ml of the clear supernatant was taken into a test-tube. 5ml of distilled water and 2ml of ammonium mohybdate were then added and mixed properly. 1ml of the stannous chloride solution was added and mixed again after 5mins but not later than 20mins, percentage transmittance was measured on the spectrophotometer at 660mm wave length.

3.7.6 DETERMINATION OF AVAILABLE PHOSPHORUS (OLSEN METHOD)

APPARATUS:

Spectrophotometer, Mechanical shaker, flask, What-man filter paper, (No 40)

Reagents:

Sodium bicarbonate Na (HCO_3), sodium hydroxide (NaOH), carbon black, Ammonium para-molybdate $[(NH_4)_6 MO_7 O_{24} . 4H_2O]$, Potassium antimony titrate $[KSbO . C_4 H_4 O_6]$, sulphuric acid (H_2SO_4), Ascorbic acid, Distilled water,

Procedure:

5g of air dried 2mm sieved soil was weighed and 100ml of the extracting solution 0.5m Na $(HCO_3)_2$ was added. This was shaken for 30mins with a mechanical shaker. The suspension was filtered through the What-man No 40 paper after the addition of carbon black which helped to obtain a clear filtrate.

5ml of the Ahquot was taken and acidify with H_2SO_4 20ml of distilled water was then added 4ml of the mixture of ammonium para-molybdate potassium antimony titrate, sulphuric acid and ascorbic acid was then added and after 10mins the percentage transmittance measured with the spectrophotometer at 882nm wave length.

3.7.7 DETERMINATION OF EXCHANGEABLE CATIONS

[Ca^{2+}, Mg^{2+} Na^{+}, K^{+}]

EXTRACTION OF CATIONS:

APPARATUS:

Flasks, Filter paper, Suction pimp, Brahnner funnel,

Reagents:

Ammonium solution, glacial Acetic Acid, Distilled water.

Procedure:

10g of air-dried 2mm sieved soil was weighed and 40ml of extracting solution (NH_4O AC) was added. It was covered and left over-night. The suspension was then leached with more NH_4O AC to a mark of 100ml using the suction pump filter with a Brahnner funnel.

3.7.8 READING OF CATIONS IN THE EXTRACT

APPARATUS:

Flame photometer, Atomic Absorption Spectrophotometer, Pots.

Procedure:

K+,Na were read on the flame photometer while Ca, Mg were read on the atomic absorption spectrophotometer.

3.7.9 DETERMINATION OF CATION EXCHANGE CAPACITY (CEC)

APPARATUS:

Flame photometer, flasks, measuring cylinder pot, filter paper, funnel.

Reagents:

SODIUM acetate (NaOAC), Ethanol 95%, Ammonium Acetate (NH4OAC)

Procedure

4g of air dried 2mm sieved soil was weighed and 33ml of sodium accetate was added. Shaken was done for 5mins and filtration done. 33ml of sodium acetate was then used four times to further leach the soil. This was followed by leaching with 33ml of ethanol three times. The decemtale was then thrown away after which the soil was then leached with 33ml of NH_40 AC twice and about 34ml with the third leaching to have approximately 100ml of the decemtale.

The sodium (Na) content of the decemtale was then determined using the flame photometer.

3.9 WATER ANALYSIS

3.9.1 DETERMINATION OF Ca2+, Mg2+ IN THE EXTRACT [COMPLEXOMETRIC TITRATION WITH EDTA]

APPARATUS:

Flask, Burette, Pipettes, Tripod Stand.

Reagents:

Ammonium chloride (NHaCl), Ammonium hydroxide (NH4OH), Ethylene diamine tetra-aceic acid, Disodium salt (EDTA disodium), potassium cyanide (KCN), sodium hydroxylamine hydrochloride (NH2OH.HCl), Potassium farocyanide (KFeCN), Mirexide indicator, Distilled water.

Procedure:

25ml of the extract was taken in duplicate distilled water was added to both to 150ml mark. For blank, 25ml of the extracting solution (NH4OAC) was taken in duplicate also and distilled water also added to 150ml mark. 10 drops each of KCN, KFeCN and NH2OH.HCl was added to the three flasks each. They were then left for 30mins.

In one flask for Ca and Mg determination and one blank flask about 15 - 20ml of NH_4Cl-NH_4OH was and they were both titrate with EDTA disodium salt.

In the second flask for Ca determination with the seconnd blank flask, about 10-15ml each of NaOH was added both of them with a little quantity of miroxide indicator after which they were also both titrated with EDTA disodium salt.

3.8.2 DETERMINATION OF AVAILABLE BORON IN SOIL (HOT WATER EXTRACT)

APPARATUS:

Spectrophootometer, centrifuge, water bath poly prophylene, test tube, Boron free, flask and measuring cylinder.

Reagents:

Calcium chloride ($CaCl_2$) h-asorbic acid, Azomethinett, Ammonium acetate (NH_4O AC), Ethylene diaminetetra acetic acid disodium (EDTA - Na), Glacial acetic acid Boric acid (H_3BO_3).

Procedure:

20g of air dried 2mm sieved was weighed and 40ml of distilled water added. The mixture was then boiled for 5 minutes. A blank was determined by placing 40ml distilled water in the extraction flask and boiled for 5 minutes also and carried through all the steps as in soil the soil suspension was then transferred to a centrifuge tube, 2.4 drops of calcium chloride was added and the suspension centrifuged for 5 - 10minutes, filtration was carried out and 1ml of the supernatant was then taken for the test.

Into 1ml of the supernatant blank and Boron standards was added 2ml of buffer solution (mixture of NH_4O AC, EDTA-Na and glacial acetric acid) and mix. Then, 2ml of the Azomethine-H reagent was added into each and after 30mins, the absorbance was read at 420nm.

3.9.3 DETERMINATION OF CARBON AND BICARBONATE IN WATER

APPARATUS:

Flasks, Burette, Pipette

Reagents:

Sulphuric acid 0.05N (H_2SO_4), phenolpthalein indicator, methyl orange indicator.

Procedure:

50ml of the water sample was taken. Black was also taken 0.15ml of phenolpthalein indicator was added to each flask. No pin coloration was observed indicating no carbonate present. 0.1ml of methyle orange indicator was added and titrated against sulphuric acid to the first change in the methyl orange colour. Blank was also sum on the reagents.

3.9.4 DETERMINATION OF CHLORIDE IN WATER

APPARATUS:

Flask, Burette, Pipette

Reagents:

POTASSIUM CHROMATE ($K_2Cr_2O_4$), silver nitrate ($AgNO_3$)

Procedure:

To the solution used in the bicarbonate determination 1ml of the chromate indicator is added and the solution titrated with silver nitrate to the appearance of the first permanent red colouration. Blank is titration consisting of the same chloride free water.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION OF RESULT

The most basic element in research work is data or numerical information gathering, since knowledge depends basically on information and information depends heavily on survey.

Water quan›ity for irrigation is generally judged by its total salt concentration as measured by its electrical conductivity, relative proportions of cations as expressed by sodium adsorption ration (SAR) bicarbonate and boron content.

Soil chemical analysis should normally be regarded as providing chiefly 'Oroler-Of-Magnitude' results. Unless supplemented by detailed correlation from crop trials, such analysis be used for accurate fertilizer or management recommendations, and their main use is usually to indicate potential excess or deficiency problems in soils.

Soil and water samples were collected and analysed in the laboratory and the result were interprete below. About 40 households were surveyed in order to ascertain the existing activities (such as water quality for irrigation and human consumption and fish farming) sample techniques were adopted in the administration of questionnaire.

At the end of it all, the following information about the study area became vivid and analysed as follows and after which logical conclusion and scientific inferences were deduced from them.

TABLE 4.1: PHYSICAL PROPERTIES UPSTREAM

Sample	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture Class
D	0 - 20	63	24	13	Sandy loam
E	20 - 40	65	21	14	Sandy loam
F	40 - 60	66	19	15	Sandy loam
Mean		65	21	14	Sandy loam
Variance		1.53	2.52	1.00	
Standard Deviation ( )		1.25	2.05	0.82	

TABLE 4.2: PHYSICAL PROPERTIES DOWNSTREAM

Sample	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture Class
A	0 - 20	64	25	11	Sandy loam
B	20 - 40	65	23	12	Sandy loam
C	40 - 60	66	20	14	Sandy loam
Mean		65	23	12	Sandy loam
Variance		1.00	2.52	1.53	
Standard Deviation ( )		0.82	0.05	1.25	

4.2 pH MEASUREMENTS

The values of the pH measuremed at both upstream and downstream for soil bank (see Table 4.3 and 4.4 respectively) are very slightly acidic when diluted with water. Soil mean pH upstream was 6.4 and 5.4 when diluted with calcium chloride (CaCl2), with standard deviation and variance were 0.09 and 0.12 respectively and 0.14 and 0.17 when diluted with CaCl2. While the downstream pH mean, variance and standard deviation had 6.4, 0.12 and 0.09 when diluted with water and 5.3, 0.15 and 0.12 respectively when diluted with CaCl2.

The pH from water sample both in sample 1 and 2 had the same valves (upstream and downstream) as shown in Tabs 4.5 and 4.6, which is 6.5. Then, the water sample of the catchment area was very slightly acidic.

All the sample analysed were within the normal range of 5.5 to 7.0 which is recommended range for most crops (Table 4.7)

TABLE 4.3: CHEMICAL PROPERTIES OF THE SOIL UPSTREAM (04 - 04 - 2000)

Sample	Depth (cm)	pH 1.1		Org. Matter (%)	Total Nitrogen (%)	Exchangeable Cations mg/100gms				Available Phosphurous ppm	Boron (B) ppm
		H2O	CaCl2			Na	K	Ca	Mg		
D	0 - 20	6.5	5.6	3.32	0.19	0.04	0.30	1.58	3.00	168	1.8
E	20 - 40	6.3	5.3	1.82	0.11	0.04	0.11	3.00	2.40	50	2.3
F	40 - 60	6.3	5.3	1.32	0.07	0.03	0.09	3.20	0.50	66	2.2
Mean		6.4	5.4	2.15	0.12	0.04	0.17	2.59	2.00	95	2.1
Variance		0.12	0.17	1.04	0.06	0.006	0.12	0.88	1.31	64.01	0.26
Standard deviation ( )		0.09	0.14	0.85	0.05	0.005	0.09	0.72	1.07	52.26	0.22

TABLE 4.4: CHEMICAL PROPERTIES OF THE SOIL DOWNSTREAM (04 - 04 - 2000)

Sample	Depth (cm)	pH 1.1		Org. Matter (%)	Total Nitrogen (%)	Exchangeable Cations mg/100gms				Available Phosphurous ppm	Boron (B) ppm
		H2O	CaCl2			Na	K	Ca	Mg		
D	0 - 20	6.5	5.5	3.12	0.16	0.04	0.27	1.50	3.00	165	1.8
E	20 - 40	6.3	5.2	1.78	0.09	0.04	0.11	2.90	2.30	49	2.4
F	40 - 60	6.3	5.3	1.44	0.07	0.03	0.08	3.20	0.47	60	2.1
Mean		6.4	5.3	2.11	0.11	0.04	0.15	2.53	1.92	91	2.1
Variance		0.12	0.15	0.89	0.05	0.006	0.10	0.91	1.31	64.03	0.30
Standard deviation ( )		0.09	0.12	0.73	0.04	0.005	0.08	0.74	1.07	52.26	0.24

TABLE 4.5: CHEMICAL PROPERTIES OF WATER DOWNSTREAM

Sample	pH	Na ppm	K ppm	Ca ppm	Mg ppm	SAR	P mg/l	CO_3 mg/l	HCO_3	Cl mg/l
Downstream 14 - 04 - 2000	6.5	0.3	3	128	77		0.3	0	37	11

TABLE 4.6: CHEMICAL PROPERTIES OF WATER UPSTREAM

Sample	pH	Na ppm	K ppm	Ca ppm	Mg ppm	SAR	P mg/l	CO_3 mg/l	HCO_3	Cl mg/l
Upstream 14 - 04 - 2000	6.5	0.25	3	130	78		0.3	0	37	11

ummary of recommended routine soil chemical analyses and their interpretation

is	Recommended method(s)	Units	Rating	Range	General interpretation	Section reference
	1:2.5 soil:water suspension	-	Very high	> 8.5	Alkaline soils: Ca and Mg liable to be unavailable; may be high Na; possible B toxicity; otherwise as below:	7.5
			High	7.0-8.5	Decreasing availability of P and B to deficiencies at higher values. Above 7.0 increasing liability of deficiency of Co, Cu, Fe, Mn, Zn	Interpretation 7.5.3
			Medium	5.5-7.0	Preferred range for most crops; lower end of range too acidic for some	
			Low	< 5.5	Acid soils: possibly Al toxicity and excess Co, Cu, Fe, Mn, Zn; deficient Ca, K, N, Mg, Mo, P, S (and B below pH 5)	
	a) Unbuffered 1 M KCl at pH of soil b) Na or NH_4 acetate at pH 8.2, 7.0	me/100 g soil	Very high	> 40	Normally good agricultural soils - only small quantities of lime and K fertilisers required	7.6
			High	25-40		
			Medium	15-25	Normally satisfactory for agriculture, given fertilisers	Interpretation 7.6.3
			Low	5-15	Marginal for irrigation (FAO (1979a) quoted low is 8-10 me/100 g soil)	
			Very low	< 5	Few nutrient reserves. Usually unsuitable for irrigation, except rice	
	Calculation: total exchangeable bases/CEC	%	High	> 60	Generally fertile soils	7.6.4
			Medium	20-60	Generally less fertile soils	
			Low	< 20		
			Eutric	> 50		
			Dystric	< 50		
changeable cations						7.7
	As CEC	me/100 g soil	High	> 10	Response to Ca fertiliser expected at levels < 0.2 me/100 g soil. If high Na levels, response occurs with higher Ca levels	7.7.3
			Low	< 4		
	As CEC	me/100 g soil	High	> 4.0	Mg deficiency more likely on coarse, acidic soils. With high Ca, Mg is less plant available	7.7.4
			Low	< 0.5		
	As CEC	me/100 g soil	High	> 0.6	Response to K fertiliser unlikely. High K effects often similar to high Na, but depends on soil type - especially texture	7.7.5
			Low	< 0.2	Response to K fertiliser likely	
PP	Calculation: K^+/CEC	%	High	> 25%	Very approximate upper limit (cf ESP > 15%)) 1/	
			Low	< 2%	Very approximate lower limit)	
Na	As CEC	me/100 g soil	High	> 1)	Alkali or sodic soils 1/	7.7.6
ESP	Calculation: Na^+/CEC	%	High	> 15%)		
		%	High	> 15%	50% yield reduction for sensitive crops 1/	
				15-25%	50% yield reduction for semi-tolerant crops 1/	
				35%	50% yield reduction for tolerant crops 1/	
Al:CEC	1 M KCl unbuffered	%	High	> 85	Tolerated only by few crops	7.7.8
			Medium	30-85	Generally toxic	
			Low	< 30	Sensitive crops affected	

Source: Landon (1984).

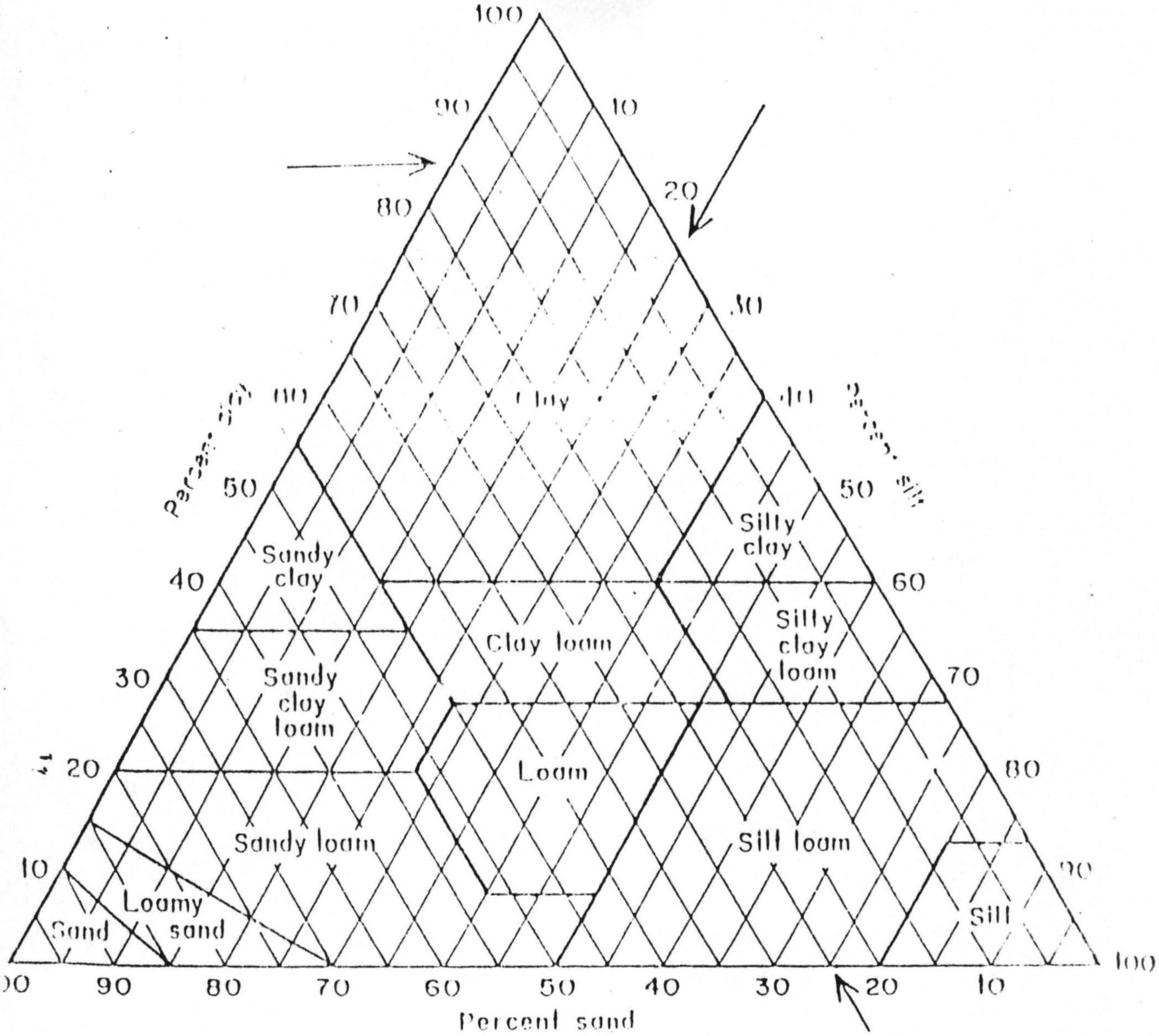

FIGURE 4. | The USDA soil triangle

4.3 SOIL TEXTURE

All the samples analysed were within the range of sandy loam as determine in the USDA soil triangle figure 4.1. The physical properties of both upstream and downstream had mean of 65% sand, 21% silt and 14% clay and 65% sand, 23% silt and 12% clay respectively as shown in Table 4.1 and 4.2. the range is suitable for almost all crops.

4.4 ORGANIC MATTER MEASUREMENTS

The valves of the organic matter measured at both upstream and downstream are in Tables 4.3 and 4.4. The mean, variance and standard deviation of the upstream (soil) are 2.11%, 0.89% and 0.73% respectively while that of downstream 2.15%, 1.04% and 0.85% respectively.

Sometimes organic carbon values are multiplied by a further factor to convert them to percent organic matter; one convention is to assume the organic carbon is 58% of total organic matter (conversion factor is 1.72). But in this ease, conversion has already done, to change it to organic carbon is by dividing your result with conversion factor. Then the mean will be 1.23% which is less than 2 and from Table 4.8 (rating table), we can see organic carbon of 1.23% range under very low. In this case, there is need of increasing the percentage organic matter for better growth of crops and is the chief sources of Nitrogen.

TABLE 4.8: BROAD RATINGS OF ORGANIC CARBON CONTENT

Organic C Content Walleley - Black Method (% of Soil by weight)	Rating
> 20	Very high
10 - 20	High
4 - 10	Medium
2 - 4	Low
< 2	Very low

Source: Landon (1984)

4.5 NITROGEN (N) MEASUREMENTS

The values of nitrogen in the soil observed to low was the mean percentage of the nitrogen was 0.11% and 0.12% of downstream and upstream respectively. From Table 4.9, we see all the samples (Tables 4.3 and 4.4) are rating under low. Nitrogen is very important to crops and its occurs in soils in several forms.

TABLE 4.8: BROAD RATINGS OF ORGANIC CARBON CONTENT

Organic C Content Walleley - Black Method (% of Soil by weight)	Rating
> 1.0	Very high
0.5 - 1.0	High
0.2 - 0.5	Medium
0.1 - 0.2	Low
< 0.1	Very low

Source: Landon (1984)

Organic compounds, nitrate and nitrite anions and ammonium ions, which can occur as exchangeable cations, nitrates are the main form of N used by plants. Landon (1984).

An adequate supply of N is associated with vigorous vegetative growth and dark green colour.

4.6 INTERPRETATION OF PHOSPHORUS (P) MEASUREMENT

From the Table 4.3 and 4.4, phosphorus can be observed as 91 and 95 ppm as mean for downstream and upstream respectively. It occurs in soil both organic and inorganic forms, the latter usually being the more important for crop nutrition. The values of P determined from the soil samples show it high concentration in the catchment area. Therefore, from table 4.10 determined by Olesen's method, we can see P is adequate.

TABLE 4.10: GENERAL INTERPRETATION OF AVAILABLE PHOSPHORUS DETERMINED BY OLESEN'S METHOD

Characteristics Crop Demand	Examples	Indicative Available P Values (ppm)		
		Deficient	Questinable	Adequate
Low P	Grass, Creals, Soyabeans, Maize	< 4	5 - 7	>8
Moderate P	Lucerne, Cotton, Sweet corn, Tomatoes	<7	8 - 13	>14
High P	Sugar beet, Sweet corn, Celery Onions	<11	12 - 20	>21

Source: Landon (1984)

4.7 EXCHANGEABLE CATIONS (Ca^{2+}, Mg^{2+}, Na^{+}, K)

4.7.1 CALCIUM (Ca) MEASUREMENTS

The values of calcium measured both in upstream and downstream are 2.59 and 2.53 mg/100gms respectively, with variance and standard deviation of each as 0.88 and 0.72 mg/100gms, 0.91 and 0.74 mg/100gns respectively. The high values of exchangeable Ca can be taken as those above 10mg/100gms soil Landon (1984), since what was gotten from our analyses was less than 10 (see Table 4.3 and 4.4) then, there is room for improvement.

4.7.2 MAGNESIUM (Mg) MEASUREMENTS

The means, variance and standard deviation of Mg measured at upstream and downstream were 2.0, 1.31 and 1.07 mg/100mgs, and 1.92, 1.31 and 1.07mg/100gms respectively as shown in Table 4.01 and 4.02. If rated, our result with exchangeable magnesium ratings table (that is Table 4.11), it rating high which indicate Mg is sufficient in soil.

The values of Mg in water samples (that is sample 1 and 2) also show sufficient of Mg in water (Table 4.5 and 4.6).

TABLE 4.11: <u>EXCHANGEABLE MAGNESIUM RATING</u>

Level		Rating	Comment
Mg/100g	ppm		
< 0.2	<30	Low	Quick-acting Mg fertilizers may be required
0.2 - 0.5	30 - 60	Medium	use Mg limestock when lime is needed
> 0.5	>60	High	Mg usually sufficient in soil

Source: Landon (1984)

When Mg is present in very much large amounts then Ca, the letter may become somewhat less available and soil structure become weaker due to increased deflocula tion of the clay; Landon (1984).

4.7.3 SODIUM (Na) MEASUREMENT

The values of Na both in upstream and downstream were the same in the soil, because the mean Na contained in both upstream and downstream were 0.04 and 0.04 mg/100gms as shown in Tables 4.3 and 4.4.

Also, the values observed in water samples and 2 (Tables 4.5 and 4.6) were 0.3 and 0.25 ppm respectively. Generally, the catchment area had less or no problem of salt accumulation in the soil and river (water) as shown in Table 4.7

Further important quantity is the sodium adsorption (SAR), which is used in estimation of water quantity and for calculating equilibrium exchangeable sodium percentage (ESP) values for soil under irrigation.

The SAR is defined as follows:

$$SAR = \frac{Na^{+}}{\sqrt{Ca^{2+} + Mg^{2+}}} \quad \text{.............. (4.1)}$$

Therefore, for water sample 1 and 2 (table 4.5 and 4.6) SAR is calculated below:

$$SAR_1 = \frac{0.3}{\sqrt{178 + 77}} = \frac{0.3}{\sqrt{102.5}} = \frac{0.3}{10.12}$$

$$\simeq 0.03$$

$$SAR_2 = \frac{0.25}{\sqrt{130 + 98}} = \frac{0.25}{\sqrt{104}} = \frac{0.25}{10.2}$$

$$= 0.025 \simeq 0.03$$

Therefore, SAR calculated was observed to be very small less than 0.1 from Table 4.12, we can see it rate on low sodium water (S1), which can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium.

Since carbonate (CO3) observed to be zero from analysed samples (Table 4.5 and 4.6) and the PHC was analysed not calculated, the ESP was then calculated from

Table 4.12 USDA classification of irrigation water sodicity (sulphate-free waters)

Sodium class and description	SAR
S1 Low sodium water can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops may accumulate injurious concentrations of sodium	< 10
S2 Medium sodium water will present an appreciable sodium hazard in fine-textured soils having high cation-exchange capacity, especially under low leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability	10-18
S3 High sodium water may produce harmful levels of exchangeable sodium in most soils and will require special soil management - good drainage, high leaching and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacment of exchangeable sodium except that amendments may not be feasible with waters of very high salinity	18-26
S4 Very high sodium water is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible	> 26

$$ESP = \frac{100(0.01475SAR-0.0126)}{0.01475SAR+0.9874} \quad ....4.2$$

Landon (1984. Residual Sodium Carbonate (RSC) is defined as

$$RSC = (Co_2+HCo_3) \quad -[Ca_2+Mg_2+] \quad .... 4.3$$

The ESP and RSC was found to be less than zero, which are negligible.

From Table 4.13 ESP our reading was rate under saline soils which indicated non-sodic soils containing sufficient soluble salts to interfere with growth of most crops. While RSC was rate under water probably safe for irrigation as interpreted in the appendix.

4.7.4 POTASSIUM (K) MEASUREEMENTS

The means values of K in samples analysed (Table 4.3 and 4.4), observed to be 0.15 and 0.17mg/100gm, which rated in rating Table 4.7 to be low. However, it should be remembered that exchangeable K levels usually after when the soil are dried. In general terms, therefore, a response to K fertilizer is likely when a soil has an exchangeable K value of below about 0.2mg/100gms. As a general rule, samples with large amounts of available K lose some by fixation and those with low amounts have their exchangable k augmented from sources that are non-available in the field; Landon (1984).

Table 4.13: USDA classification of salt-affected soils

Soil	EC_e (dS cm^{-1})	ESP	pH	Description
Saline soils	> 4	< 15	Usually < 8.5	Non-sodic soils containing sufficient soluble salts to interfere with growth of most crops
Saline-sodic soils	> 4	> 15	Usually < 8.5	Soils with sufficient exchangeable sodium to interfere with growth of most plants, and containing appreciable quantities of soluble salts
Sodic soils	< 4	> 15	Usually > 8.5	Soils with sufficient exchangeable sodium to interfere with growth of most plants, but without appreciable quantities of soluble salts

Source: Landon (1984).

4.8 AVAILABLE BORON (B)

A mean value of Boron observed in the soil upstream and downstream to be 2.1 ppm for both soil. From the rating table (Table 4.14), observed B range between 1.5 - 3ppm (under hot water extractable) which is satisfactory for most crops.

TABLE 4.14: INDICATIVE RATING OF SOIL BORON LEVEL IN THE ABSENCE OF HIGH CALCIUM CONTENTS.

B Concentration (ppm)		Category
saturated extract	Hot water extracable	
-	<1	Possible deficient
-	1 - 1.5	Border line fr deficiency
0.5	1.5 - 3	satisfactory for most crops
0.5 - 5	3 - 6	Possibly toxic, depending on crop sensitivity
>10	>6	Toxic to meet crops

Source: Landon (1984)

Deficiencies in B are commonly encountered with light - textured acid soil are leached drastically by rain or irrigation, or are limed. Liming can, however, decrease toxicity symptoms in plants grown on high B soils, which has led to speculation about a possible chemical interaction between calcium and barate, $(B(OH)_4$. It appears that plants only grow normally when a critical balance exists in the taken of Ca + B (Landon, 1984).

4.9 CHLORINE (Cl) MEASUREMENTS

From the samples analysed (Table 4.5 and 4.6), observed that Cl had 11mg/l, which is less than 60ppm, then the rating table (table 4.15) show that for Cl less than 600 ppm, the water is free or low salinity water (C_1) can be used for irrigation with most crops on most soils. With little likelihood that a salinity problem will develop.

4.10 CARBONATE (CO_3^{-2}) MEASUREMENT

When CO_3^{-2} range between 0 to 0.005 is slightly affected; between 0.005 to 0.01 moderately affected; and strongly affected greater than 0.01 Landon (1984). From our samples analysed (Tables 4.5 and 4.6) CO_3^{-2} is zero (0), therefore, CO_3^{-2} is slightly affected.

4.11 CONSUMER PERCEPTION OF DRINKING WATER QUALITY

In assessing the quality of drinking water the consumer relies completely upon his senses. Water constituent may affect the appearance, smell, or the taste of the water and the consumer will evaluate the quality and the acceptability essentially on these criteria. Water that is highly turbial, highly coloured, or has an objectionable

Table 4.15 USDA classification of irrigation water salinity (sulphate-free waters)

Salinity class and description	EC range ($\mu S\ cm^{-1}$)	Equivalent salt concentration (approximate) TDS 1/ ($g\ \ell^{-1}$)	TDS 1/ (ppm)	Cl (ppm)
C1 Low salinity water can be used for irrigation with most crops on most soils, with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices, except in soils of extremely low permeability	< 250	< 0.2	< 200	< 60
C2 Medium salinity water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control	250 - 750	0.2 - 0.5	200 - 500	60-200
C3 High salinity water cannot be used on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected	750 - 2 250	0.5 - 1.5	500 - 1 500	200-600
C4 Very high salinity water is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected	> 2 250	1.5 - 3.0	> 1 500	> 600

Source: Landon (1984)

taste will be regarded as dangerous and will be subjected for drinking purposed s. However, we can no longer rely entirely upon one sense in the matter of quality judgement. The absence of any adverse sensory effects does not guarantee the safety of water for drinking. However, from one water samples analysed show in Table 4.5 and 4.6. The following chemical fall under desirable level they are: Mg, Cl, CO_3, Na and K while pH and Ca fall under maximum permissible level. The taste and odour are unobjectionable. Therefore, the rivers water is fairly okey recommended standard for WHO and Swan as shown in Table 4.16 and figure 4.2.

The primary aim of the guidelines for drinking water quality is the protection of public health and thus the elimination, OC reduction to a minimum of constituent of water that are known to hazardous to the health and well being of the commonly.

4.12 DISCHARGE OF POLLUTANTS INTO WATER RECEIVING BODIES.

Oral interview of the farmers along the bank revealed that only 7.5% of them noticed oil entering the river at Izom after Izom bridge from one of the distributries Such pollutant are not only objectionable

Table 4.16 **STANDARD FOR PHYSICAL AND CHEMICAL QUALITY OF DRINKING WATER. WHO RECOMMENDED STANDARD.**

QUALITY	HIGHEST DESIRABLE LEVEL	MAXIMUM PERMISSIBLE LEVEL
PHYSICAL		
Turbidity (Jtu-units)	5	25
Colour (on platinum cobalt siale)	5 Hazen	50 Hazen
Taste and colour	Unobjectionable	-
CHEMICALl		
Ph	7.0 - 8.5	
Dissolved solids	500mg/l	6.5 - 9.2
Suspend solids	500mg/l	1500mg/l
Total hardness	100mg/l as Ca Co_3	-
Calcium	75 mg/l	500mg/l as Ca Co_3
Magnesium	150mg/l	200mg/l
Iron	0.05mg/l	1500mg/l
Manganese	0.1mg/l	1.5mg/l
Copper	0.05mg/l	1.0mg/l
Zinc	5.0mg/l	15.0mg/l
Chloride	200mg/l	600mg/l
Sulphate	200mg/l	400mg/l
Phenolic substance (as phenol)	0.00mg/l	0.002mg/l
Cyanide	0.05mg/l	0.1mg/l
Bicarbonate	500mg/l	-
Load	0.1mg/l	0.1mg/l
Sodium	-	-
Potassium	-	-
Amion Detergents	0.2mg/l	1.0mg/l
Mineral oils	0.01mg/l	0.3mg/l
Source: Karath (1987).		

in water but a threat to agriculture cultivation, all (irrigation and fish fauna). This problem is getting worse and worse though the people of the area are not noticing it. Due to the fact that the effect are not noticing very easily it will take time before the advance effect of this pollution can be noticed. The phootos of the effecting side of the pollutants discharge by the Izom pump station are shown in appendix.

4.13 METHOD OF PRACTICE

Almost all the farmer around the catchment area practices border method of irrigation. The basic reason or objective for this method of irrigation is to advance a sheet of wtaer down the narrow strip of land, allowing it to enter the soil as the sheet advances. Provision is mde during such that as nearly as possible, the required amount of water must have been delivered to the border by the time it approaches the end of stop. This methid has wide adaptability and it not suitable for fine texture soils nwith low intake salt.

Majority of the farmers uesed family labour for farm management while others used hired labour to compliment that of the family.

4.14 AVAILABILITY OF WATER FOR IRRIGATION FARMING

The values of daily water stages of the River Gurara at Izom were attached in appendix including the calculation discharge and the oral interview (questionnaire) shown that the water is available for irrigation purposes in the area. No farmer complained of short water in the catchment area.

CHAPTER FIVE

5.1 CONCLSUI0N AND RECOMMENDATION

5.1.1 CONCLUSION

In general analysis of water and soil alone river bank shown no variation in the concentration of micro-elements. The observation indicated that the water and soil possessed good quality for irrigation purposes, but certain measures have to consider to improve the soil structure that become weaker due to increased defloculaiton of the clay resulting from high amount of high amount of Mg.

However, the pump station of NNPC at Izom discharge their pollutants into the River Izom and the likelihood of minor leakages can contributed to depressed crops yield and fish fuana in the catchment area as complained by the most down stream farmers.

In general the river water is much available even for additional farm plots but there is need for proper water management to enable the farmers use the water throughout the year without shortage.

Furthermore, this work is not exhaustive, there is still room for further research to take place most especially in the area (most down stream) where farmers complained of low crop yield, as well as low production of fish in the catchment.

5.1.2 RECOMMENDATION

From the result of the analysis of the water and soil along the river bank, there is need to take measures on how to conditioned the soil and prevent some measures too. The following are some of the recommendation to check these effects.

1. Niger State water board and Niger River Basin development authority should install gauge stations for proper monitoring of the River and a better and trained staff should be employed in any zone, so that data should be up to date.

2. The FEPA and state environmental protection agency should complement it laws to the NNPC or any company that will be attract with the natural and human resources of the area, incase of valuating the law.

3. The farmers along the river bank should used the following fertilizer to conditioned their soil.

   - There is need to increase the Ca by using Ca-fertilizer because from the analysis the soil structure become weaker due to increased defloculation of the clay resulting form high amount of Mg.

- nitrogenous fertilizers should also increase or use in the catchment area as is the chief sources of organic matter (e.g Uria fertilizer) and
- promoting micro-organisms activities. This can be done by using manure.

4. The farmers of the area should be guided very well on modern agriculture techniques by the agric extension workers (by using good and improved varieties of crops and fishes). Determine when and how much water to apply and the best crop to cultivate.
5. In most cases to apply water from channel in to the farm fields (more particularly February and March where the level are so low) it is quite necessary to raise the water level in order that siphon tubes or pipe turn out may be used efficiently. Check gates can be used for the purposed mention above
6. The local government should educate Izom people on the impact of discharge sewage to the river and water should be boiled and filtrated before consumption
7. Damming of the River Gurara at Izom will help increasing both crops and fish production.

8. Bore holes should also increase in numbers to reach the peoples demand and quality or biological treatment plant should be constructed.

9. There is need of setting up a multi disciplinary organisation that could be held fully accountable for the results in respect of production. A suitable monitoring and diagnostic analysis team along a performance auditing group will assess the target achieved, examine why, if any, the achievements are lower than the target and account for the short fall.

10. The NNPC should be mandated to treat their pollutants before discharging it into the river and regularly checking their pipes to avoid minor leakages which can lead to major ones.

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APPENDIX

APPENDIX

Date:

b (width) is measured to be = 123.6m

d (depth) is varies but shown in water stage paper.

Therefore, the maximum d obtained since from 1985 to 2000 and the minimum of d obtained from the same years will be used for calculating our area (A).

$Q = AV$ (minus formular)

where A = area and

V = Velocity

Maximum $d_{(1985)} = 4.64m$

Minimum $d_{(1985)} = 0.12m$

$$\text{Max } A_{(1985)} = (b + 2d)d$$

$$= [123.6 + 2(4.64)]4.64$$

$$= 616.5632m^2$$

$$\text{Min } A_{(1985)} = (b + 2d)d$$

$$= [123.6 + 2(0.12)]0.12$$

$$= 14.8608m^2$$

$Q = AV$ (minus formular)

∴ To determine V Biro case used to allowed it to follow flow for certain distance and stop watch was also used to determined time taking to reach the point. Distance (d) = 22m, & t (time taking) = 52s

$$V = \frac{d}{t} = \frac{22.0}{52} = 0.4231 m/s$$

$$\therefore Q_{max} = A_{max} \times V$$

$$= 616.5632 \times 0.4231$$

$$= 260.8679 m^3/s$$

$$Q_{min} = A_{min} \times V$$

$$= 14.8608 \times 0.4231$$

$$= 6.2876 m^3/s$$

<u>FOR 1986</u>

$d_{max} = 5.00m$, $d_{min} = 0.24m$ $V = 0.4231 m/s$

$$\therefore A_{max} = (b + 2d)d = [123.6 + 2(5.00)]5.00$$

$$= 668.00 m^2$$

$$A_{min} = (b + 2d)d = [123.6 + 2(0.24)]0.24$$

$$= 29.7792 m^2$$

$\therefore \quad Q_{max} = A_{max} \times V = 668.00 \times 0.4231$

$= 282.6308m^3/s$

$Q_{min} = A_{min} \times V = 29.7792 \times 0.4231$

$= 12.5996m^3/s$

FOR 1987

$d_{max} = 4.67m, \quad d_{min} = 0.11m$

$A_{max} = [123.6 + 2(4.17)]4.17 = 620.829800m^2$

$A_{min} = [123.6 + 2(0.11)]0.11 = 13.6202m^2$

$\therefore \quad Q_{max} = 620.8298 \times 0.4231 = 262.6731m^3/s$

$Q_{min} = 13.6202 \times 0.4231 = 05.7627m^3/s$

FOR 1988

$d_{max} = 5.40m, \quad d_{min} = 0.02m$

$A_{max} = [123.6 + 2(5.40)]5.40 = 725.7600m^2$

$A_{min} = [123.6 + 2(0.02)]0.02 = 02.4728m^2$

$\therefore \quad Q_{max} = 725.7600 \times 0.4231 = 307.0691m^3/s$

$Q_{min} = 02.4728 \times 0.4231 = 01.0462m^3/s$

FOR 1989

d_{max} = 5.29m, d_{min} = 0.07m

A_{max} = [123.6 + 2(5.29)]5.29 = 709.8122m^2

A_{min} = [123.6 + 2(0.07)]0.07 = 08.6618m^2

∴ Q_{max} = 709.8122 x 0.4231 = 300.3215m^3/s

Q_{min} = 08.6618 x 0.4231 = 03.6648m^3/s

FOR 1990

d_{max} = 5.98m, d_{min} = 0.46m

A_{max} = [123.6 + 2(5.98)]5.98 = 810.6488m^2

A_{min} = [123.6 + 2(0.46)]0.46 = 57.2792m^2

∴ Q_{max} = 810.6488 x 0.4231 = 342.9855m^3/s

Q_{min} = 57.2792 x 0.4231 = 24.2348m^3/s

FOR 1991

d_{max} = 5.88m, d_{min} = 0.25m

A_{max} = [123.6 + 2(5.88)]5.88 = 795.9168m^2

A_{min} = [123.6 + 2(0.25)]0.25 = 31.0250m^2

$\therefore \quad Q_{max} = 795.9168 \times 0.4231 = 336.7524 m^3/s$

$Q_{min} = 31.0250 \times 0.4231 = 13.1267 m^3/s$

<u>FOR 1992</u>

$d_{max} = 5.82m, \quad d_{min} = 0.29m$

$A_{max} = [123.6 + 2(5.82)]5.82 = 787.0968 m^2$

$A_{min} = [123.6 + 2(0.29)]0.29 = 36.0122 m^2$

$\therefore \quad Q_{max} = 787.0968 \times 0.4231 = 333.0207 m^3/s$

$Q_{min} = 36.0122 \times 0.4231 = 15.2368 m^3/s$

<u>FOR 1993</u>

$d_{max} = 5.63m, \quad d_{min} = 0.20m$

$A_{max} = [123.6 + 2(5.63)]5.63 = 759.2618 m^2$

$A_{min} = [123.6 + 2(0.20)]0.20 = 24.8000 m^2$

$\therefore \quad Q_{max} = 759.0207 \times 0.4231 = 321.2437 m^3/s$

$Q_{min} = 24.8000 \times 0.4231 = 10.4929 m^3/s$

FOR 1994

d_{max} = over flooded cannot be determined

d_{min} = 0.00 (The area and discharge the same with the d_{min} above

FOR 1995

d_{max} = 5.35m, d_{min} = 0.18m

A_{max} = [123.6 + 2(5.35)]5.35 = $718.5050m^2$

A_{min} = [123.6 + 2(0.18)]0.18 = $22.3128m^2$

∴ Q_{max} = 718.5050 x 0.4231 = $303.9995m^3/s$

Q_{min} = 22.3128 x 0.4231 = $9.4405m^3/s$

FOR 1996

d_{max} = 5.98m, d_{min} = 0.10m

A_{max} = $810.6488m^2$ and Q_{max} = $342.9855m^2$

A_{min} = [123.6 + 2(0.10)]0.10 = $12.3800m^2$

Q_{min} = 12.3800 x 0.4231 = $5.2380m^3/s$

FOR 1997

d_{max} = 5.46m, d_{min} = 0.28m

A_{max} = [123.6 + 2(5.46)]5.46 = $734.4792m^2$

A_{min} = [123.6 + 2(0.28)]0.28 = $34.7648m^2$

$\therefore$ Q_{max} = 734.4792 x 0.4231 = $310.7581m^3/s$

Q_{min} = 34.7648 x 0.4231 = $14.7090m^3/s$

FOR 1998

d_{max} = 5.78m, d_{min} = 0.86m

A_{max} = [123.6 + 2(5.78)]5.78 = $781.2248m^2$

A_{min} = [123.6 + 2(0.86)]0.86 = $107.7752m^2$

$\therefore$ Q_{max} = 781.2248 x 0.4231 = $330.5362m^3/s$

Q_{min} = 107.7752 x 0.4231 = $45.5997m^3/s$

FOR 1999/2000

d_{max} = 4.98m, d_{min} = 0.21m

A_{max} = [123.6 + 2(4.98)]4.98 = $665.1288m^2$

A_{min} = [123.6 + 2(0.21)]0.21 = $26.0442m^2$

$\therefore \quad Q_{max} = 665.1288 \times 0.4231 = 281.4160 m^3/s$

$Q_{min} = 26.044 \times 0.4231 = 11.0193 m^3/s$

Therefore, the maximum discharge ever observed were on 13-08-1994 and 08-09-1994 on which the river over flood and destroyed peoples farms crops, shelters, animals, human and properties. While the minimum discharge ever observed were on 19-03-1989 and 20-03-1989 where the discharge was calculated to be $1.0462 m^3/s$.

$\therefore$

PLATE3: IMPACT OF THE EFFLUENTS TO THE FARM LAND[2].

PLATE4: DRAINED EFFLUENTS FINALLY INTO RIVER IZOM.

PLATE 1: EFFLUENTS DISCHARGE FROM IZOM PUMPING STATION

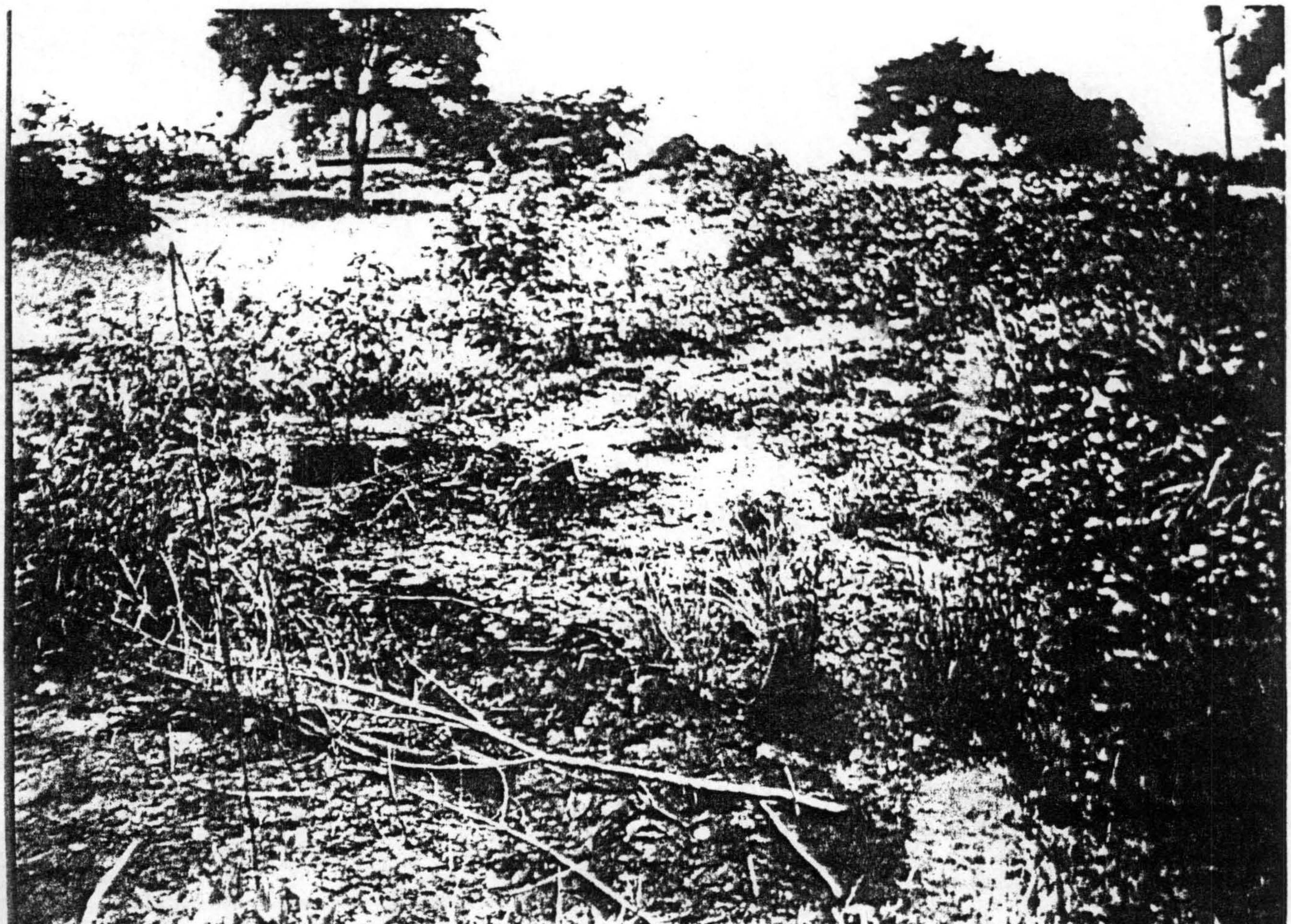

PLATE 2: IMPACT OF THE EFFLUENTS TO THE FARMLAND [I]

WATER-STAGE

IN CENTIMETERS (METERS)

1999 / 2000

HYDROLOGICAL YEAR

CODE NUMBER

STATION: IKOM

GAUGE DATUM

METERS ABOVE MEAN SEA LEVEL

RIVER/LAKE: GURARA

	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MA
1	0.86	0.82	0.99	4.98	1.99	3.79	2.97	3.72	1.84	1.72	0.42	0.31
2	0.86	0.81	0.98	4.78	1.98	3.77	2.96	3.70	1.84	1.72	0.41	0.31
3	0.86	0.99	0.98	2.97	1.97	3.89	2.99	3.63	1.83	1.71	0.41	0.30
4	0.86	0.98	0.97	2.99	1.96	3.88	3.99	3.55	1.83	1.71	0.40	0.30
5	0.85	0.97	0.97	2.98	2.98	3.87	3.98	3.54	1.82	1.70	0.40	0.30
6	0.85	0.96	0.96	2.97	2.97	3.85	3.97	3.52	1.82	1.70	0.39	0.29
7	0.85	0.96	0.99	2.97	2.96	3.99	3.96	3.50	1.81	1.70	0.39	0.29
8	0.85	0.95	0.99	2.99	2.96	4.59	3.95	3.49	1.81	1.69	0.39	0.28
9	0.84	0.95	0.98	3.99	2.93	4.44	3.93	3.48	1.81	1.69	0.38	0.28
10	0.84	0.94	0.96	3.89	2.99	4.43	3.86	3.45	1.81	1.68	0.38	0.28
11	0.84	0.96	1.95	4.89	2.98	4.42	3.85	3.43	1.80	1.68	0.38	0.27
12	0.83	0.96	1.60	3.88	2.98	4.40	3.83	2.99	1.80	1.67	0.37	0.27
13	0.83	0.95	1.25	3.79	2.97	3.99	3.82	2.98	1.79	1.67	0.37	0.27
14	0.82	0.94	1.29	4.82	4.98	4.55	3.81	2.96	1.79	1.66	0.37	0.27
15	0.82	0.94	1.28	4.78	4.98	4.52	3.79	2.94	1.78	1.66	0.36	0.26
16	0.82	0.93	1.28	4.78	4.97	4.50	3.79	2.92	1.78	1.65	0.36	0.26
17		0.93	1.27	4.77	4.96	4.55	3.78	2.91	1.78	1.65	0.36	0.26
18		0.92	1.27	4.75	4.95	4.54	3.76	2.90	1.77	1.64	0.36	0.26
19		0.98	1.28	4.74	4.95	4.53	3.75	1.99	1.77	1.64	0.36	0.25
20		0.98	1.26	4.99	4.94	3.99	3.74	1.99	1.76	1.64	0.35	0.25
21		0.98	1.26	4.98	3.99	3.98	3.74	1.98	1.76	1.63	0.35	0.25
22		0.99	1.24	4.96	3.98	3.94	3.72	1.97	1.76	1.63	0.34	0.24
23		1.08	1.23	3.88	3.97	3.92	3.72	1.97	1.75	1.62	0.34	0.24
24		1.08	1.23	3.87	3.96	3.91	3.73	1.96	1.75	1.62	0.34	0.24
25		1.07	1.22	3.86	3.96	2.99	3.72	1.96	1.75	1.61	0.33	0.23
26		1.07	1.29	3.79	3.95	2.99	3.72	1.96	1.74	1.61	0.33	0.23
27		1.06	1.29	4.99	3.94	2.98	3.74	1.95	1.74	1.60	0.32	0.23
28		1.06	1.28	4.98	3.93	2.97	3.73	1.95	1.73	1.60	0.32	0.22
29		1.05	2.99	5.99	3.99	2.99	3.72	1.95	1.73	1.59	0.31	0.22
30		1.04	2.99	5.99	3.99	2.98	3.71	1.95	1.72	1.59	X	0.22
31	X		X	5.98	3.98	X	3.71	X	1.72	1.58	X	0.21
Max												
Min												

HYDRO-YEAR

	Value		TIME	DAY.Month.YEAR	TIME	DAY.Month.YEAR
MAXIMUM	4.98	m	h	14.08.1999	h	15.08.1999
MINIMUM	0.21	m	h	31.03.2000	h	. .

HL-04 EVER OBSERVED

	Value		TIME	DAY.Month.YEAR	TIME	DAY.Month.YEAR
MAXIMUM	Ø/Flood	cm	h	13.08.1994	h	08.09.1994
MINIMUM	0.02	m	h	19.03.1989	h	20.03.1989

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