DETERMINATION OF WATER TABLE DEPTH AND CROP YIELD RELATIONSHIP

BY

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DECLARATION

I here by declare that this project work was absolutely conducted by me, Falade Olawumi Kehinde. Under the close supervision of Engr.Dr N. A Egharevba of the Department of Agricultural Engineering, Federal University of Technology, Minna, Niger State during the 2004/2005 academic session.

_______________________ 30/12/05

Falade Olawumi Kehinde Date

CERTIFICATION

This is to certify that this project work was carried out by Falade, Olawumi Kehinde in the department of Agricultural Engineering, Federal University of Technology, Minna, Niger state.

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DEDICATION

The work is humbly dedicated to my entire family and in loving memory of my late Father Tijani Otun Falade and my late brother Tajudeen Abayomi Falade. May their souls rest in peace.

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My unlimited thanks go to Allah the most beneficent, the most merciful for giving me the health, wisdom, strength and courage through out my academic pursuance.

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ABSTRACT

Determination of water table depth and crop yield (maize and rice) relationship was carried out at Chanchaga irrigation scheme along Minna Suleja road and Gidankwanu inland valley along Minna Bida road. Structured questionnaire as well as personal contact were used to obtain needed data on Maize and Rice for the period under study (2001-2003). Ground water table data was obtained from earlier studies done by other Researchers. The climatic data was obtained from Minna airport meteorological station. The rainfall amount ranged from 3mm to 409mm. It was clearly seen from the results that the yield of maize and rice are influenced by water table depth. The yield of crops as a function of the water table depth can be represented by two degree polynomial expression.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Niger State is characterized by low and high variable rainfall, air, temperature and high evaporation demand. The increase in soil productivity the distribution of water within the soil profile and proportion that remains in the root zone for the plants to utilize appear to be a more crucial limitation than the total rainfall. Payne et al (1990).

In such an environment an understanding of the water uses is important to formulate a rational management strategy to monitor and make more efficient use of the limited seasonal rainfall.

Ground Water: this is the water beneath the soil or ground surface, where the void spaces are substantially filled with water table. Its upward movement (capillary) from the water table into the root zone can be a major source of water for plant growth. To be must effective without seriously restricting growth, ground water should be near but below the depth from which the major potion the plant water need are extracted. If the ground water is within the normal root zone of plant growth, the plant growth is definitely suppressed, on the other hand, if ground water is too near or close to the surface the land's ability to economically produce most crops becomes almost nil. A water table within the lower portion of the root zone may supply considerable amount of water and thereby reduces the cost of irrigation more than it offsets the loss of production.

Much has been published or written on aspect of water relation to crop growth and the management of water table [Egharevba(2000)Soli(1998)]. Attempt to understand crop response to water through crop growth modeling have met with success. However for practical purpose a method is required to measure yield response to water supply which should be simple, required only common available climatic, water, soil depth crops, data, be widely applicable with acceptable accuracy and allow easy verification through adaptive research. Based on the present knowledge of the water soil plant system and using the impressive amount of related of research data, a methodology is presented for estimating yield response to water at the field level. The selected crops are maize and rice.

The research stations are located at federal university of technology main campus (Gidan Kwano) and Chanchaga irrigation scheme.

1.2 Nature of the Problem

The problem of inadequate water supply and lack of data on crop water needs, water table depth and their relationship to yield have continued to pose major problems in agricultural production in most of the developing countries. These may be as a result of lack of development of available water resources and lack of available relevant study that should provide such information.

Consequently, agricultural production in the country has continued to be limited to single rainfall cropping season even in areas where available water resources can easily harvested for multiple cropping (Feddes, 1975).

1.3 Aim and Objectives.

The aim of this study is to determine the water table depth and crop yield relationship .Specifically the objective is to evaluate the effect of water table depth on crop yield (maize and rice),

(i) For same location over a period of time.

(ii) For different locations over same study period, and

1.4 Justification of the Objective

In many African countries like Nigeria we do not have full information on water requirement of our major agricultural crops let alone know the impact of water table on the yield. Thus there is an important need for relevant and sustained studies on estimating crop yield response to water table depth in different ecological zones of country. It is only with such information/data that we can plan and design effectively irrigation system at a minimum cost and help in planning cropping seasons.

CHAPTER TWO

LITERATURE REVIEW

2.1 Maize Crop

A crop is a plant carefully selected and developed over many years, sown on cultivated land to produced food for man and animals or raw materials.

Maize crop belongs to gramanae family. It is one of the world's three most important cereals crops (the orders are rice and wheat). The crop is primarily grown for its grain, which is consumed as human food. In some developed countries maize is also grown for animals feed and as a base for industrial product such as oils, syrup and starch. The grain may be fermented to produce beverages and then distilled to provide whisky or industrial alcohols, acids, acetaldehyde, acetone and glycerol. The crop residues can be used as folder, bedding, building materials and fuel. Maize has the same calorific value as wheat or rice but has lower levels of essential amino acids lysine and tryptophane. It also has lower levels of triacin but it is higher in thiamine.

2.1.1 Botany (Zea Mays)

Maize is an annual plant belonging to the grass family. It matures over in short period of a few months. Individual plants are fairly large and unlike many species, usually only one or two stems grow from each seed. Height varies from about 1.5m in short varieties to over three meter. Maturity time is usually 100-120 days, but some variation exists in this respect. Male flowers, called tassels, emerge after 50-60 days at the apex of the plant. Female flower are formed in the axils of the flowers, called silks emerge from the leaf axils shortly after tasseling. The seeds are formed on cobs which are the compacted stalks of female inflorescence.

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2.1.2 Harvesting and Varieties

When the crop is matured the leaves dry and the husk surrounding the cob becomes dry and parpery. The grains become hard as they lose moisture and the crop is often left in the field until the grain moisture content has dropped to 15-20%. Maize is harvested by hand by the removal of cob and husk from the plant. When required for eating as fresh vegetables, the cob are picked before they are fully ripe, but if required for the grain they are left till the grain is harden.

Maize varieties have been classified on the basis of the grain. The main groups are grown in tropical countries (William,1990);

(i) Dent Maize: - It has large cob and large grains which shrunk on drying to produce shallow hallow at the end of each grain.

(ii) Flent Maize: - This generally have smaller cob which have round grain.

(iii) Sweet Corn: - The grains are soft and sweet with little starch and are grown for eating as a fresh vegetable.

(iv) Soft or Flour Maize: - The grains do not have a dent. It consists also of soft starch.

2.2 Rice Crop

Rice is a semi aquatic plant and hence its water requirement is much more than most other food crops. It is therefore a major consumer of the water resources to most country and thus needs careful water use. Rice is grown under varied soil and climatic condition and one to three crop per annum are taken in most part of Nigeria though plant is grown on variety of soil but it grows better on clay loam, to clays since these are characterized by high retentivity of moisture and low percolation rates (1-5 mm/day), it can also grow on soil with relatively short round grains and also IRAT 13 which has a period of sowing to heading 95 days to 125 days and have good adaptability and has average yield of 2.5t/ha to maximum yield 5t/ha. The crop thrives well under condition of high temperature and humidity in most tropical and sub-tropical condition as in southern. Rice can be grown practically through out a year. In temperate region at high altitudes the crop is grown only in the warm part of the year. The cultural practice of rice varies widely depending on the variety and the local climatic conditions. The conditions under which rice is grown however could broadly be grouped into two namely low land rice and upland rice.

Upland rice is directly grown by drilling or by broadcasting the seeds it mostly depends on as the source of water. It constitutes only a small percentage (less than 5%) of the total area. Lowland rice culture is widely accepted practice for high production. Under lowland conditions rice is generally transplanted on puddle soils and land is kept under submerged in general has been found reduce percolation losses, check weed control, increase the availability of plant nutrients, regulates soil and water temperature. Vamadevan and Dastane (1968) observed that out of 1680mm of water needed by rice 1200mm where lost through deep percolation (about 70%) on sandy loam soil in some part of the world and only 480mm were actually used consumptively.

Great economy in water used by rice crop can be achieve if suitable measures were adopted to reduce deep percolation losses which consumes 50 – 75% of water required by rice plant culture as per the result discussed above. Some of the recommended practices to improve water use efficiency in low land rice are:

(1). Selecting heavy soils or those with hard pans in subsurface depths to reduce permeability. The soil having percolation rates below 5mm/day are considered to be good for rice cultivation.

(2). Growing crops in large blocks instead of isolated small holdings. The see page is proportional to the parameter of the area.

2.3 Soil Moisture Availability

Water is one of the main requirements for healthy plant growth. Most arid and semi arid regions, however, suffer from insufficient and unreliable rainfall. In these areas a high rate of evaporation in the growing season is also common (Otterloo, 1997). The availability of soil moisture to plant is function of water input, moisture retention and rooting depth Rusell, (1983) reported that roots are readily able to absorb soil moisture at field full capacity, 0.1-0.5 bar; depending on mineralogy and soil structure and become less able to do so until 15 bar is reached referred to as the wilting point. The universality of this relationship is challengeable (Sanchez, 1990). At farm level, however, it may be said that unless irrigation is possible, water inputs from the rainfall are beyond the control of farmers.

Moisture retention is both an intrinsic property of soils and subject to management. The pores of sandy soils are emptied of gravitational water at 0.1 bar, while silicate layered clayed soils retain this moisture until 0.5 bar (Sanchez, 1990). Other soils, including most of those in the tropics, fall some where in between farmers manage moisture retention in many ways, the most obvious and important are being the reduction of water run off along the soil surface by terracing, contour ridges and other more elaborate water capture strategies (Weomer and Muchena, 1993).

Often scarcity of water is the most severe constraint for crop production in arid and semi arid regions. Surfaces water is usually not available in amount sufficient to maintain natural rainfed agriculture. The agricultural production in these regions is widely affected by the sporadic character of rainfall. Production could be largely increased by a better utilization of water resources. Simple techniques, which do not require heavy investigations or entail high maintenance costs, could bring considerable improvement.

A number of studies (Philip-Howard et-at 1990, Konyhan et-at, 1992) have shown that one of such techniques involves crops cultivation on residues moisture. Taver and Humborg (1992) noted that a rational utilization of water, collected from small water sheds, enables adequate water savings for crop production, Essien (2002) has found that water savings irrigation technology is successful in Enyong Creek catchments. This involves utilization of recessional soil moisture within the moisture recession period to reduce irrigation requirement in the after rains (dry season) farming.

2.4 Soil-Water and Plant Relationship

2.4.1 Soil Retention

Soil serves as the storage reservoir of water. In most all areas the soil contains it maximum quantity of water at the end of the cold period. Water enters a ground water reservoir from natural or artificial recharge. The water table marks the division between the ground water and the moisture zones in the soil.

In the unsaturated soil above the water table, the pores are partly occupied by water and partly by air. The soil water in these zones is commonly referred to as soil moisture. The amount of soil moisture varies greatly with depth. The narrow zone above the water table, pores fill by capillary rise from ground water. In the lower part of this capillary zone all pores are filled with water, making the soil in this so called capillary fringe saturated as in the ground water below the water table.

2.4.2 Soil Structure and Texture

(i) Soil Structure

Structure is used to describe the arrangement of the primary particles into the natural aggregates or peds. The sand, silt and clay particles the soil are cemented together in the soil to formed natural units of compound particles or aggregates separated by pores, cracks or planes of weakness. Soil organic matter plays a major role in soil aggregations. The best structure is that which increases soil aeration and water holding capacity and facilitates microbiological activity. The structural development in the soil greatly affects its agricultural productivity. A loose, friable, freely draining soil is easier to cultivate than a heavy compact soil. Wetting and drying, tillage and biological activities all contribute to the continuous building up and breaking down of soil aggregates.

Soil texture refers to the fineness or coarseness of the mineral particles of the soil and is commonly defined as the relative proportion of sand, silt and clay. It has considerable influence on the capacity of the soil to hold water and to circulate air.

Soil texture critically influences the response of crops to fertilization. Three broad soil textural classes are recognized; sands, loams and clays. Most agricultural soils are in this group.

2.5 Movement of Water and Terminology

The movement of water within the soil controls not only the rate of infiltration but also the rate of supply of moisture to plant roots and the rate of underground flow to springs and stream and recharge of groundwater. Water filled pore space phase flows through the water filled pore space under the influence of gravity. In the films surrounding soil particles (under unsaturated conditions), it moves under the influence of surface tension forces. Water also diffuses as vapour through the air filled pores spaces along gradient of decreasing vapour pressure. In all cases, the movement is along gradient of decreasing water potential.

2.5.1 Water Intake

The movement of irrigation water from the soil surface into and through the soil is called water intake. It is the expression of several factors including infiltration and percolation.

2.5.2 Percolation

Percolation is the downward movement of water through saturated or nearly saturated soil in response to the force of gravity. Percolation occurs when water is under pressure. Percolation rate is synonymous to infiltration rate with the quantitative provision of saturated or near saturated conditions.

2.5.3 Infiltration

It's the downward and lateral movement of water into soil or substrata from a source of supply such as irrigation canal or reservoir such water may reappear at the surface as not spots or seeps or may percolate to join the ground water or may join subsurface flow to springs or stream.

Infiltration rate depends on the welted perimeter of the reservoir or the canal and the capacity of the soil to conduct water both vertically and laterally. The infiltration characteristic of the soil is one of the dominant variable influencing irrigation. The actual rate which water is entering the soil at any given time is termed infiltration velocity and the infiltration rate decreases during irrigation. Accumulative infiltration also called cumulative infiltration is the total quantity of water that enters the soil in a given time. Infiltration rate and accumulated infiltration are two parameters commonly used in evaluating the infiltration characteristics of soil.

2.5.4 Permeability

Permeability is defined as the readiness with which a soil transmits fluids. Soil permeability also depends on soil structure, texture and depth of water table. A high permeability is essential for leaching down the excessive salts or removal of sodium released by the application of gypsums in alkali soil. Again the permeability of soil decreases with the increases of dispensability and exchangeable sodium percentage of the soil. Generally, water moves slowly downward through highly dispersed clay. However, when the apply water contains sufficient divalent cations it suppresses the diffused double layers of clay particles and increases soil permeability.

In other to predict the success of irrigation in a particular situation, it is essential to have adequate information on the quality of irrigation water, its effect on the physical characteristics and salts build up.

2.5.5 Hydraulic Conductivity

The hydraulic conductivity potential applied to an aquifer is defined as the rate of the flow of water in litres per day through a horizontal cross sectional area of one square metre of the aquifer under a hydraulic gradient of one metre perimeter at the prevailing temperature of water. The first rational analysis on the movement of water through sand was the work of (Henry Darcy 1856 AD) who proposed the relationship expressed in the equation below which formed the basis of all studies of flow through porous media. Darcy's experiment showed that the flow of water through a column of saturated sand is proportional to the to the difference in hydraulic head at the ends of the column and inversely known as Darcy's law(Egherevba,2000), expressed as;

$$V = k (h_1-h_2) / L \quad 2.1$$

Where, V= velocity of the flow, m/day

K= hydraulic conductivity, depending upon the proportion of sand and the liquid m/day h_1-h_2 = difference in hydraulic head in meters

L= distance along the flow path between the points h1 and h2 in meters.

We can also express the velocity of flow V in terms of K and I (hydraulic gradient).

$$V= Ki \quad 2.2$$

Often the quantity of flow may be of greater interest then the velocity. Hence, in terms of quantity of flow, Darcy's law may be expressed as follows.

$$Q = Av = kiA \quad 2.3$$

Where Q = volume of water discharged in standard length of time usually expressed as m^3/day.

i = Gradient

A = cross-sectional area through which water moves m^2

K = Hydraulic Conductivity in cm per sec.

The value of K can be obtained by laboratory tests of the samples of the formation material. For field use, however, it is more appropriate to determine the values of K from pumping test data.

2.6 Water Table Control Structure

There are two forms of water table management (i) controlled drainage restricts the discharge from a subsurface drain outlet or open main drain resulting in a higher field water table. The water table drops naturally over time due to evaporation and deep seepage, and slowly and nearly continually into open ditches or a subsurface drainage system to maintain a near contact water table. When large rainfalls occur and the field water table rises above desired level the irrigation pump is stopped. The excess water then drains from a control structure in the ditch or drain outlet such system are shown in the fig below.

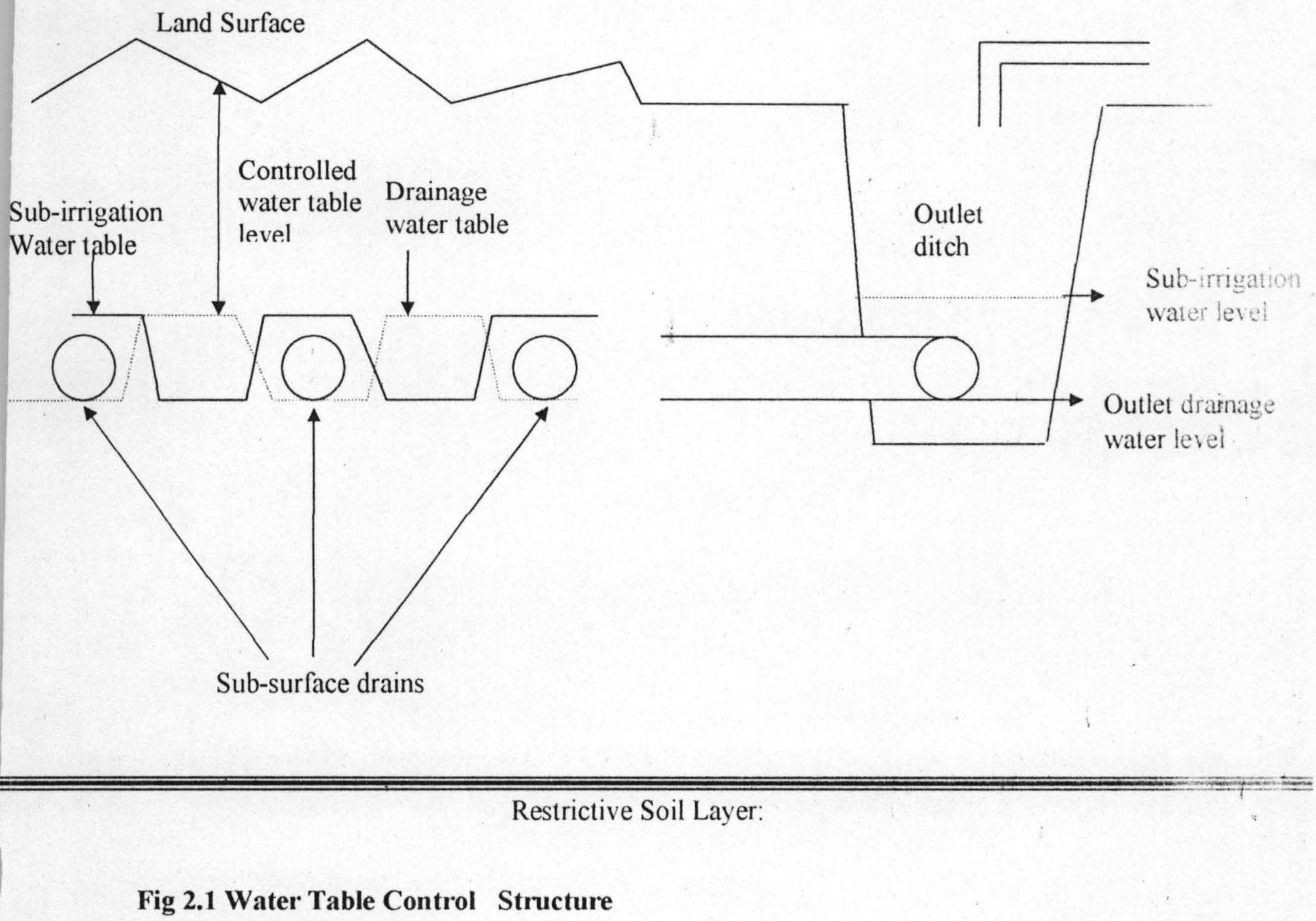

Fig 2.1 Water Table Control Structure

In areas with open canal drainage system (with or without subsurface drainage) flash board riser control structures may be used. These are installed in ditches and by either inserting or removing a flashboard the water level in the ditch is either raised or lowered. These structures can also be used to store run off in canal, which can later be used for sub-irrigation. Surface run off from drained field can also be controlled with the aid of the flashboard risers.

2.7 Evapotranspiration (ET)

Water from precipitation or irrigation can enter the soil where it comes into contact with the crop root system. Evapotranspiration is the water removed from soils by soil evaporation and plant transpiration.

Plant transpiration is evaporation of water from leaf and plant surfaces. Soil evaporation is a direct pathway for water to move from soil to the atmosphere as water vapour. Both evaporation and transpiration are driven by a tremendous drying force the atmosphere exerts on soil and plant surfaces. Water is drawn or pulled by more negative tensions as it moves from the soil through the plant and into the atmosphere. ET is important to irrigation management because crop yield relates directly to ET.

2.8 Factors that Affect (ET)

2.8.1 Weather: - The power of the atmosphere to evaporate water is the driving force for soil evaporation and crop transpiration. Weather factors that have major impact on this evaporation power includes:- air, temperature, humidity, solar radiation, wind high, air temperature, low humidity, clear skies and high winds cause a large evaporative demand by the atmosphere.

2.8.2 Crop type: Different crops use different amounts of water over the course of the growing season. Crop planting times and water use patterns are sometime different among different type of crops.

2.8.3 Crop Growth Stage: - During the course of the growing season, ET from crop depends not only on the potential ET demand from the atmosphere but also on the crops stage of growth. ET is related to leaf surface area, so small plants transpire less water than large ones. Due to growth patterns of different crops, maximum ET occurs at different times during the calendar year.

2.8.4 Crop Variety: - The relative maturity range of a particular variety has the most impact on seasonal crop ET. At the same location a corn variety with maturity of 120 days will use more water than an 85 day variety. However, if both varieties are able to mature fully, the grain or crop produced for each inch of ET is approximately equal.

2.8.5 Surface Cover and Tillage: - The amount of soil surface cover influences soil evaporation. When the soil surface is wet, evaporation depends on the amount of radiant energy at the soil surface lowest evaporation rate occur from shaded and mulched soil surface.

2.9 Seasonal Variation of Ground Water

2.9.1 Seasonal Variation of Water Quality

(a) Salinity of ground water is considerably influenced by the climatic conditions, it increases during the summer and is significantly reduced during the monsoon due to dilution by rain water. The degree of variation is salinity and its ionic composition depends upon the depth of water table infiltration capacity of the soil and the rainfall characteristics of the area concerned. Besides these factors, some recharge flooding of rain water.

(b) Variation in water quality with depth: - the quality of ground water in many regions shows wide variation with depth of the aquifers, the depth at which good quality water occurs varies from place to place and even within the same area at a distance of few meters, however in general locations the water quality has been found to deteriorate with depth.

2.9.2 Origin of Salts in Available Water

Saline or alkaline soils are selection formed in-situ by residual weathering of primary rocks on the other hand, hydrological conditions contributes substantially to the development of soil salinity and alkalinity.

The hydrological processes release the salt constituent.

Table 2.1; Salt tolerance of crops.

Tolerance	**Semi-tolerance**	**Sensitive**
Tobacco	Rice	Field beans
Cotton	Sorghum	Peas
Wheat	Pear millet	Green beans
Sugar cane	Maize	
Drite palm	Sunflower	
Coconut	Tomatoes	
	Onions	

Sources: (Michael 1980)

From the primary and secondary minerals to surrounding waters in arid regions, due to high evaporative condition, salt concentration is gradually increased in the water sources. In humid regions salt thus released are transported to lower layer and ultimately by streams to the ocean. Moreover the salts deposited by irrigation are leached down to lower layers of the soil by rainfall. On the contrary in arid regions the released salts may not be transported far away because of insufficient rainfall and what ever leaching of salts may occur, it could mostly be local. However high evaporating condition of the arid regions trend to decrease further the limited available ground water for leaching the salts, moreover, the salts again to move down due to rain, come back again to the surface by capillary action during the hot season.

2.9.3 Factors Affecting Ground Water Quality

Of the several factors affecting the quality of the ground water, the generally accepted factors (criteria) for judging the quality are:

(i) Total salt concentration, as measured by electrical conductivity.

(ii) Relative proportion of cations as expressed by sodium ration (SAR).

(iii) Bicarbonates and boron contents.

The suitability of irrigation water (SIW) can be expressed as SIW= F (QSPCD).

Where:

Q= quality of irrigation water

S= soil type

P = salt tolerance characteristics of the plant

C= climate

D= drainage characteristics of the soil.

Some water factors like depth of the water table. Presence of hardpan or clay calcium carbonate content in the soil and KT and nitrate ions in the irrigation water, also indirectly affect the suitability of irrigation water. This is probably the main reason for the classification varying in limits of salinity and other chemical indices. The soil type, major crops of the area, climate and drainage characteristics profoundly influence the suitability of particular water for irrigation. Highly saline water may be suitable in a well drained textured, fertilized soil while much less saline water may be most harmful. For the same crop grown on a heavy textured soil with impacted drainage. It is the actual salt concentration near the zone which determined the suitability of irrigation water rather then the chemical properties of irrigation water alone.

In summary the quality of irrigation water is judged by its salt concentration, relative proportion of cations or (SAR) and the content of bicarbonates and boron.

2.10 Classification of Irrigation Water

The following classification has been developed at the salinity laboratory, riverside, California and is based on the field and laboratory observations.

2.10.1 Soluble Salt Classification

(a) Low salinity water (c_1) can be used for irrigation with most crops on most soils with leaching likelihood that soil salinity will develop. Some leaching is required but this occurs under normal irrigation practices except in soils of extremely low permeability.

(b)Medium salinity water (c_2) can be used if a modern salt tolerance can be known in most case without special practices for salinity control.

(c) High salinity water (c_3) can not be used on soils with restrictive drainage. Even with adequate drainage, specially management for salinity control may be required and plants with good salt tolerance should be selected.

(d) Very high salinity water (c_4) 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 – tolerance crops should be selected.

2.10.2 Sodium Classification

Low sodium water (S_1) can be used for irrigation on almost all soil with little danger of the development of harmful level of exchangeable sodium. However, sodium sensitive crops such as fruit trees and avocados may accumulate injuries concentration of sodium.

Medium sodium water (S_2) will present an appreciable sodium hazard in fine exchange capacity, especially under low leaching condition, unless gypsum is present in the soil. This water may be used on coarse textured or organic soils with good permeability.

High sodium water (S_3) may produce harmful levels exchangeable sodium is most soils and will require special soil management good drainage, high leaching and organic matter additions

Very high sodium water (S_4) is generally unsatisfactory for irrigation purposes expect at low perhaps medium salinity, when the solution of calcium from the soil or use of gypsum.

CHAPTER THREE

MATERIALS AND METHOD

3.1 The Study Area.

Minna is a typical settlement of Gwari Tribe but mixed with all other tribes that migrated from various towns and rural areas in search of jobs.

It is the capital of Niger State created in 1976, located our latitude 9^0 30'' and longitude 6^0 3'' in the southern guinea savannah ecological zone. The specific study areas are situated at Federal University of Technology Minna permanent site form (120m X 170m X 150m X 124m) and banded by natural stream channel, which flours in the east west direction and the Chanchaga irrigation scheme.

The author therefore found these locations suitable for the study area because of the following reasons.

Being an elite environment, it is envisaged that there will be no communication problem especially in administrating the questionnaires

Agricultural systems were practiced in both dry and wet seasons

3.1.1 Climatic Conditions.

The climatic of the project area is essentially the same as typically of the middle belt of Nigeria, with high temperature and humidity during most part of the year (Tables 3.3 and 3.4) this favors growth of various species of vegetables in Chanchaga irrigation scheme in the dry season. But with rainfall ranging between 1047.3-1491.7mm, rice being grown in the rainy season always give a high yield in view of its semi-aquatic nature and hence its higher water requirement than most other crops.

Rain fall: - The project areas lie in the portion of Niger State where normal annual rainfall ranges between 1047.3-1491.9mm. Rain normally occurs between the months of April or May to October. The peak rainfall is recorded in August or September (Tables 3.3 and 3.4)

Temperature: - The hottest periods are in the months of March and April table 3.1

Sunshine Hours: - The sunshine record of the area indicates that November and December have the highest mean valve for the past ten years.

Relative Humidity: - The relative humidity varies all the year round but generally it rises to 80% and above in the past ten years and as low as 18% (Tables 3.4)

3.1.2 Chanchaga Irrigation Scheme.

Chanchaga irrigation scheme is located between latitude $9^0\ 34^1 - 9^0\ 37^1$ N and longitude $6^0\ 36^1 - 6^0 39^1$ E, (Ndako 2004) and situated at Chanchaga village at the outskirt of Minna the Capital of Niger State, this village is about 10km along Minna-Suleja trunk road. The total field area is 12ha, while investigations were in 2.5ha only.

3.1.3 Gidan Kwano Inland Valley.

The Gidan Kwano in land valley is located between latitude $9^0 45^1$ North and longitude $6^0 15^1$. It forms the low land area of GARTU HILL and also extended to YADNA HILL (TOPO sheet 40, FMWH) (Sand-rich 2004). The valley is diminutively located at the western end of Minna Township the State Capital of Niger State in the north central geopolitical zone of Federal Republic of Nigeria.

3.1.4 Relief: - The relief features consists of large level landscape, which generally varies from 200m above sea level on the crest (TOPO sheet 40 FMWH). Tributaries of river Daga, river Wayin and river Chanchaga on the hinterland delineate the entire valley. They are fed with seasonal streams that flour generally from east to west, rain water drain fast into these streams due to slopping nature of the land. This creates problem of runoff in most cases.

These river discharges into bounded river Niger at the west end. Most of these rivers are seasonal thereby creating problem of water sear city both for domestic and agricultural purposes.

3.2 Data Collection.

All the information used in this project work were obtained through a primary source (i.e. by personal interview and survey questionnaires) and the secondary source (i.e. data collected based on the figures and values of the measurement on the water table depths .

3.2.1 Survey

The questionnaires was designed to retrieve as much information as possible from the farmers based on both the present and past experiences in farming practices, these includes: the aim and type of farm practices, the crop planted, the years and duration the framer has been farming in the farm and means of transportation, water application, fertilizer application, duration of the crop from the planting dates to harvesting date, & quantity harvested per plot e.t.c (For details see appendix A).

3.3 Data Analysis

The water table and crop yield data were expressed inform of bar charts and line graphs. Regression analysis method was used to obtain the relationship between the crop yield and water table depths.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Water Table Depth.

The water table depth on monthly basis for year 2002 is given in table 4.1. Most parts of the under study had water table level above the ground surface. This shows that surface or sub-surface drainage system may be required.

Table 4.1 mean monthly water table depth at Chanchaga irrigation scheme (2002)

Location	July (cm)	Aug (cm)	Sept (cm)	Oct (cm)	Total mean depth (cm)
W_1	-2.00	-1.00	8.50	35.0	10.13
W_2	-32.50	-38.00	-23.00	27.00	-16.62
W_3	-10.50	-20.5	-17.00	27.50	-9.63
W_4	-34.50	-34.00	-33.00	-22.50	-31.00

Note;-W_1, W_2, W_3 and W_4 are the well points. The negative signs are period when water depths are above the water surface.

4.2 Relationship between Water Table Depth and Rice Yield

The result of the relationship between the maize yield and water table depth at chanchaga irrigation scheme during raining season (July to October)can be see in fig 4.1 . The graph shows an increase in yield in this variety of rice with increase in water table depth in the region up to a depth of -20cm.Thereafter the yield decreased with additional increase in height of water to the ground surface. The reason for this is that the variety has limit of water requirement for optimum yield.

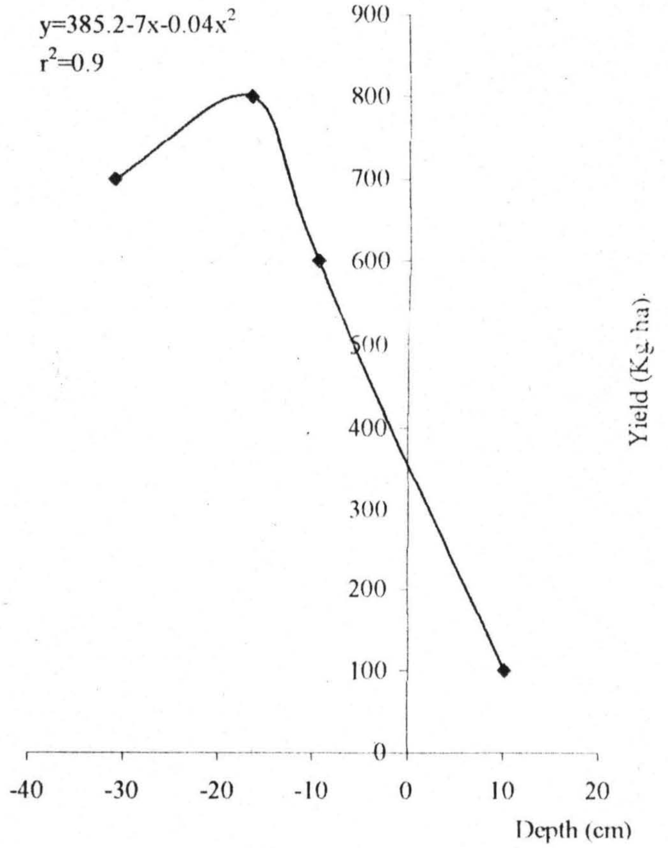

FIG 4.1: Relationship Between Water Table Depth and Rice Yield at Chanchaga

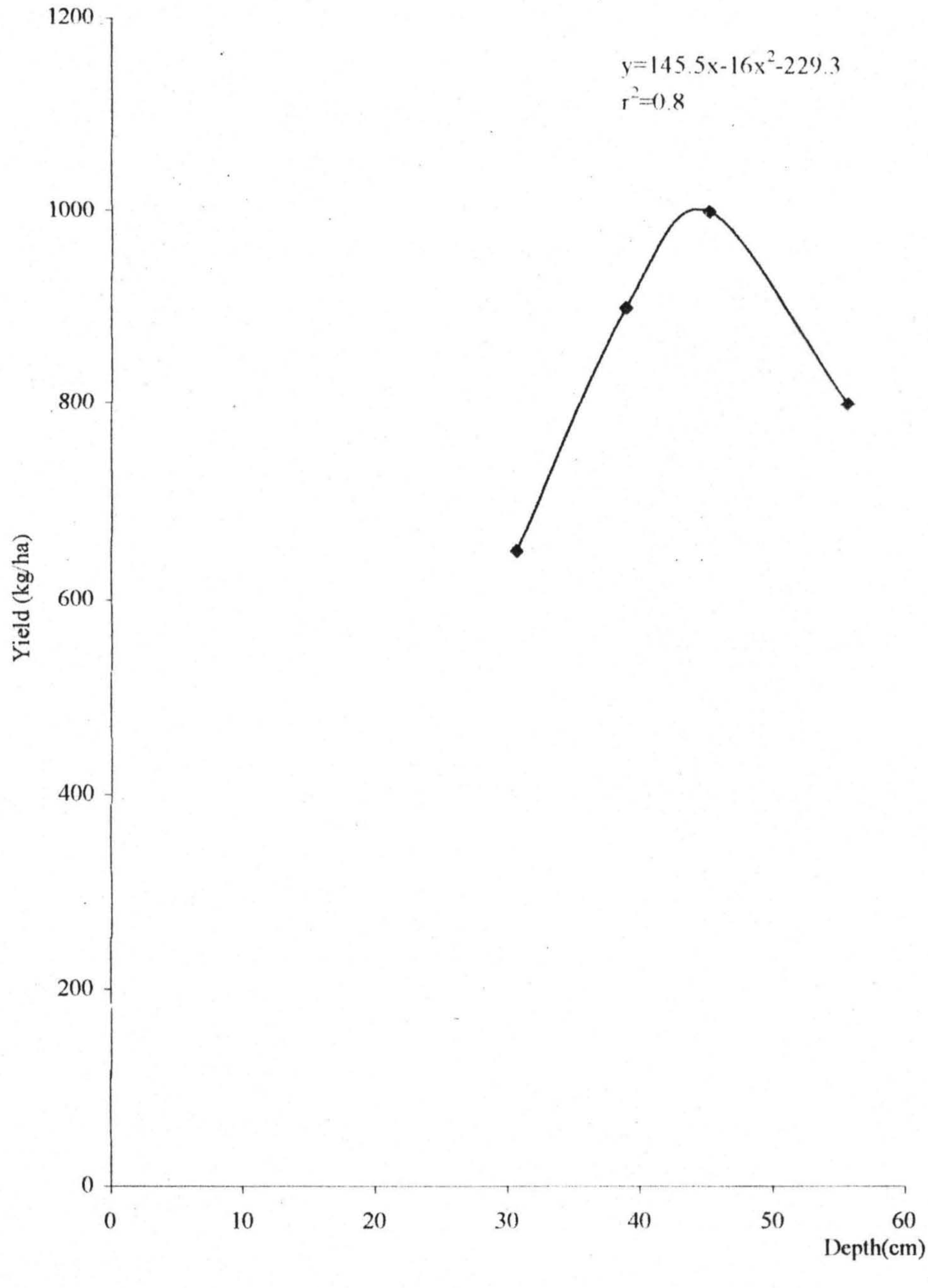

Fig:4.2 Relationship between Water Table Depth and maize yield at Chanchaga.

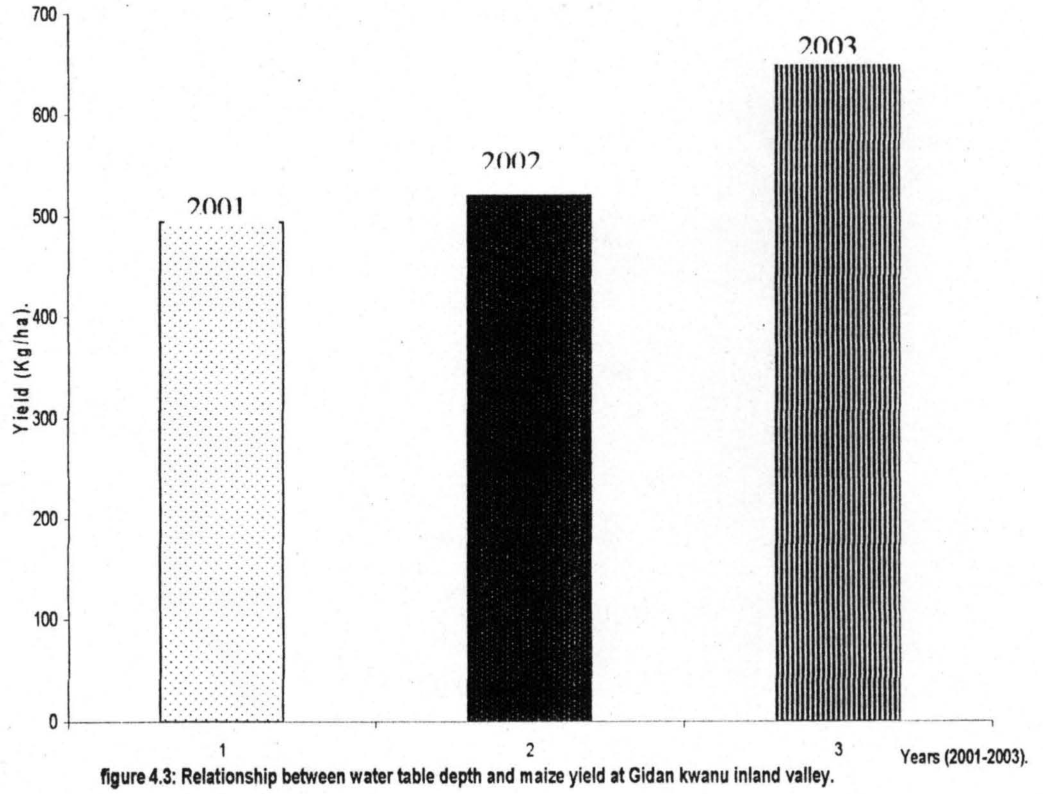

figure 4.3: Relationship between water table depth and maize yield at Gidan kwanu inland valley.

4.3 Relationship between Water Table Depth and Corn Yield

The relationship between the water table depth and corn yield is given in fig 4.2. The graph showed that the corn yield decreased with increase in water table depth.. At well location W_1 with depth 55.55cm yielded the corresponding yield was 800/ kg/ ha,W4 with depth 45.08 yielded 1000kg/ha, W_3 with depth 38.83cm yielded 900kg/ha and W_2 with depth 30.64cm yielded 650 kg/ha.

4.4 Water Table Depth and Rainfall Characteristics.

Table E3 indicates the affect of rainfall as it affect depths, the rainfall was very low in the month of February for the past ten years (meteorological station minimum airport) and high from May to September and this make rice which among other crops need enough water for survival.

For the ten years monthly rainfall collected (table 3.3) it shows that the rainfall was at its peak between August and September and with little or no rainfall within November to February of every year, this gives reasons why there are two season in Chanchaga irrigation scheme i.e. dry season for corn and rainy season for planting of rice.

4.5 Crop Yield and Water Table Expressions Using Regression Analysis

The following regression equations were obtains from the analysis;

1 the equation in fig 4.1 is given as;

$$Yrice= 385.2 -7.1x - 0.04x^2$$ which gives R^2 values to be 0.9

2 the equation on fig 4.2 is given as;

$$Ycorn = 145.5x - 1.6x^2 - 2297.3$$ which gives R^2 value to be 0.8

From the first equation , positive coefficient shows that at zero water table depth ,the yield of rice is 385.2kg/ha.The second equation shows that at zero water table depth their would be no yield for corn at the location.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Due to the nature of the soil, the water table depth that gave the best yield for maize on the clayed loamy soil at Chanchaga was in the range of 40 to 50cm depth below the soil surface.

Also it was discovered that on the same type of soil, the depth of water table for a better yield is within the range of 16 to25cm depth above the ground surface for rice crop.

Similarly, the research carried out at Gidan Kwano inland valley which is characterized by sandy loam, the depth that gives the maximum yield was 63.33 cm water table depth in year 2003.for maize crop.

The results from both Locations showed that the yield of maize and rice were affected by the depth of water table.

5.2 Recommendation

Based on the research carried out and the findings the following are recommended.

(1) Selecting heavy soils or those with hard pans in subsurface depth to reduce permeability and this will improve water use efficiency in low land rice practices.

(2) Maize should be planted in well drained soil for optimum yield.

(3) More work should be done on the measurement of water table depth for better comparison

(4) More research work should be encourage to secure more crop yield and water table depths over a along term period. Statistical analysis of such pool of data will result in a more reliable predictive equations..

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16. How many days doe your crop lasted (i.e. from the date of planting to harvesting time) ☐ laize ☐ kra ☐ ce

17. Do you irrigate your crop? Yes ☐ No ☐

18. Fertilizer Application (if any)?

(i) Types of Fertilizer Organic ☐

Inorganic ☐

(ii) Method of Application Broadcasting ☐ Ring ☐

Others______

(iii) Number of times the application is done

Rice ☐

Maize ☐

Okra ☐

Other Crops ____

(iv) Quantity Applied _______________kg/ha

19. List of the farm tools use in your farm

1__________________________ 2________________________ 3_____________

4__________________________ 5________________________ 6_____________

20. Use of herbicides (if any)

(i) Types of Herbicides applied ______________________________

(ii) Quantity applied per plot ________________________________

(iii) Method of Application_________________________________

SECTION C

21. Time and date of harvesting.

22. How many times do you harvest your crops within a week.

Maize ☐ Rice ☐ Okra ☐

23. Do you harvest alone in your farm? Yes ☐ No ☐

If No, How many people do assist you ____________________________

Relatives ☐ Employed ☐

24. How does harvested crops preserved?

	Silos	Barn	Sack	Basket
Maize	☐	☐	☐	☐
Okra	☐	☐	☐	☐
	☐	☐	☐	☐

Rice

Others ☐ ☐ ☐ ☐

25. What total quantity (bags) do you harvest per season per plot

Maize ☐ kg Rice ☐ kg Okra ☐ kg

26. Do you suffer any loss during harvesting? Yes ☐ No ☐

Quantity loss________________________________

If Yes, What do you think is responsible for the damage?

No Good Harvesting Equipment ☐ Weather ☐ All ☐

27. What steps are you taking to avoid future occurrence?____________________________

____

___

28. How do you package your harvested crops?

Sack ☐ Basket ☐ Others ☐

29. What means of transportation do you use for your harvested crops?

Pick up Van ☐ Trailer ☐ Wheelbarrow ☐ Others ☐

30. Any other information not stated above

____

____

___

____

___

____

___

APPENDIX A

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

NIGER STATE (F U T MINNA)

A questionnaire on crop yield within some specific location in Minna, Niger state

Please Tick as Appropriate

SECTION A (PERSONAL DATA)

1 Date____________________________

2 Name of the Farmer____

3 Age of the farmer (in years) 16 -25 ☐ 25& above ☐

4 Highest Qualification of the Farmer ______________________________

5 Location of the Farm____

____

6 Years of Farming Experience: 1- 3 years ☐ 4 – 6years ☐ 6 and above ☐

7 Years of farming in the area: 1 year ☐ 2years ☐ 3years ☐
4 years ☐ 5 and above ☐

8 System of Farming Practiced: Subsistence ☐ Large Scale Commercial ☐
Small Scale Commercial ☐

9 Do you work alone in your farm: Yes ☐ No ☐

SECTION B

10 Which type(s) of crop do you plant? Maize ☐ Rice ☐ Okra ☐
Others (Specify)__________________________

11 When do you normally start planting? Maize ☐ Rice ☐ Okra ☐ Others ☐

12 Size of the farmland in which each types of crop is grown? Maize ☐ Rice ☐ ☐
Okra

13 What are the crops duration______________________________________

14 Weeding time

(i) First Weeding - First Week After Planting ☐
Second Week after Planting ☐

(ii) Second Weeding – Fifth Week ☐
Sixth Week ☐

15. Season of farming; Raining Season (R), Dry Season (D) Both (B)

Maize ☐ Okra ☐ Rice ☐

APPENDIX B

Crop yield computation for 2001 to 2003 (Chanchaga plots)

Well location (W_1) at area (50 X 50 m)

No of %0 bags obtained = ½ bags

Yield in (50 X 50 m) plot = ½ X 50 Kg = 25 Kg

Yield in Kg / ha = 100Kg / ha

Since 10,000 m^2 = 1 hectors

2500 m^2 = ¼ hectors = 0.25 ha

Well location (W_2) at area (50 X 50m)

No of 50 bags obtained = 4 bags

Yield in (50 X 50) m2 plot = 4 X 50 = 200 Kg

Yield in Kg / ha = 800 Kg / ha

Since 10,000m^2 = 1 ha

2500 m^2 =0.25 ha

Therefore no of Kg / ha = $\frac{200\ Kg}{0.25\ ha}$ = 800 Kg / ha

Well location (W_3) at area (50 X 50) m2

No of 50 bags obtained = 3 bags

Yield in (50 X 50) m^2 plot = 3 X 50 = 150 Kg / plot

Yield in Kg / ha = 600 Kg / ha

Since 10,000m^2 = 1 ha

2500 m^2 =0.25 ha

Therefore no of Kg / ha = $\frac{150\ Kg}{0.25\ ha}$ = 600 Kg / ha

Well location (W_4) at area (50 X 50) m2

No of 50 bags obtained = $3^1/_2$ bags

Yield in (50 X 50) m^2 plot = $3^1/_2$ X 50 = 175 Kg / plot

Therefore no of Kg / ha = $\frac{175 \text{ Kg}}{0.25}$ = 700 Kg / ha

Rice (Chanchaga plots)

Well location (W_1) at area (50 X 50) m^2

No of 50 bags obtained = 3 bags

Yield per plot = 3 X 50 = 150 Kg / plot

Yields in kg / ha = 200 = 600 Kg / ha

0.25

Well location (W_2) at area (50 X 50) m^2

No of 50 bags obtained = 4.5 bags

Yield per plot = 4.5 X 50 = 225 Kg / plot

Yield per hectors = 900 Kg / ha

Well location (W_3) at area (50 X 50) m^2

No of 50 bags obtained = 3 $^3/_4$ bags 30 Kg / ha

Well location (W_4) at area (50 X 50) m^2

No of 50 bags obtained = 3 $^1/_2$ bags 30 Kg / ha

= 3 $^1/_2$ X 50

= 175 Kg / Plot

yield per hector = $\frac{175}{0.25}$ = 700 Kg / ha

Maize (Gidan Kwanu plot)

For year 2001

No of bags = 19 bags

Hand area = 19200 m^2.

Yield per hectors = 494.50 Kg / ha

For year 2002

No of bags = 20 bags

Hand area = 19200 m^2.

Yield per hectors = 520 Kg / ha

For year 2003

No of bags = 25 bags

Hand area = 19200 m^2.

Yield per hectares = 651.04 Kg / ha

APPENDIX C

Statistical Analysis

From regression equation: $Y = a + bx + cx^2$

Where a, b, c are constants

TABLE C1: Statistical data

X	Y	XY	X^2	X^2Y	Y^2	X^3	X^4
10.13	100	1013	102.61	10260	10000	1039.5	10530.2
-16.62	800	-1329	276.2	220960	640000	-4590.8	76299.9
-9.63	600	-5778	92.7	55620	360000	-893.1	8600
-31.0	700	-21700	961	672700	490000	-29791	923521
-47.12	2200	-39761	22994.32	959540	1500000	-34235.4	1018951.2

From Table C1,

$Y = 385.2 - 7.1X - 0.04X^2$

From table C_1

$A = 385.2$

$B = -7.1$

$C = -0.04$

$Y = 385.2 - 7.1_x - 0.04x^2$

R^2 values = 0.9

$SSR = \sum B_{j}g_i \ (\sum^n I = n\ y_i)^2 / n$
$i = 1$

$\sum^k b_i\ g_i = bo \sum y + b_i \sum xy + \sum x^2 y$

where $bo = a_1\ b_1 = b_2 = c$

$SST = Syy = \sum^n y_1^2 \ (\sum^n_{i=1} y_i)^2 / n$

TABLE C2:

X	Y	XY	X^2	X^2Y	Y^2	X^3	X^4
55.55	800	44440	3085.8	2468642	640000	171416.3	9522177.1
30.64	650	19916	938.8	610226.24	422500	28765.1	881363.5
38.83	900	34947	1507.8	1356992.01	810000	58546.7	2273367.1
45.08	1000	45080	2032.2	2032206.4	1000000	91611.9	4129862.9
170.1	3350	144383	7564.6	6463624.65	2872500	350340	16806770.55

From Table C2,

$Y = 145.5X - 1.6X^2 - 2297.3$

From table C_2

A = -2297.3

B = 145.5

C = -1.6

$Y = 145.5x\ 1.6x^2 - 2297.3$

R^2 = SSR/SST

Where SSR = Residual sum of square

SST = Total sum of square

R^2 values = 0.8

APPENDIX D

Table D1 Mean water table depth and rice yield relationship at Chanchaga irrigation scheme (2002).

Well location	**Depth (cm)**	**No of bags 50kg**	**Yield per plot (kg)**	**Yield Kg/Ha**
W1	10.13	½	25	100
W2	-16.62	4	200	800
W3	-9.63	3	150	600
W4	-31.00	3.5	175	700

Table D2 Mean monthly water table depth at Chanchaga.

Location	Feb (cm)	Mar (cm)	April (cm)	May (cm)	Mean (cm)
W1	79.85	76.60	34.20	31.55	55.55
W2	43.20	39.45	14.30	25.20	30.54
W3	46.45	55.05	26.70	27.10	38.83
W4	95.75	54.10	12.80	17.65	45.08

Table D3 Mean water table depth and corn yield relationship at Chanchaga irrigation scheme.

Well location	Depth (cm)	No of bags (50kg)	Yield per plot	Plot Yield kg/ha
W1	55.55	3½	175	800
W2	30.64	3	150	650
W3	38.83	4½	225	900
W4	45.08	5	250	1000

Table D4 Mean monthly depth of water table at Gidan Kwano inland valley (2003)

Month depth of water table (cm)

Month	W1	W2	W3	W4	W5	Mean depth (cm)
July	95.52	87.29	71.58	85.53	87.74	84.33
August	48.40	43.70	41.27	33.86	50.85	43.62
September	8.30	18.65	49.08	7.58	16.21	19.96
October	10.33	18.00	35.53	12.76	12.09	17.74
November	61.23	61.42	75.15	71.45	55.80	65.01

Table D5 Mean monthly water table at Gidan Kwano inland valley from 2001-2003 from (July- December)

Month	2001 Water depth (cm)	2002 Water depth(cm)	2003 water depth (cm)
July	70	53.75	85
Aug	37.5	45.00	46.25
Sep	36.25	43.75	20.00
Oct	60	48.75	20.00
Nov	130	128.75	67.5
Dec	111.25	113.75	141.25

Table D6 Mean yearly water table depth and corn yield at Gidan kwanu inland valley from (2001-2003)

Year	Mean depth	Yield (bags)	crop area (m^2)	Yield kg/ha
2001	74.17	19	19200	494.80
2002	72.29	20	19200	520.80
2003	63.33	25	19200	651.05

APPENDIX E

Table E.1: Monthly Minimum Temperature °C for 1994-2003

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1994	14	17	21	24	23	22	22	22	22	23	22	18
1995	18	18	24	24	24	23	23	23	23	23	19	15
1996	15	17	24	26	24	24	23	23	23	23	19	17
1997	15	21	24	25	23	22	23	22	21	21	16	16
1998	22	20	23	24	23	22	23	23	23	23	21	17
1999	17	21	23	27	25	24	24	24	23	24	20	17
2000	17	20	25	25	24	23	23	23	23	23	21	16
2001	19	18	19	24	23	22	23	23	23	23	21	20
2002	17	22	22	24	23	23	22	23	19	20	18	14
2003	13	14	21	23	22	23	21	21	21	21	19	14
TOTAL	167.00	188.00	226.00	246.00	234.00	228.00	227.00	227.00	221.00	224.00	196.00	164
MEAN	16.70	18.80	22.60.	24.60	23.40	22.80	22.70	22.70	22.10	22.40	19.60	16.40

Source: meteorological station Minna Airport

Table E.2: Monthly Maximum Temperature °C for 1994-2003

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1994	34	37	37	38	37	32	31	31	32	33	35	35
1995	34	40	37	37	34	32	31	31	33	34	34	15
1996	34	39	36	38	35	33	32	31	32	33	35	35
1997	35	38	37	39	34	32	31	30	31	33	35	36
1998	36	38	37	36	34	32	32	32	32	33	36	35
1999	35	40	39	39	34	33	32	30	31	33	36	35
2000	35	38	37	37	34	32	31	30	31	33	35	35
2001	34	39	37	36	33	33	30	31	31	33	35	35
2002	35	37	37	35	32	32	30	30	32	32	35	33
2003	35	38	36	35	34	32	32	30	31	33	34	34
TOTAL	347.00	384.00	370.00	370.00	341.00	323.00	313.00	306.00	314.00	329.00	350.00	347.00
MEAN	34.70	38.40	37.00	37.00	34.10	32.30	31.30	30.60	31.40	32.90	35.00	34.70

Source: meteorological station Minna Airport

Table E.3: Total Monthly Rainfall (mm) 1994 - 2003

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1994	0.00	0.00	0.00	0.00	174.40	170.50	189.70	271.10	178.30	63.30	0.00	0.00
1995	0.00	0.00	7.30	72.50	114.40	239.00	142.50	267.20	261.30	208.10	0.00	0.00
1996	0.00	0.00	0.00	100.50	123.20	144.00	153.70	409.00	189.10	135.70	236.00	0.00
1997	0.00	0.00	0.00	48.60	164.70	225.00	259.70	257.00	191.10	127.90	0.00	0.00
1998	0.00	0.00	3.60	80.60	238.40	233.00	172.40	192.90	273.30	115.00	6.10	0.00
1999	0.00	0.00	TR	92.20	121.20	221.00	155.50	243.00	261.90	212.60	0.00	0.00
2000	0.00	7.90	0.00	35.70	102.80	164.20	243.90	254.70	237.10	212.20	0.00	0.00
2001	0.00	0.00	0.00	3.60	135.90	161.00	208.80	308.50	303.00	153.40	0.00	0.00
2002	0.00	0.00	0.00	93.90	139.00	331.70	244.60	230.20	298.80	25.70	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00	250.00	195.60	300.00	350.00	130.50	0.00	0.00
TOTAL	0.00	7.90	10.90	527.60	1314.00	2139.90	1966.40	2833.60	2543.90	1384.40	242.10	0.00
MEAN	0.00	0.00	1.09	52.76	131.40	213.99	196.64	283.36	254.39	138.44	24.21	0.00

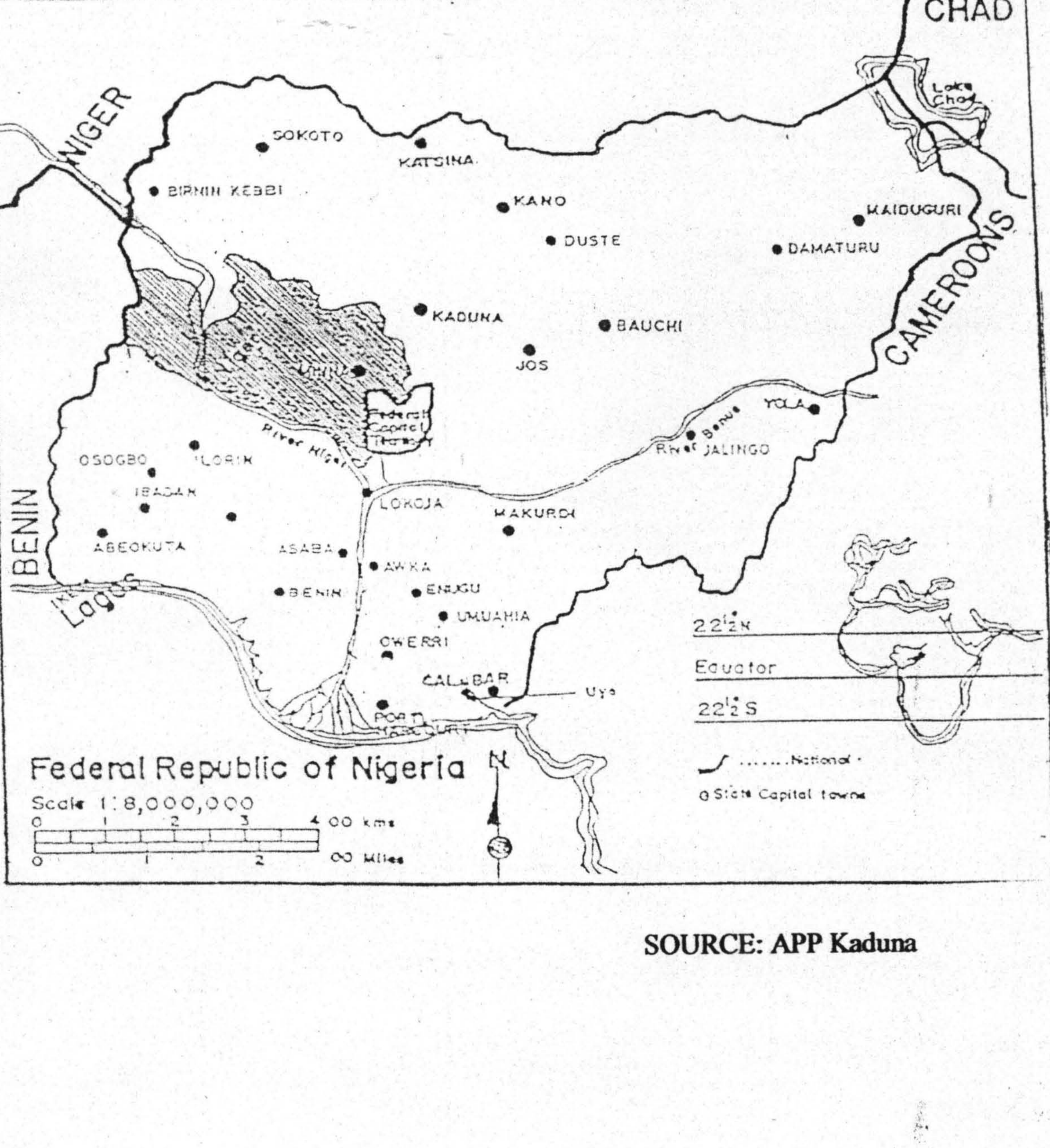
Source: meteorological station Minna Airport

Table E.4: Total Monthly Relative Humidity in Percentage 1994-2003

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1994	33.00	40.00	53.00	63.00	72.00	80.00	86.00	86.00	81.00	71.00		44.00
1995	40.00	25.00	55.00	63.00	74.00	80.00	84.00	87.00	85.00	76.00	45.00	30.00
1996	34.00	27.00	48.00	62.00	72.00	77.00	81.00	86.00	80.00	73.00	39.00	34.00
1997	33.00	42.00	57.00	63.00	73.00	81.00	87.00	85.00	84.00	74.00	32.00	31.00
1998	31.00	18.00	46.00	64.00	70.00	82.00	85.00	85.00	82.00	78.00	45.00	28.00
1999	32.00	32.00	25.00	61.00	76.00	80.00	86.00	87.00	83.00	77.00	47.00	36.00
2000	31.00	36.00	58.00	57.00	70.00	78.00	84.00	81.00	82.00	79.00	50.00	33.00
2001	40.00	25.00	34.00	63.00	69.00	74.00	85.00	87.00	84.00	74.00	45.00	33.00
2002	31.00	30.00	44.90	57.00	61.00	70.00	76.00	79.00	73.00	52.00	43.00	35.60
2003	29.00	24.00	53.00	66.00	78.00	84.00	89.00	90.00	88.00	89.00	48.00	32.50
TOTAL	334.00	299.00	473.90	619.00	715.00	712.00	843.00	853.00	822.00	743.00	394.70	337.10
MEAN	33.40	29.90	47.39	61.90	71.50	79.11	84.30	85.30	82.20	74.30	43.86	33.71

Source: meteorological station Minna Airport

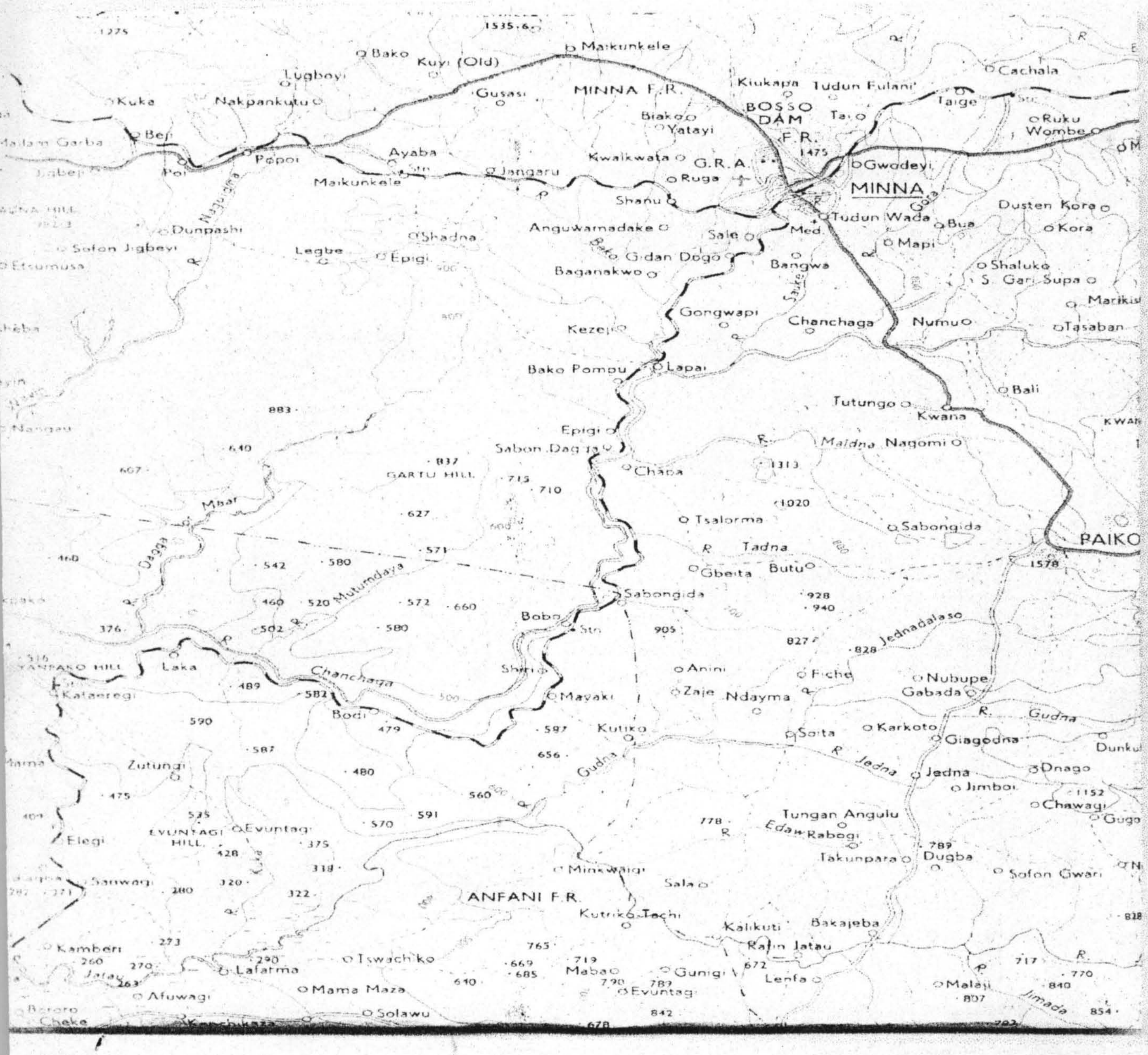
APPENDIX G



SOURCE: APP Kaduna

Fig G: Niger State in the context of the Federal Republic of Nigeria.

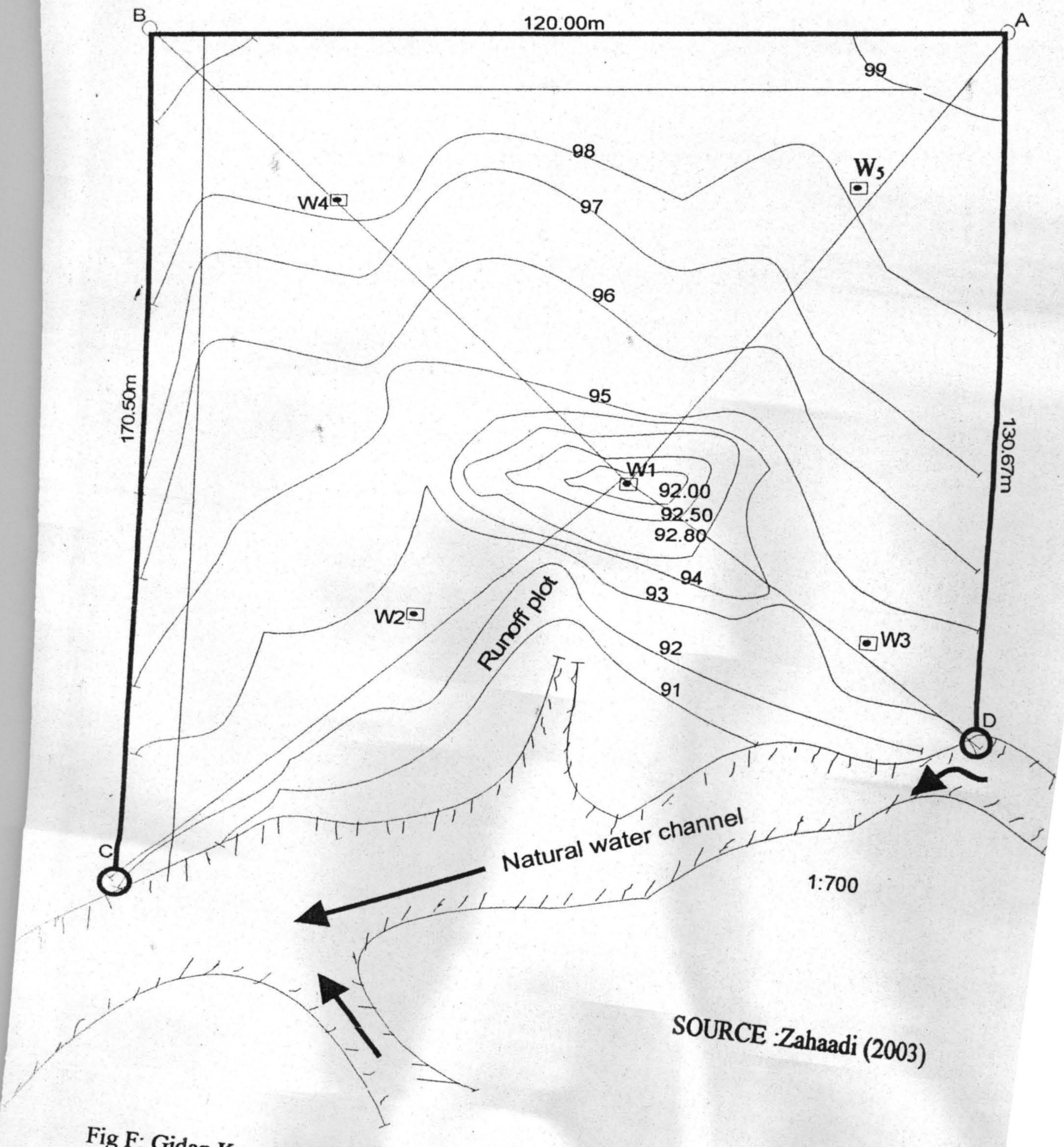
APPENDIX H



SOURCE: NSMW MINNA

Fig H: Niger State in the context of the Federal Republic of Nigeria.

APPENDIX F



SOURCE :Zahaadi (2003)

Fig F: Gidan Kwanu Inland Valley land area