DESIGN AND EVALUATION OF BORDER IRRIGATION ON GUSSORO AWULO MODEL FARM

BY

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YEAR. 2000

CERTIFICATION

ABDULRAHAMAN BABA, a post graduate student in the Department of Agricultural Engineering with Reg. No PGD/AGRIC/98/99/47 has satisfactorily completed the requirements for the course and project works for the award of Postgraduate Diploma (PGD) in Agricultural Engineering.

The work embodied in this project report is original and has not been submitted in part or full for any other Diploma or Degree of this or any other University.

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Date: Year 2000

DEDICATION

I dedicate this project to my late father Mallam Baba Na Mallam Bida who introduced me to Western Education but has not lived to reap the fruit of his labour.

May his gentle soul rest in perfect peace, Amen.

ACKNOWLEDGMENT

I wish to express my sincere appreciation and gratitude to Allah-suba- Anahu wota Alla for giving me the wisdom coupled with sound health to pursue and complete the course of study.

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My profound gratitude to my beloved wives, children, my mother and also my elder brother Alh. Saidu Baba for their moral support through the period of studies.

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ABSTRACT

This project report presents the design and evaluation of border irrigation on Gussoro Awolu Model farm, Introduction, objectives and importance of the studies our presented. Literature review and description of the study are also presented. Full information about the location, topography, climate, hydrology and hydrogeology are also included. Soils and water analysis of the study area were carried out. In the report, the methodology, site selection and levelling work carried out are highlighted. Design, construction, results and discussions are also part of this report. We have also presented the results of field evaluation and interpretation as well as the laboratory tests. Cost analysis, conclusions and recommendations form last part of the project report.

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CHAPTER 1

1.0 INTRODUCTION

Agriculture based entirely on rain fall is a high rish business. This is because we don't have rainfall at the required amount all the year round. Therefore irrigation agriculture is necessary. Irrigation water is supplied to augment the water available from rainfall and the contribution to soil moisture from ground water for the purpose of crop production. In many areas of the world, especially the arid regions, the amount and timing of the rainfall are not adequate to meet the moisture requirement of crops. Therefore irrigation is essential to raise crops in order to meet the food needs of the people and to provide pasture for livestock.

Irrigation is an old age art, as old as civilization (Michael, 1978) and the increasing need for crop production for the growing population is causing the rapid expansion of irrigation throughout the world. Irrigation is basically an agricultural operation, supplying the water need of plants. To agriculturists it is a component of successful crop husbandry in a dry climate ranking in importance with application of fertilizer the control of needs and destructive pests, cultivation, and the provision of drainage. It does not function in isolation but defends on the other operations in a beneficial or harmful manner based on the skill with which it is carried out. For example, irrigation can function in harmony with the drainage system to provide a moist aerated- soil ideal for plant roots, or it can over load the drainage system and eventually destroy it. Similarly, water which is correctly applied makes nutrients readily available to the plant but water applied excessively leaches nutrients from the soil.
In many countries, agricultural land and water source are widely separated. The conveyance of water requires extensive and costly

If one of the resources, such as land or water, were severely limited then optimum yield might be defined in terms of that alone. The important step is that the purpose of an irrigation development be clearly decided before the design begins. As such the followings are the objective of the study.

1. To design a suitable Border irrigation net work and suggest appropriate recommendations from the findings of the study.
2. To determine how to come up with maximum benefit in terms of yield and land management.
3. To bridge the idle period between the raining season and dry season in order to occupy the farmers all the year round.

1.2 IMPORTANCE OF THE STUDY.

The majority of the farmer are yet to know the use of irrigation system in the area. At present the farmers in the area are usually idle during the dry season.

The irrigation scheme is new in the place and the indigenous farmers are yet to start the new system even though the Niger State Government is willing to help them by providing some equipment and other facilities. Farmers from other States, like Kano, Kaduna and Sokoto are the ones practising the irrigated agriculture. Therefore my interest is to stimulate awareness in the farmers with a view to encouraging them.

1. To make best use of the water from the down stream of the Shiroro dam.
2. To increase food production in the area and State at large.
3. To improve their economic well being
4. To improve on the irrigation system being adopted presently by the dry season farmers in the area in order to get maximum yield.

The minimum plot size is calculated on the basis of economic viability: the size that provides the farming household with a cash income that is deemed socially acceptable and generates a marketable surplus (Diemer and Speelman, 1990). The farming model employed is that of the profit maximizing producer. Hence, planners and designers tend to assume that irrigated agriculture is the most profitable form of agriculture. Consequently, they expect farmers to give it priority when it comes to the input of labour and other resources. This reasoning is linked to the assumption that irrigated agriculture replaces rather than complements the so-called traditional agriculture. This is a common assumption especially with regard to larger schemes. In some cases farmers do behave like market oriented agricultural profit maximizers. In a scheme on mount Kili Manjaro, Tanzanian farmers who grew coffee switch to other crops after a fall of international coffee price. In a scheme in Kenya, when farmers were given opportunity to grow tobacco as a cash crop, they switched to vegetables for export, which was more profitable. (Vaughn E.H, O.W Israelsen, G.E Stringham (1979)

The rationality of African farmers is seldom so straight - forward. The strongest deviation from plot use, as intended in project plans, occurs when farmers use the water for other purposes and not to grow crops. In another scheme in Cameroon, the lake created by a dam was used for fishing. Farmers found this a more interesting activity than the irrigated agriculture down stream of the dam envisaged by the planners. (Vaughn E.H, O.W Israelsen, G.E Stringham (1979) . In another case in Keyan, Masai livestock keepers managed to secure fonds for an irrigation system through political pressure. It turned out that they did not want the scheme for irrigating crops, but for watering cattle. (Vaughn E.H, O.W Israelsen, G.E Stringham (1979). Commercial crops such as cocoa, and rubber have all been given considerable attention by researchers over years, mainly, perhaps, because these kinds of crops have been the principal source of foreign exchange for many sub-saharan African nations.

water available to the farmer in certain localities. However, due attention has not been paid to building the necessary on-farm irrigation and drainage infrastructure and to improving water management and allocation practices. In many developing countries man exists in arid and semi-arid areas of erratic rainfall where irrigation is a must to produce crops and stabilize agricultural production. But irrigation has some serious implication. The implications and hazards of irrigation technology, particularly in large scale irrigation projects have necessitated the need for field drainage and land reclamation.

Some of these implications are as follows:-

a. Major irrigation projects have a profound effect on the farming community.

b. They also have an attenuated effect spreading through the towns and cities of the region, especially if irrigation on the large scale is newly introduced and there is no renovation or development of the existing schemes.

c. The economic and social patterns of life may be radically altered over a few short years.

d. Nomadic people may be settled, ancient values and customs set aside, and money-consciousness appear where none existed.

Those in authority must be awake to all the implications of a proposed irrigation development before deciding to proceed.

3.3 CLIMATE OF THE STUDY AREA

The climate of the project area is considered as one of its resources. In many countries the local meteorological service is able to provide long-term climatological data. Ideally this includes daily or even continuous measurements of rainfall, temperature, humidity, hours of sunshine and evaporation, but methods have been developed which make use of limited information. But in this work enough of these information were available and were used.

The climate of the project area is generally characterised by distinct wet and dry seasons. The wet season occurs from April to October. The dry season, for a period is usually marked by harmattan conditions prevailing for several days, lasting from October to March. The area consists mainly of Savannah vegetation. The project area belongs to the southern Guinea zone, type or transition woodland. This is in accordance Keays' classification indicated in the agroclimatological Atlas of Northern States of Nigeria (Keays, 1980). The dry season from October to April is accompanied by high temperatures. The possibilities of growing crops decrease considereably except for certain hot season crops. During the wet season and tempered heat, favourable conditions exist for a certain range of crops to be grown during six months between April and October.

Kaduna River Basin was subjected to a pre-feasibility study, carried out by Niger Agricultural promotions company Ltd in 1978 for the Niger River Basin development Authority. This involved reconnaissance study of the area. The pre-feasibilty report has been studied and in conjunction with photo- interpretation of the 1:25,000 scale photographs and inspection of the area. The following paragraphs describe the soils of the area. Generally the area is undulating and gossed by a tracery of multiple streams and their tributaries. There are a number of rocky hills mainly to the east of the basin. The hills have a maximum height of 200m above the general surroundings with maximum altitude in the range of 500m.

Hydrological suvey is undertaken to asssess the water resources available to the proposed project. Long-term records of river flows and water quality are required. All these have already been caricd out by the National Electric Power Authority. River Kaduna is the major source of watersupply to the project area although, there are other minor streams within the vicinity. The flow of there streams are seasonal and not enough to be used for irrigation during the dry season. The project is underlain by the basement complex.

This information has been produced from geological map of Nigeria produced by geological survey in 1974. About Ninety percent of the project area is covered by the undifferented basement and is sandwiched between two areas of older granite, undifferentiated metal sediment. The basement complex includes the oldest Known rocks in Nigeria and is an igneous of granitic rock, mignatite, gneiss and schist which has been faulteed, folded, intruded by quarts and dykes ranging from pegmatite to bafalt, metamorphosed in saveral stages and remobiliged in places. The end result is generally very hard crystalline rock which many grade imperceptibly from granite into gneiss or schist and back again, and in which major discontinuities appear to relatively unimportant.

The three physiographic elements that dominates the project of area are:-

(a) Dissected terrain

(b) Undulating plains

(c) Hills.

This information was extracted fram the feasibility studies of Esse Valley Irrigation Project and Jibwa Valley Development project carried out by Arewa Consultancy Centre Kaduna and BEACON SERVICES KANO respectiuely for Niger River Basin and Reral Developement Authority, Minna in 1980.

behaviour of water in the pore space, the properties of the bounding surfaces and on the mechanisms which supply plant nutrients both to the water in these channels and also to the solid surfaces. Soil structure is used to describe both the sizes and shapes aggregates of soil particles clustered together and also the distribution of pores brought about by this clustering. The power of forming clods and crumbs resides partly in the organic matter and partly in the mineral parties of smallest size, of which a relatively small percentage sufficies.

The stucuture of the soil is very important in aeration, water percolation, drainage and growth of plant roots. Good soil structure enhances adequate aeration, improves water holding capacity of the soil, allows for unimpeded growth of plant roots and encourages good drainage. It also contributes to optimum working (tilling) of the soil.

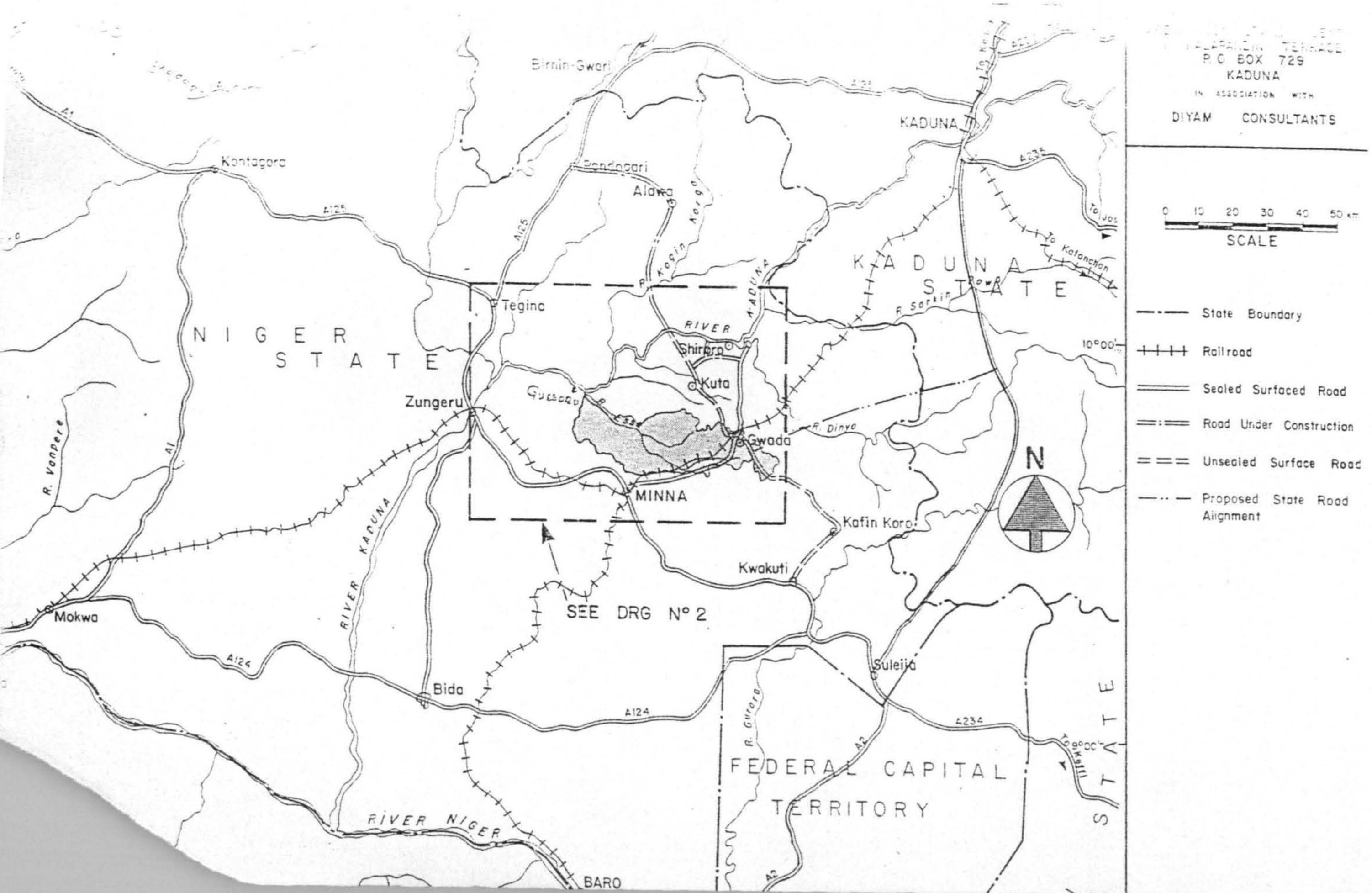
3.5.3 DRAINAGE PATTERN

The water content of the soil following the surface run-off after a down-pur has decidedly marked influence on soil characteristics. Prolonged saturation of soil with water can have a long term harmful effect on crops and leaves, characteristic colour variations on soils called mottles. Mottling in soils implies some how imperfect drainage at one time or the other in a year. The degree of mottling and depth, however vary with slope angle and soil texture. Excessive water content affects the fertility of the soil. It leads to poor aeration of soils as most micropores become filled with water to the exclusion of air.

Lack of acration leads to shallow rooting crops. Excessive water in the soil also leads to a slowing down in the warm-up of soils because of the higher specific heat of water. Water logging leads to a highly reduced microbial activity leading to a decreased rate of nitrification and consequently poor nutrient recyling.

Much of the soils in the area are of ferruginous tropical type and the rock and laterite present deep percolation and free drainage of water. Deeper soils are in scattered patches and approximately 80-120cm deep and over lie iron segnegation mottles or laterite. Soils are medium to fine texture with many gravels in the shallow soils. The soils are mainly derived from breaking down of the basement rocks being left as exposed hills. Surface texture of the soil vary from generally loamy sand to small areas of sandy loam. The dissected terrain and rocky hills with their shallow soil have truncated soils and are mostly well drained. Drainage in the undulating plains is poor in the lower and middle slopes. Soils in the area rage from comber soils to lithosols and Gley soils.

The most important for good farming and agriculture is the deeper soils. These as mentioned above are scattered. It is thought that these are formed by the erosion of soils from the upper slopes being collected in the localised areas. These areas provided the best potentials for agricIture and irrigation in the study area.



P.O BOX 729
KADUNA
IN ASSOCIATION WITH
DIYAM CONSULTANTS
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SCALE
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Railroad
Sealed Surfaced Road
Road Under Construction
Unsealed Surface Road
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FEDERAL CAPITAL TERRITORY
Birnin-Gwari
KADUNA
Kontagora
Alawa
Tegina
Shiroro
Kuta
Zungeru
Gwada
MINNA
Kafin Koro
Kwakuti
Mokwa
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R. Vanpere
R. Gurara
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To Jos
To Kafanchan

CHAPTER FOUR

4.0 METHODOLOGY

Among the crops to be irrigated in the field are vegetables, (e.g) maize, Okro and Tomatoes. To allow for flexibility of the system the crop (Maize) with the highest Evapotranspiration was used in the design. The work entails collection of available topographical information, comprising contour maps of scales varying from 1:100, 000 to 1:50,000 along with meteorological, hydrological and geological data from various agencies. Of particular significance to the study, were the information obtained from NEPA Shiroro regarding the proposed Zungeru Dam and the discharge from Shiroro dam.

4.1 SITE SELECTION

In site selection, we considered the availability of water supply. The thought of having the irrigation scheme in the place is because of the excess water from the dam which is just flowing without any usage. Also the climatic condition of the place favoured irrigation practice as stated in section 3.3. We have both wet and dry seasons which give us the chance of using the dry season for the irrigation practice. Also, there is the availability of a large mass of land with correct soil texture as stated in section 3.5. The topographical map covering an area of about 1ha was prepared. This is used to determined the slope of the selected area for the model farm on a scale of 1:500 (horizontal) and vertical itnerval of 1m.

4.2 LEVELING TO KNOW THE SLOPE AND DIRECTION OF FLOW.

The purpose of soil survey is to define soil types, drainage characerisitcs and agricultural potentials of land within the project area. As such the slope has to be defined in order to avoid errosive activities during the application of water and also to attain uniform applciation of water. Since the vast part of the land has already been cleared, I only carried out checking on the levelling of the exact area of the farm by taking levels and recording them and later on reduced them. The result is presented as Table 1

able 1: Levelling Survey Results

Station	B.S	I.S	F.S	H.I	R.L	Remark
B.M	1.250	-	-	101.250	100	At the surface of the field.
0	-	1.250	-	-	100	Top Begining of the farm
20	-	1.450	-	-	99.80	
40	-	1.650	-	-	99.80	
60	0.970	-	1.850	100.370		Turning poing
80	-	1.170	-	-	99.20	
100	1.350	-	1.370	100.350	99.00	T.P Down end of the farm.
B.M	-	-	0.350	100.00	Far closing survey proof	

ARITHMETIC CHECK:

EB.S - EPS = 1st R.L - Last R.L

3.570 - 3.570   100 - 100

= 0   = 0

KEY

B.M = Bench mark

B.S = Back sight

I.S = Intermidate sight

F.S = Fore sight

H.I = Height of Instrument

R.L = Reduced level

The slope is 1% and the direction of flows is as stated in the design diagram.

4.3 DESIGN AND CONSTRUCTION

DESIGN DATA

1. Area of the field is 1ha
2. Soil type after analysis is clay 1oam
3. Available water holding capacity of clay - 10am was found to be 70mm/m soil depth
4. Fraction of available water that is for resticted evapo transpiration is (p) 0.60
5. Rooting depth of maize (d) is averagely 1.2m
6. Applicaiton Efficiency (Eq) is 0.60 (FA0, 1974)
7. Slope of the field = 1%
8. Crop Evapotranspiration (ETc)
9. Depth of irrigation application (d) is determined using the formular -----------------------(1)

$$d = \frac{(pSa)\ D}{Ea} \text{ ------------- (1)}$$

Where

d = depth of irrigation mm

p = fraction of available soil water permitting for restricted evapotranspiration

Sa = total available soil water, mm/m soil depth

D = rooting depth, m

Ea = application efficiency decimal, %

$$\therefore \quad d = \frac{0.60 \times 70 \times 1.2}{0.60} = 84\text{mm}$$

Net depth of irrigation

$$d^1 = pSa\ D \quad \text{----- (2)}$$

$$= 0.60 \times 70 \times 1.2 = 50.4\text{mm}$$

Total volume of water (m^3) required to apply 50.4mm over a hectare can be detemined using equation

$v = qt = 10/Ea\ (pSa)\ DA$ ---- (3)

where q = Stream size, m^3/sec

t = Supply duration, Seconds

$\therefore$ $v = 10/0.6(0.6 \times 70)\ 1.2 \times 1 = 840m^3$

10 Intake rate of clay - loam (varshney etal, 1982) = 0.8cm/hr.

11. Irrigation water supply duration; Time to take water application to enter the soil

$t = di/si$ ---------------------- (4)

Where t = irrigation supply duration, min.

di = net depth of water application, min.

si = soil intake rate mm/hr.

$= \frac{50.4\ hr}{8} = 6.3hrs$

To supply adequate flow that will distribute to a level border, it is recommended that flow should be (40%) (FA024, 1984) of the time necessary for depth of water to enter the soil.

This is $6.3 \times 0.4 = 2.52$ hrs

12. Irrigation wate supply rate (q) (Afzal, 1978):

$q = v/t$ ------------------------ (5)

$= \frac{840m3}{2.82 \times 3600s} = 0.09259m^3/s$

$= 0.093m^3/s \times 1000 = 93l/s$

13. Supply rate of $0.093m^3/sec$ (93l/sec) is requred to irrigate 1ha (100m x 100m).

14. 12m wide border strips with slope length of 100m was proposed considering the soil type and slope. There required flow rate will be $0.00093 m^3/s/m \times 12m$

$= 0.0116 m^3/s$ (or 11.16l/s)

4.4 BORDER CONSTRUCTION PROCEDURE:-

1 The site was already levelled by the Upper Niger River Basin Development Authouity to 1% grade and this was verified by runing a levelling survy through the centre of the field and the slope computed.

(2) Border strips of 12m wide each with slope length of 100m were marked out on the field on a basin line located at head of the border (up slope). In between the strips an allowance of 60 cm was given for levee construction.

3. A longitudinal level of 45cm high was constructed in between the border strips.

4. Irregularities on the land surface of the strips were then removed with help of planks, and other hand tools, like hoes and pick axe.

5. Already field canal and drains exist at up stream and down streams of the border for water supply and disposal from the field.

4.5 FIELD CANAL WATER SUPPLY:

The existing canal studied to ascertain its capacity to supply the designed stream size $0.093 m^3/sec$ has the following parameters.

Bottom width	(b)		=	0.20m
Water depth	(d)		=	0.30m
Side slope	(Z)		=	1.5:1
Roughness coefficient	(n)	assumed	=	0.03
slope	(S)		=	0.2%
Area	(A)		=	(b + Zd) d--------- (4)

$A = (0.2 + 1.5 \times 0.03)\ 0.3 = 0.20 m^2$

Wetted perimeter	(p) =	$b+2d\sqrt{z^2+1}$ --------------- (6)	
	=	$0.2 + 2 \times 0.3 \sqrt{1.5^2 + 1}$	
Wetted permeter P	=	1.09m	
Hydraulic Radius	(R) +	A/P -------------------- (7)	
:.	R =	0.2/1.09 =	0.18m
velocity	V =	$\frac{R^{2/3} S^{1/2}}{n}$ -------------------- (8)	
Velocity	v =	$\frac{0.18^{2/3} \times 0.002^{1/2}}{0.03}$ = 0.5m/sec	
Discharge capacity	=	AV ------------- (9)	
Discharge capacity	=	<u>0.2 x 0.5</u> =	$0.10m^3/s$
	=	$1.8972m^{3/s}$.	

4.6 EVALUATION

The above proposed border strip was evaluated to ascertain its performance over the soil condition.

Performance parameters.

1. **Infiltration rate of the field:** This is the rate at which water enters the soil.

ii. **Depth of penetration of water:** This is the depth at which water can reach into the soil.

4.6.1 FIELD EVALUATION PROCEDURE:

1. Infiltration rate of the field was determined using double ring infiltro meter. The infiltrometer was filled with water to 30cm depth. The rate of water entering into the soil was observed by measuring depth of water drop against time. The depth of penetration of water and the elapsed time are

recorded and infiltration rate against time was plotted on log-log paper to determine the infiltration rate parameter.

Secondly, Advance test was conducted.

4.6.2 ADVANCE FLOW TEST:

Station of 10m interval was marked (Pegged) along the border. The choosen advance stream is directed onto the strip and its rate of advance determined. The flow rate was observed to see if it is large enough to spread uniformally across the strip. When the water front reaches three-quarters of the strip (75m) the supply was shut off. The result of infiltration rate is presented in Table 2 while the result of Advance test is presented in Table 3.

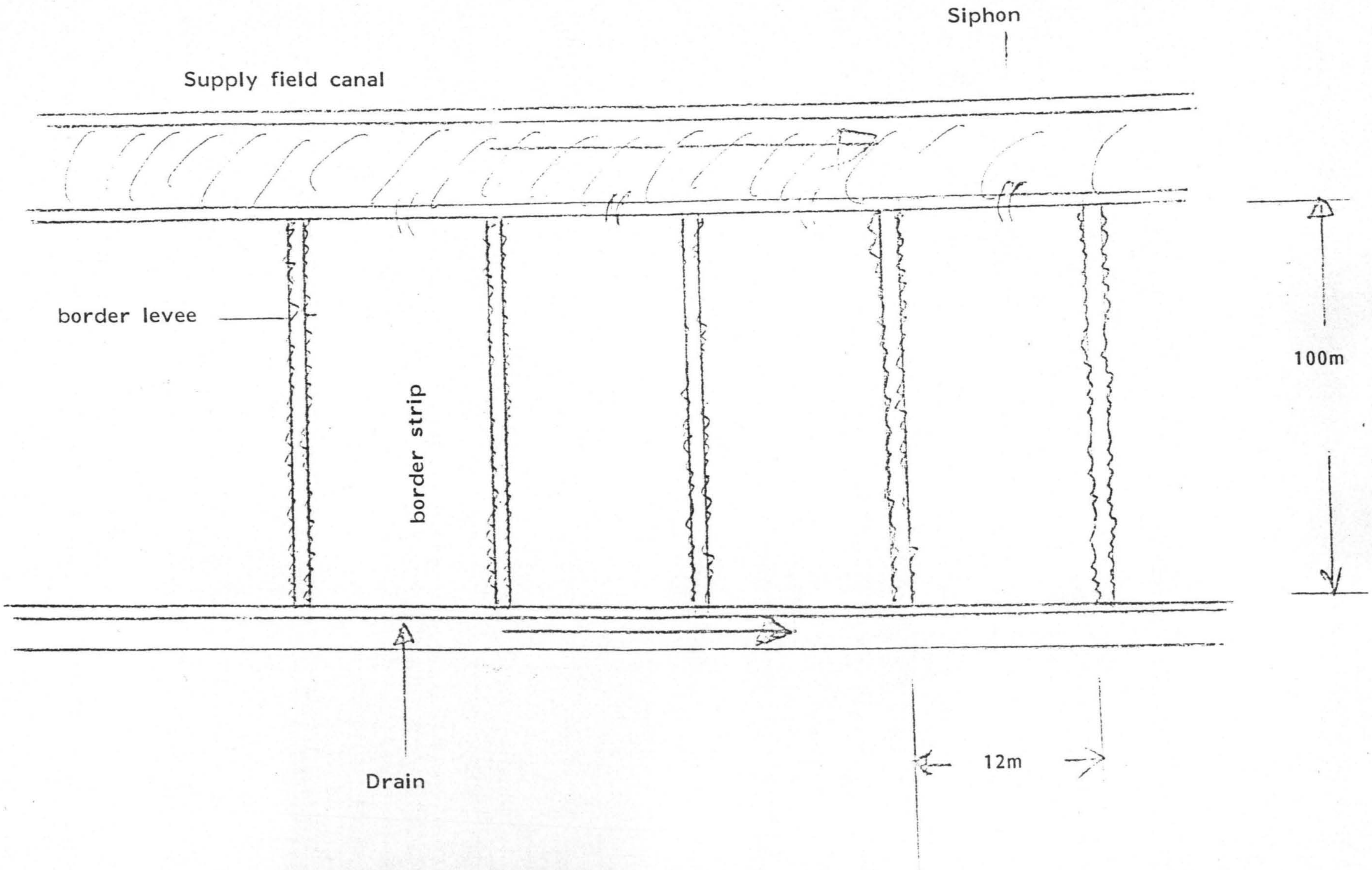

Fig. 1 A Sketch of Border Irrigation System

CHAPTER FIVE

5.0 RESULTS AND DISCUSSION

5.1 RESULTS:

Results of the infiltration test and advance test conducted are presented respectively in table 2 and table 3. The infiltration rate against elapsed time of the above result is plotted in fig.2 on a log - log paper.

The parameters of the infiltration rate are obtained from figure 3 using

1 = KTn ------- (10)

Where	I	=	Infiltration rate, mm/hr
	T	=	Wetting time, mm
	k and n	=	are soil constants.

The value of K is the intake rate where T= 1mm, and it is found from the intercept of the intake against time curve in fig 2 and n is the slope of the line. The values are: K = 1.9 and n = 0.875.

Advance flow test conducted to determine the length of run is presented in table 3. The depth of infiltration for each corresponding station is computed using equation (9) with values of constants obtained, as shown in the column of infiltration depth in table 3. Average depth of infiltration rate is used incalculating irrigation efficiency (Ea).

$$Ea = \frac{Wrz \times 100}{Fn} \quad \text{-----(11)}$$

Where Ea = Application Efficiency, %

Wrz = Water in the Root zone, mm

Fn = Net Water application, mm

Fg = 100 Fn/Ea ------ (12)

Where Fg = Gross water application, mm

$$Ea = \frac{23.6 \times 100}{50.4} = 46.83\%$$

$$Fg = \frac{100 \times 50.4}{46.83} = 107.62mm$$

Using the relationship

$Tt/Tn = Fn/fg$, to get Tt

$$\therefore \quad Tt = \frac{TnFn}{Fg} \text{ ---------------- (13)}$$

where Tt = Total time taken by water to reach the end of the border

Tn = Net irrigation time for water to enter soil

Fn = Net application (mm)

Ta = Time of application when water reaches the end of border (min)

If Tn equals to Ta of Fn then Tn can be calculated from $Fn = aT^n$ ---- (14)

$$50.4 = 1.9T^{0.875}$$

$$\frac{50.4}{1.9} = T^{0.875}$$

$$Log \frac{50.4}{1.9} = 0.875 \, Log \, T$$

$$1.4237 = 0.875 \, Log \, T$$

$$LogT = \frac{1.4237}{0.875} = 1.627$$

$$Log \, T = 1.627$$

$$\therefore \quad T = Log \, 1.627$$

$$\therefore \quad T = 42.4mm$$

$$Tt = \frac{Tn \times Fn}{Fg} \text{ ----------------- (15)}$$

$$= \frac{42.4 \times 50.4}{107.62} = 19.856 \text{ mins}$$

$$= 19.86min$$

$$L = \frac{3Qu.E}{5Fn.Ta} \text{ ----------------- } (16)$$

Where L = Length of the border strip (m)

Qu = Stream size applied l/m/min

E = application efficiency = (%)

$$\therefore L = \frac{3 \times 11.16 \times 46.83}{5 \times 0.0504 \times 19.86} = 313m$$

That the border can be irrigated up to 313m length without hindrance but due to easy management and field boundary the length is limited to 100m. During the design and construction, cross slope is avoided within the border to avoid advance flow shift to one side affecting irrigation efficiency, and the selected stream size is large enough to complete lateral spread throughout the length of the strip.

5.2 DETAILS OF THE DESIGNED BORDER STRIP ARE:

1. Border length of 100m
2. Border width of 12m
3. Border slope of 1%
4. Stream size of 11.16L/s or 0.0116m^3/sec.
5. Irrigation time of 2hr. 31min
6. Number of border strips = 8
7. Supply canal capacity of 0.093m^3/S or 931/s.

5.3 OBSERVED FARMERS PRACTICE AT GUSORO SCHEME:

At Gussoro irrigation scheme size border strip practised by the farmers are quite short and narrow border width of 4m and length of 20m.

With this practice major part of the farm meant for cultivation are taken up by levees, canal and drains. Apart from being labour intensive, it is not economical. Mechanisation is not possible in this type of borders. Also there is no design stream size, water is just turned into the burder by cutting field channel bannks.
Consequently erosion of the soil from ponding at the bottom of the basin does occur.

5.4 COMMENTS ON THE DESIGNED BORDER

In the course of design and construction of the border, the cross slope is elimiated in the border width to avoid advance flow shifting to one side producing poor application uniformity and possible erosion. The stream size is designed to suit the border width, slope and type of soil to avoid possible erosion. During the field test evaluation it was observed that the stream size can successfully irrigate 1ha of border strip without erosion and run-off at down stream end of the border after 3/4 cut back rule was applied. With the spacing and the length of the border, more area will be available for crop cultivation compared to farmer's practice. Field turn outs of siphons or spile are suggested to be used in transfering water from header ditch to head of border at a kown rate instead of the habit of breaking canal bank which will not only weaken the banks but also poses the danger of reducing design capacity and ultimately damages the canal. Drains are provided at the down stream of the border to take away excess water or run off from the border.

Table 2 **Infiltration Test Results**

Elapsed Time		Initial Reading	Final Reading	Water intake	Accumulate Intake	Infiltrate cm/hr
Mn	hr					
0	-	-	-	-	-	-
5	0.08	30	29.72	0.28	0.28	36
10	0.16	29.72	29.18	0.54	0.82	33.6
15	0.25	29.18	28.48	0.76	1.52	28.6
28	0.42	28.48	27.48	1.0	2.52	28.6
95	1.58	27.48	24.78	2.7	5.22	17.09
145	2.42	24.78	21.58	3.2	8.42	13.22
360	5.00	21.58	15.98	5.6	14.02	11.2

Table 3 **Advance Flow Test Results**

Station (10m)	Advance (min)	Depth of Infiltration (mm) based on advance time f = atb
0	0	0
1	10	14.25
2.	20	14.25
3	30	14.25
4	50	26.13
5.	60	14.25
6.	80	26.13
7.	100	26.13
8.	130	37.26
9.	150	26.13
10	180	37.26
		Total 236.04/10 = **23.6**

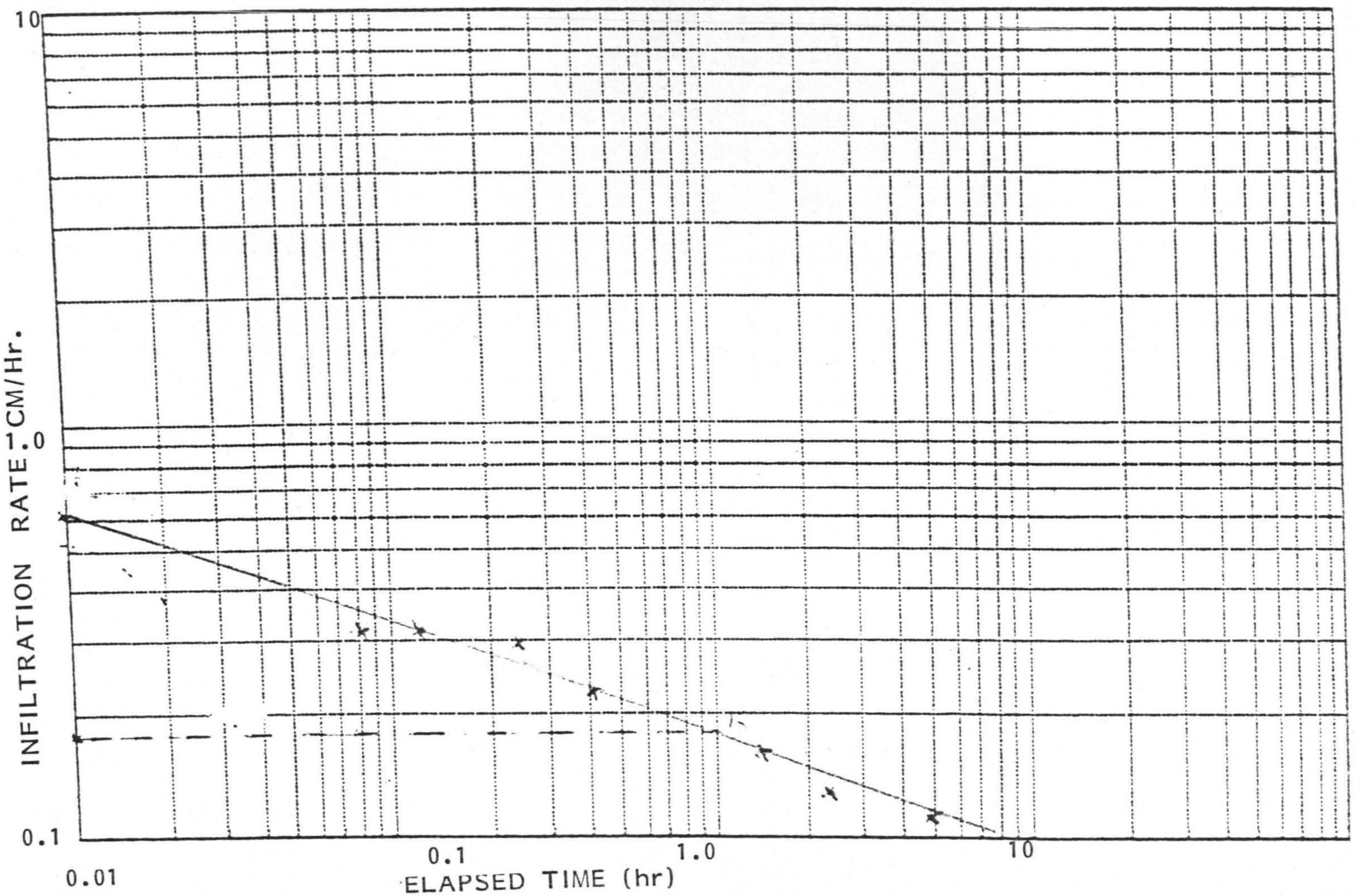

Fig. 2 GRAPH OF INFILTRATION AGAINST ELAPSED TIME

CHAPTER SIX

6.0 COST ANALYSIS

In discussing cost analysis some factors have been considered. The factors are:-

1. Actual cost of the construction of one hectare border strip system. The farmers in the area are using local manual labour for the work. The labour includes clearing of the grasses and small trees, levelling of the area to be cultivated and marking out of the border itself. Implements being used are hoes, cutlass and pick axe. When the total cost was added it amounts to about N32,100.00 (Thirty - two thousand, one Hundred Naira). This includes the cost of the seeds. The cost is not bad, the only problem is with the skill for the preparation of the border itself. If they can improve and heed to the suggestions and recommendations given in this work, they can cultivate more areas with this amount Mechanised irrigation will be very good there and will be cheaper than the present system.

6.1 MARKET AND TRANSPORT

The increase in farm production can benefit the entire community or State only if the product can reach the consumer at reasonable price. In this case the project area is about 3-4km to Kuta main market. Kuta is the Local Government Headquarters. It has a very big market for yams, animals, and other food items. The market days are every five days. People come to this market from all over the State. There is abundant transport system at a fair price. The farmers produce a lot of tomatoes, maize, pepper, etc.

6.2 COST OF PRODUCTION (MAIZE) PER HA.

From a recently conducted survey during evaluation exercise, year 2000.

1.	Land preparation including border construction	=	N5,000.00
2.	Seed 40kg @N60/kg	=	N2,400.00
3.	Planting, using 3 labourers per ha @N300.00	=	N 900.00
4.	Weeding	=	N2,000.00
5.	Fertilizer, 6 bags @N1,300.00 per bag	=	N7,200.00
6.	Fertilizer application labour	=	N 400.00
7.	Irrigation application 2 labourers	=	N 600.00
8.	Harvesting (5 labourers) @N200.00 each	=	N1,000.00
9.	Cost of 50 bags (empty) @ N40.00 each	=	N2,000.00
10.	Labour for bagging 2 labourers @ N300.00 each	=	N600.00
11.	Transportation	=	N5,000.00
12.	Supervision	=	N5,000.00
	Total Cost	=	**32,100.00**

From the data collected during the border construction in terms of cost and also the information collected from Niger River Basin Development Authority, interms of yield and final amount realised by the farmers, it is very clear that once all the technical corrections are made, the chances of increased yields and more money to the farmer yearly are very high.

CHAPTER SEVEN

7.0 CONCLUSION AND RECOMMENDATIONS

7.1 CONCLUSION

This study has presented appropriate border irrigation specifications to be constructed at Gussoro Awulo scheme for desined economical and efficient irrigation method. The existing practice of border construction by the local farmers where by short border length of 20m and narrow width of 4m are carried out should be discontinued. This increases cost of construction and is of low efficiency due to field management problems. These cummulatively, apart from economic reasons, reduces potential cultivable areas and this should be discouraged. The border size of 12m width, 100m length up to 300m depending on the field boundary designed in this study should be adopted.

7.2 SUGGESTIONS AND RECOMMENDATIONS:

The border has the following characteristics and therefore it is recommended for practice.

1. Farmers should extend the border length to 100m with spacing of 12m
2. The farmers should avoid the practice of breaking the bank of the border in order to direct water into the border.
3. Farmers should use siphons or spiles and it should have discharge capacity of 11.6l/s and this should be used to turn water from the field ditch to borders.
4. Drains should be provided at down stream end of the border to take away any possible run-off from the field.
5. Always care should be taken to avoid cross slope on the border width during border construction to ensure uniformity in water application.
6. Portable checks should be provided to impound water in field channel, so as to facilitate turn out into the border instead of using earth material to block it.
7. Border irrigation system should be encouraged there, for it is easier and needs not too much impliements to construct.

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APPENDIX A

CLIMATIC DATA

Table 4 MONTHLY RAINFALL FOR 1985-1998 (MM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	-	-	-	30	127	132	262	205	331	24	-	-
1986	-	-	13.4	58.8	66.4	186.9	277.6	279	350.2	60.1	34.5	-
1987	-	-	12.5	13.5	62.5	217.5	151.5	188.7	245	84.5	-	-
1988	-	-	-	155.1	88.2	174.9	239.6	289.5	361.4	11.7	-	-
1989	-	-	2.5	91.2	189.8	152.6	152.5	289.6	118	80.5	-	-
1990	-	-	-	174.7	160.0	227.5	416.1	276.1	350.1	143.3	-	-
1991	-	-	5.6	22.2	300.3	146.1	450.3	238.1	158	37.7	-	-
1992	-	-	2.6	74.9	198.3	183.2	188	280.4	368.1	139.1	78	-
1993	-	-	21.9	27.2	118.3	164.5	377.7	257.5	334.5	72.8	-	-
1994	-	-	-	58.7	74.5	225.9	106.8	264.7	208.7	238.2	-	-
1995	-	-	-	2	107.7	132.1	192.0	443.8	178.2	147.6	0.8	-
1996	-	-	1.1	44.4	164.7	214	189.6	233.9	307.2	88.1	-	-
1997	-	-	41.6	63.3	191.85	190.1	308.7	271.1	473.2	180.7	0.5	-
1998	-	-	-	69.1	102.9	185.5	278.6	280.3	194.9	142.1	-	-

Source: Shiroro hydroelectric power station.

Table 5 MEAN MONTHLY DAILY TEMPERATURE IN ^0C FOR 1986-1998

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	29.41	32.64	32.86	33.52	31.52	28.71	27.31	27.53	27.68	29.74	29.74	27.18
1987	29.75	31.72	32.87	34.51	33.42	29.34	28.9	28.92	28.88	29.83	30.36	29.58
1988	28.6	31.24	33.92	32.71	30.36	28.69	28.07	26.36	27.36	29.25	30.14	29.48
7989	27.16	29.36	33.56	33.2	30.02	28.83	27.55	27.39	27.93	28.94	31.00	29.4
1990	30.47	30.39	33.18	32.52	30.1	29.63	28.03	27.68	28.53	30.12	30.83	30.29
1991	29.63	32.66	33.4	32.53	29.52	29.25	27.18	27.76	28.62	28.69	30.82	28.82
1992	27.15	31.46	32.98	32.42	31.32	29.72	28.31	27.1	27.1	29.00	29.25	28.24
1993	26.92	28.57	33.23	33.18	31.79	-	-	26.67	26.94	27.74	28.12	26.65
1994	25.33	26.96	29.6	29.54	28.39	27.15	26.53	25.8	25.82	26.21	26.09	24.02
1995	23.85	25.79	29.35	29.8	31.21	28.68	27.39	26.90	27.80	29.58	30.45	29.18
1996	27.34	29.67	31.99	32.84	29.61	27.78	26.71	27.01	26.81	27.41	26.93	28.56
1997	29.07	26.21	29.64	30.25	29.04	27.45	26.66	26.71	27.79	28.45	29.35	26.65
1998	25.06	28.13	30.40	33.39	30.08	25.87	27.72	28.38	28.24	28.46	29.04	29.90

Source: Shiroro Hydroelectric Power Station.

Table 6 **MONTHLY DAILY RELATIVE HUMIDITY (%) FOR 1985-1998**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	40.8	36.8	37.6	47.8	60	80.7	81.5	81.7	85.6	75.2	33.9	33.9
1986	23.7	22.57	37.74	40.5	53.38	65.5	70.6	76.1	65.2	57.2	46.8	40.3
1987	75.4	43.6	78.8	69.3	76	65	65	71.9	66.6	54.1	34.2	31.2
1988	29.4	28.1	30.8	44.3	57	65.4	57	93.6	86.4	62.6	44.2	38.6
1989	33.2	34	43.9	52	72.5	73.3	76.5	83.5	78.4	66.9	42.5	40.6
1990	49.1	42.1	51.7	76.8	82.6	86.3	89.2	89.1	88.5	86.9	65.8	67.9
1991	70.8	91.3	92.1	92	87.3	86.8	90.7	91.4	88	85.3	56.8	60.8
1992	55.1	36.3	35	73	80.7	79.3	87	87.58	88.2	81	55.8	42
1993	34	41	59.3	65.1	75.6	82.4	80.5	86.3	80	26.1	64.3	36
1994	32.4	16.73	41.8	67.47	66.9	72.8	75.3	87.2	88.9	81.7	47.8	25.6
1995	23.3	19.6	36.2	51.5	55.4	70.4	85.2	89.7	88.8	84.1	58.0	49.7
1996	55.1	64.2	67.2	72.6	85.5	86.7	91.7	91.1	90.7	84.1	51.3	46.4
1997	47.9	52.0	58.5	76.4	85.1	90.4	93.1	93.8	92.0	90.8	75.0	50.5
1998	45.1	47.5	42.2	69.7	87.2	91.7	95.8	96.1	89.2	85.4	57.0	29.9

Source: Shiroro Hydroelectric Power Station.

TABLE 7

MONTHLY SUNSHINE HOURS FOR 1985-1998

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1985	7.1	7.2	6.3	6.4	7.2	7.2	5.6	6.6	5.5	7.7	8.7	5.9
1986	7.2	8.4	6.8	8.2	8.7	7.5	5.5	5.8	5.1	7.6	5.1	7.6
1987	8.3	7.6	7.0	7.2	7.9	6.7	5.2	3.5	4.7	8.0	9.5	8.9
1988	8.4	8.5	8.2	7.8	7.5	6.3	4.3	4.0	5.2	7.1	8.7	8.5
1989	8.3	8.2	8.4	8.9	8.8	7.3	5.1	3.9	5.3	8.3	9.4	8.9
1990	8.2	7.8	7.2	8.0	7.9	7.2	5.6	4.7	6.3	8.5	9.1	8.8
1991	6.9	8.6	6.7	8.3	6.9	7.3	4.8	4.6	6.0	7.6	8.4	8.9
1992	8.4	6.8	7.5	7.7	7.8	6.4	5.3	4.5	5.9	7.3	8.0	8.3
1993	5.5	8.4	7.1	7.3	8.2	6.5	6.1	4.3	6.6	6.5	8.6	8.0
1994	7.1	6.8	7.3	6.5	7.4	6.6	6.4	6.1	6.7	7.2	6.1	6.5
1995	8.8	9.0	8.2	6.4	7.8	6.5	5.9	5.2	6.1	6.3	9.0	8.8
1996	6.5	6.1	8.1	7.8	7.2	9.0	5.7	5.8	6.3	7.6	9.1	8.2
1997	6.8	7.2	6.2	7.9	7.5	7.2	5.9	4.4	5.4	7.9	8.9	8.7
1998	8.5	8.8	7.9	7.8	7.4	6.8	6.7	4.8	5.8	6.9	8.5	7.4

Source: Shiroro Hydroelectric Power Station

APPENDIX B

WATER ANALYSIS

ANALYSIS OF WATER SAMPLE FROM RIVER KADUNA AT GUSORO.

METHODOLOGY

Two water samples were analysed for the following parameters: PH, soluble salts, electrical conductivity, calcium, magnesium, sodium, chloride, sulphate, carbonate, bi carbonate, phosphate, nitrate, silca, boron, potassium and hardness.

The PH was determined by the use of PH meter. The quantity of the wa ter sample used is 10ml. Electrical conductivity was determined through titration with 0.05m using phenophthalein indicator. The same solution was titrated with 0.05 Ag NO_3, using 0.5% potassium chromate as indicator. Nitrate Nitrogen (NO_3 - N) was determined by phenoldisulphonic acid method; 25ml of water sample was evaporated to chyness on a water bath and allowed to cool.

The residue was dissolued with 2ml phenol disulphonic acid, 10ml of destilled water was added after 10minutes and transferred to 100ml flask. 40ml of NH_4OH was then added and made up to volume.

Absorption of the yellow solution was measured at 460mm using spectronic - 20 electrospectrophotometer.

Ammonium Nitrogen (NH_4-N) was determined using manual indophenol blue colorimetric method. Pour 10ml of water sample in a 50ml volumetric flask and add the following solutions; 8ml of 10% sodium potossium tatarate, 1ml of 0.16% Sodium nitroprusside, 2ml of sodium Bicarbonate reagent and 1ml sodium hypochlorite. Mix and make up to 50ml. Incubate in water bath at 40^0c for 10minus. After cooling, absorption or obsorbance was read within 10minutes at 625mm using spectronic - 20 electrospectrophoto meter.

ANALYTICAL RESULTS

Table 1 Parameters

Characterisitics of water samples from River Kaduna at Gusoro in Niger State.

Parameters	Sample I	Sample II
PH	6.70	6.72
EC x 10^6	25	23
Calcium PPM	2.5	2.5
Magnisium PPM	0.8	0.8
Sodium PPM	1.8	1.7
Chroide PPM	6.5	6.5
Sulphate	3.8	26.0
Carbonate	25.5	N.D
Bicarbonate	N.D	N.D
Phosphate	N.D	0.09
Nitrate	0.08	1.89
Silica	1.90	N.D
Boron	N.D	6.0
Hardness	5.8	2.3
Sar	4.5	4.6
Potassium	2.2	2.4
Total dissolved solids	60.5	60.0

Mg/litre)

Sulphate content was by the Turbidometric method. 40ml of wa sample was taken in 100ml of gelatin Bade and made up to volumes. T content was mixed thoroughly and allowed to develop for 30 minut Absorbance or absorption was mesured at 420mm with spectronic - electrocolorimeter.

For the determination of Boron, 3ml of curcumin in was added to 5 of water sample and mixed thoroughly then followed by 3ml of HOAC H_2SO_4. After mixing thoroughly, it was allowed to stand for two hours. 2ml of the above mixture, 10ml of methanol was added mixed and allow to stand for 30 minutes. Absorbance was measured at 555mm.

For silica, take 15ml of water sample in 100ml volumetric flask. A 1ml of ammonium molybdate. Mix and allow to stand for 30 minut Absorbance was measured at 555mm.

For silica, take 15ml of water sample in 100ml volumetric flask. Ad 1ml of ammonium molybdate. Mix and allow to stand for 10minutes. Ad 4ml of reducing agent and make up volume of solution to100ml. Mix we and allow to stand for 30 minutes. Absorbance was read at 650mm.

Potassium, sodium and calcium were *detemined* by the use of th flame photometer. Magnesium was determined by the use of atom absorption spectrophoto meter.

APPENDIX C

POTENTIAL EVAPOTRANSPIRATION DETERMINATION

Blany Morin Nigeria (1984) method:

Etp = rf (0.45T+8) (520 - R1.31)/100

Where:

Etp	=	Potential evapotranspiration, mm/day
rf	=	Ratio of maximum possible radiation to the annual maximum.
T	=	Summation of mean daily temperature (°c) over a month divided by number of days in that month.
R	=	Summation of the daily mean of relative humidity over a month and divided by the number of days in that month.

The period of irrigation of the designed scheme is during the month of November to April. As such the maximum data for the period is used for the cacluation.

rf = $\frac{9.4}{91.8}$ = 0.10

T = 31°c

R = 42.5%

Therefore Etp = 0.10 (0.45 x 31 + 8) (520- 42.5 - 1.31)/100

Etp = 0.10 (21.95) (384.11) = 8.43mm/day

Crop Evapotranspiration (Etc) is ther calculated by mutiplying Etp by Kc (Crop Coefficient).

Kc value for maize is 1.15 at maturit stage - FAO (1984)

∴ Etc = 8.43 x 1.15 = 9.6945

APPENDIX D

ANALYSIS OF THE SOIL TYPE

EXPT: To find out the percentage consitutents of soil in Gussoro Awolu Constutents of soil in Gussoro Awolu.

AIM:- To find out the percentage consitutents of soil in Gussoro Awolu Constutents of soil in Gussoro Awolu.

APPARATUS: Measuring cylinder, water, stiring rod, pestle and mortar.

METHOD:

An amount of soil was grand in a mortar using a pestle to some what powdery form. The content was then put into a measuring cylinder containing some water. This is stirred with a rod for few minutes and was then put a side to settle down.

OBSERVATION:

After about 32 hours, the sand settled as water became clear again. The soil was measured to determin the percentage contents of clay, silt and sand. From the results, the soil measured 2 inches sand, 2 inches silt and 3 inches clay. This is interms of depth.

CALCUATION:

1.	% of sand	=	2/7 x 100/1	= 28.57%	
2.	% of filt	=	2/7 x 100/1	= 28.57%	
3.	% of clay	=	3/7 x 100/1	= 42.9%	= 42.86

CONCLUSION:

This shows that the soil sample contains 28.57% sand, 28.57% silt and 42.86% clay which indicate clay loam from United State Department of Agriculture (USDA) soil textural class in fig. 3.

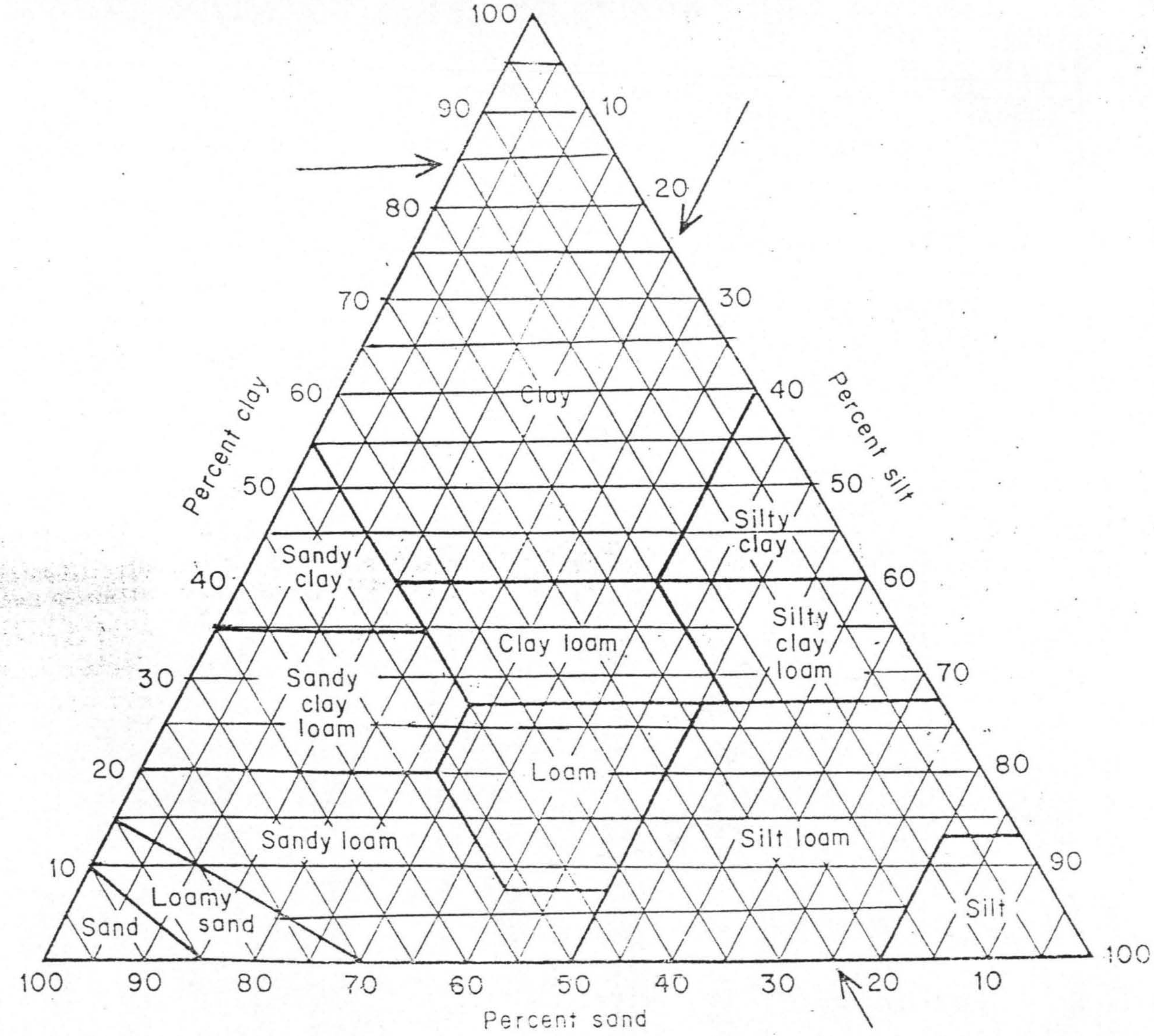

Fig. 3 —The USDA Soil Triangle