DESIGN OF SPRINKLER IRRIGATION SYSTEM FOR WHEAT PRODUCTION AT TUNGAN KAWO DAM, WUSHISHI, NIGER STATE.

SCHOOL OF ENGINERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

BY

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DEPARTMENT OF AGRICULTURAL ENGINEERING

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Approved By

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Project Supervisor

17/11/2001.
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Head of Department

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DEDICATION

This Project is dedicated to my success and Progress of my family.

ACKOWLEGMENT

I whole heartedly express my profound gratitude and appreciation to almighty GOD the most exalted for sparing my life throughout the course of my study.

I am extremely indebted to many people directly or indirectly for their immeasurable contribution to the success of this research work.

My most sincere feeling of appreciation's and thanks goes to my project supervisor Mohammed Bashir. Same goes to my HOD Eng. (Dr) M.G. Yisa, the programme co-ordinators Engr. (Dr) N.A. Egharevba, Engr. (Dr). D. Adgidzi and Engr. (Dr). A Ajisegiri, for their co-operation and willingness to help throughout the project work. I have not forgotten the rest of the department staff, whose concerned and suggestion really inspired me to work.

In a very special way, I would like to express my gratitude to Mr. & Mrs. Danjuma S. Noma and his family for their inestimable support, care and concern.

Finally, and in no way the least. I wish to express my sincere thanks to my wife Mrs. Mary T. Dauda for her solid support.

TABLE OF CONTENTS

ABSTRACT

This Project Work presents the designing of sprinkler irrigation system of one hectare of land for wheat production at Tungan Kawo Dam at Wushishi Local Government Area of Niger State.

The design criteria were based on the design information data obtained from the irrigation charts, tables and calculations using the experimental results. Soils and water analysis carried out shows that they are suitable for sprinkle irrigation system. The design involves main line, selection of sprinkle, nozzles and risers, lateral and pump units design. The application efficiency was assumed to be 75%, water holding capacity of 10cm/m (100mm/m), peak consumptive use of (3.1 mm/day), depth of root zone of (0.9m), soil moisture extraction level of (50%), application rate of (0.4cm/hr) and soil intake of (13mm/hr) values were obtained. With these result, the project is viable and therefore recommended for the farmers in Tungan Kawo irrigation scheme.

CHAPTER ONE

1.0 INTRODUCTION

Irrigation is generally defined as the application of water to the soil to supply the moisture essential for plant growth and thereby eliminating the moisture limitation to the crop production. The practice includes the development of water supply, the conveyance system, the method of application and waste water disposal system along with necessary management to achieve the intended purposes.

Gulhati (1958) stated well the importance of irrigation in the world. Irrigation in many countries is an old art as old as civilization but for the whole world it is a modern science the science of survival. The pressure of survival and the need for additional food supplies are necessitating a rapid expansion of irrigation throughout the world. Even though irrigation is of first importance in the more arid region of the earth, it is becoming increasingly important in humid regions, which introduce us to sprinkler irrigation system, as it needs in Tungan Kawo irrigation scheme.

1.1 GENERAL OBJECTIVE

The main objective of this work is to design a sprinkler irrigation system for 1 hectare of land in Tungan Kawo irrigation scheme at Wushishi.

1.1.2 SPECIFIC OBJECTIVES

The specific objectives are:-

1. To design a sprinkler irrigation system for 1 hectare of farm using the discharge as a source.
2. To design the sprinkler irrigation system for 1 hectare of wheat farm.

1.3 GENERAL

Tungan Kawo Dam and irrigation project is one of the multi-purpose project embarked upon by the defunct Niger River Basin Development Authority. The project was conceived as far back as 1955 by the defunct Northern Nigeria Government as a solution to the frequent floading of valuable agricultural land in the project area by Rivers Ubandawaki and Bankogi. The reservior was therefore, intended to provide controlled facilities for down stream irrigation of a gross area of 900 hectares as well as flood and drainage control work for about 1,215 hectares.

This work intended to design a sprinkler irrigation system for wheat production of one hectare (1ha) that is (10,000m^2) using a channel water in the scheme as a source of water.

1.4 HISTORICAL BACKGROUND

The project first featured in the Northern Nigerian Government Development Plan of 1962- 68 along with other reservior projects like Sokoto, Rima, Yobe, South Chad basin and Hadejia.

Following the creation of North Western State, the project was transferred to it. In early 1976, the then North Western State Government commissioned a firm of consultants – Messrs. Associated Engineers, to undertake necessary investigation and design works of the project. The Niger State government inherited the project as a result of state creation in late 1976. In 1977, the consultants submitted their preliminary report to the State Government.

The project was eventually transferred to the defunct Niger River Basin Development Authority for execution in 1978. The consultants (Associated Engineers) were again commissioned by the Authority too embark on the detailed designs of the project and produce contract documents. Today the Project is managed by the Upper Niger River Basin and Rural Development Authority.

1.5 DESCRIPTION OF PROJECT AREA

1.5.1 Location

The Tungan Kawo dam is built across the flood plains of Rivers Ubandawaki and Bankogi. It is located at 7.5km from Wushishi town in Wushishi Local Government Area of Niger State.

1.5.2. Topography.

The land surface is fairly elevated and undulating throughout the project area. The elevation varies from 83m to 103m a.m.l.

1.6.0 CLIMATOLOGY

1.6.1 Climate

The climate of the project area is essentially the same as that of the middle belt of Nigeria with temperature and excessive humidity during the greater part of the year. The nearest meteorological station which has got continuous records for a considerable period is at Minna, some 50km on the Eastern side of the project.

1.6.2 Rainfall

The normal rainfall ranges between 1200mm and 1300mm.

1.6.3 Temperature

From available records, temperature varies from 37.5^0c maximum to 18^0c minimum. The hottest period is being the month of February, March and April of every year.

1.7.0 Hydrology

Rivers Kaduna and Ubandawaki (Gabuko) are the two main streams in the vicinity of the project area. River Ubandawaki, on which the dam is located, has a catchment area in the order of 166sqkm at the dam site. The River comprises of several minor tributaries which ultimately discharge into River Niagi which in turn joins Kaduna River on the down-stream end of the project area.

1.7.1 Geology and Geomorphology

The project area is situated more or less on the border of the basement complex and Nupe sand stones. The basement complex consists, mainly of metamorphic rocks with local granite and basic intrusions (Wushishi) while the Nupe sand stones consist of fine sand stones sometimes overlain by pliuthite (iron-stone or laetrile)

1.8.0 DRAINAGE

The entire survey area generally drains into River Kaduna. Two small tributaries to River Kaduna namely:- Rivers Bankogi and Gabuko, flow through the survey area.

1.9.0 JUSTIFICATION OF THE PROJECT

This research work is carried out to provide adequate information for designing of sprinkler irrigation system in the area. It will enable the peasant farmers to set up more successful sprinkler irrigation scheme, and boast food production, especially the rice and wheat during the dry season and better water management.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 IMPORTANCE OF IRRIGATION

Irrigation in many countries is an old art as old as civilization but for the whole world it is a modern science the science of survival.

The pressure of survival and the need for additional food supplies are necessitating a rapid expansion of irrigation throughout the world. Even though irrigation is of first importance in the more arid regions of the earth, it is becoming increasingly important in humid regions.

Isrealsen and Hansen (1962) stated that irrigation is an age old art. Historically, civilization has followed the development of irrigation. The antiquity of irrigation is well documented throughout the written history of mankind.

2.2 IRRIGATION IN NIGERIA

Irrigation by Shadoof method was introduced in to Nigeria between 1297 and 1596 from Egypt, (Usman, 1972), since then the importance of irrigation to increase food production had been taken seriously. However, the rate of expansion of irrigated area had been very slow (Nwa, 1991).

Small independent farmers continued to use the Shadoof method of irrigation and small pumps for irrigation along rivers, streams, banks, near ponds, lakes and fadama areas for the growth of their crops such as tomatoes, vegetables, wheat, rice e.t.c.

Today, the involvement of private sector in large scale irrigation is very limited. Infact installation and maintenance of large scale irrigation systems had been left solely into the hands of both the Federal and State Governments as a result of high cost of the initial installation and maintenance.

The Federal Government of Nigeria had established a number of large irrigation schemes such as Nigeria Sugar Company Bacita (NISUCO), River Basin and Rural Development Authorities (NRB and RDA), the Savanua Sugar Company (NUMAN) (SSCN) that produce sugar cane under large scale irrigation.

2.3 TYPES OF IRRIGATION

There are four major types of irrigation method:-

a. Surface irrigation method

b. Sub surface irrigation method

c. Trickle or drip irrigation method

d. Over head irrigation method

2.3.1 OVER HEAD IRRIGATION METHOD

The over head irrigation method includes watering can, hose, pipes and sprinkler systems.

2.3.2 SPRINKLER IRRIGATION SYSTEM

The sprinkler irrigation system is the method whereby water is supplied to the surface of the soil in form of spray, some what as in ordinary rain. This is achieved by the flow of water under pressure through the conveyance and distribution systems and discharged through small orifices or nozzles. (Isrealsen and Hansen 1962).

2.3.3 COMPONENT OF SPRINKLER SYSTEM

(a) Sources of Water.

The source of water is a place where water is obtained for irrigation purposes, mostly dams, well e.t.c.

(b) Sources of Energy (Water Pump).

Water pump is usually used to generate the pressure required to lift the water from the source to the point of usage through pipes.

System capacity $Q = \frac{25Adg(L/S) - (1)}{9HFI}$ ....(1)

where Q = System capacity in L/S or M^3/S.

A = Areas of the field to be irrigated (M^2)

Dg = Gross depth (MM)

H = Operational hours per day (hr)

Fi = Irrigation frequency.

<u>OR</u>

$Q = 2780 \frac{A xd}{FXH xE}$ ....(2)

Where

Q = discharge capacity of the pump, litres/sec.

A = Area to be irrigated, hectares.

d = Wet depth of water application, CM

F = Number of days allowed for the completion of one irrigation

H = Number of actual operating hours per days

E = Water application efficiency, percent (%)

A.M. Micheal (1982)

(c) Main Line

This is the medium through which entire water lifted by water pump is transmitted and later distributed to the laterals.

$$\frac{\Delta H}{\Delta L} = 15.270 \text{ X } Q_n \, 1.852 \text{ X } D^{-4.871} \text{.........................(3)}$$

Where ΔH = Energy dropped by friction (M)

ΔL = Length of the pipe section (M)

Qn = Total discharge in pipe (LS)

D = Inside diameter of the pipe (CM)

(d) Lateral Lines

These are the medium, into which water conveyed from the main line branches and finally spray out from the nozzles.

$$\frac{DH}{DL} = 5.35 \text{ Qn } 1.852 \text{ X } D - 4.871 \text{................................(4)}$$

Where DH = Energy dropped by friction (M)

DL = Length of the pipe section (M)

Qn = Total discharge in pipe (L/S)

D = Inside diameter of the pipe (CM)

RISER AND NOZZLES

The riser direct water to the sprinkler head which finally sprayed out from the nozzles or ovivies stream into the air and eventually dropped on the plants or soil surface like rain.

2.4 TYPES OF SPRINKLER IRRIGATION SYSTEM

The type of sprinkler irrigation system is classified into six classes according to portability.

(a) portable system

(b) semi portable system

(c) semi permanent system

(d) permanent system

(e) solid set system

(f) centre pivot system

(Israelsen and Harisen 1962)

2.4.1. TYPE OF SPRINKLERS

(a) Rotating sprinkler head

(b) Fixed nozzle pipe

(c) Perforated pipe

(d) Big bus/Traveler irrigation gum

(e) Centre pivot irrigation head.

(f) Hydrostatic power roll wheel irrigation head

Rotating sprinkler head will be used in this project research.

2.5 ADAPTABILITY OF SPRINKLER METHOD

Sprinkler irrigation method could be used for almost all types of crops except rice and jute, which required a lot of water (pounding) which is achieved mostly through flooding. It is equally suitable for almost all type of soils, except fine textured soils (heavy clay soils) having infiltration rate less than 4mm/hr.

Sprinkler irrigation system does not require land leveling operation, which is one of the expensive aspect of irrigation practices, although, it is not very good where there is drainage problem. Sprinkler irrigation method is widely used.

2.6 WATER REQUIREMENT

The estimation for water requirement (WR) is defined as the quantity of water regardless of the source by a crop or diversity pattern of crops in a given under field condition and it is given as:-

WR = ET + application losses + special needs

WR = IR + Er f S……………………………………………(5)

Where Ir = Irrigation requirement

Er = Effective rainfall.

S = Soil profile contribution.

2.6.1 EVAPO – TRANSPIRATION

Evapo – transpiration or consumptive use is the sum of two terms.

(a) Transpiration:- which is water entering plant roots and used to build plant tissue or being passed through leaves of the plant into the atmosphere.

(b) Evaporation:- Which is water evaporating from adjacent soil, water surface, or from the surface of leaves of the plant.

Water deposited by dew, rainfall or sprinkler irrigation and subsequently evaporating without entering the plant system is part of consumptive use.

Consumptive use can apply to water requirements of crop on a field, a farm, a project or a valley. When the consumptive use of the crop is known, the water use of large units can be calculated. Hence, the term "consumptive use" and the following discussion generally refer to the crop.

B/aney – craiddle developed a simplified formula using temperature and day-time hours for the arid western portion of the United States. Their formula has been used extensively by the soil conservation service of the United States Department of Agriculture wherein considerable data has been collected to determine the value of the co-efficient to be used for various crops. (Israelsen and Hansen 1962).

By multiplying the mean monthly temperature (t) by the monthly percentage of day-time hours of the year (p) there obtained a consumptive factor expressed.

$Et_o = C [P (0.46T + 8)] - 7$ ....(6)

Where.

C = The adjustment factor which depends on main humidity and wind condition.

Et_o = Reference evapo-transpiration in mm/day.

P = Mean daily percentage of total annual day time sunshine hours for a given month and latitude.

T = Mean daily temperature in O^c.

2.6.2 NET DEPTH IRRIGATION WATER

The depth of water required from total available water point of view is given as the difference in the soil's field capacity and the soil moisture content in the root Zone.

$$Dn = \frac{O_a \times MAD}{100} \quad \ldots\ldots (7)$$

WHERE

Dn = Net irrigation required (mm)

MAD = Management allowed Defficiency (%)

O_a = Available moisture in the soil (mm)

2.6.3 AVAILABLE MOISTURE CONTENT

$$Oa = \frac{ch \times Dr\ (mm)}{100} \quad \ldots\ldots (8)$$

where

O_a = Available moisture content (mm)

Ch = Moisture holding capacity (mm)

Dr = Root Zone depth.

2.6.4 GROSS DEPTH OF WATER APPLICATION

This is the total amount of water applied through irrigation and it is needed for the determination of the application rate.

$$Dg = \frac{1000n}{E_0} \text{ (mm)} \qquad (9)$$

Where

Dg = Gross depth of water application (mm)

Dn = Net irrigation requirement (mm)

E_0 = Water application efficiency (%)

2.6.5. IRRIGATION FREQUENCY (ff) DAYS

The number of days between irrigation's during periods without rainfall irrigation frequency depends on:-

(a) The consumptive use rate in the crop zone and the amount of available moisture in the crop root zone.

(b) It is a function of crop, and soil diameter.

$$Fi = \frac{Dg}{Cu} \text{ (days)} \qquad (10)$$

Where

Fi = irrigation frequency

Dg = Cross depth of water application

Cu = Peak daily consumptive use (mm/day).

2.6.5 !RRIGATION PERIOD

This is defined as the number of days that can be allowed for applying one irrigation to a given designed area during the peak consumptive period of the crop being irrigated.

The irrigation system is designed such that the irrigation period is always less or equal to the irrigation efficiency.

$$Ip = \underline{Tn} \text{ (Day)} \qquad (11)$$

Ho

Where

Ip = Net amount of moisture in soil between start of irrigation and lower limit of moisture depletion.

Tn = Minimum opportunity time

H_0 = Number of actual operating hours per day.

2.6.7 TIME REQUIRED FOR IRRIGATION

This is the ratio of the gross water requirement to the infiltration rate of the soil expressed in hour.

$$Tri = \frac{\text{Gross water required (hour)}}{\text{Infiltration rate}}$$

Where

Tri = Time required for irrigation

2.6.8 PRECIPITATION RATION (PR)

This is the ratio of the gross water required to the time required per irrigation

$$Pr = \frac{\text{Gross water required}}{\text{Time required per irrigation}} \quad \text{......(12)}$$

2.6.9 CEOFFICIENT OF UNIFORMITY

This is the measurable index of the degree of uniformity obtainable for any size of sprinkler operating under a given condition. The uniformity coefficient is affected by the pressure nozzle size relation, sprinkler spacing and by the wind condition.

It is expressed by the equation developed by Christiansen (1942)

$$Cu = 100\,)\left[1.0 - \frac{\Sigma X}{Mn}\right] \qquad (13)$$

Where

Cu = Uniformity coefficient

X = Numerical deviation of individual observation from the average application rate (mm)

M = Average value of all observations (average application rate) (mm)

N = Total number of observation points.

2.7.0 EXTENT OF IRRIGATION

The extend of irrigation depends largely on two main factors viz:

(a) Availability of land.

(b) Availability of water.

The area of land irrigated in the world id four hundred million acres (162 million hectares). Israelsen and Hansen (1962) explained the area of land irrigated in the world.

2.7.1 FUTURE OF IRRIGATION GROWTH

As the population of the world continue to increase, the demand for food and fiber for the people also increased. With irrigation water many of these lands will become highly productive. By the application of irrigation water, the productivity of lands now producing food under natural rainfall had been increased greatly.

As long as the population is increasing materially each decade, the demand for further utilization of water for irrigation will also increase.

2.7.2 ECONOMICS OF IRRIGATION

Economics is very important in evaluation irrigation practices, for irrigation is largely for the purpose of profit maximization. Higher profit resulting from more efficient production will ultimately result in lower prices for consumers, and lower prices result in more consumptive of food and fibers.

The greater availability of food and fibers results in higher standard of living for people of the world.

Irrigation projects as well as other Engineering and Agricultural works are for the purpose of making the world a better place of living.

2.7.3. INFILTRATION

infiltration is the movement of water from the surface into the soil. The infiltration characteristic of the soil is one of the dominant variables influencing irrigation.

Many factors influence the infiltration rate, including the condition of the soil surface and its vegetative cover, the properties of the soil, such as its porosity and hydraulic conductivity, and the current moisture content of the soil.

Infiltration rate is the soil characteristics determining the maximum rate at which water can enter the soil under specific conditions, including the presence of excess water.

Accumulated infiltration, also call cumulative infiltration, is the total quantity of water that enters the soil in a given time.

Infiltration rate and accumulated infiltration are the two parameters commonly used in evaluating the infiltration characteristics of the soil. For design purposes, the relationship between accumulated infiltration and unclasped time are usually expressed by the following empirical equations.

$Y = at^{\alpha}$ ....(14)

$Y = at^{\alpha} + b, t \neq 0$ ....(15)

Where Y = Accumulated infiltration in time t, cm

T = Clapsed time, min.

, a, α & t = Characteristics constants.

Field experimental data on accumulated infiltration verses time, when plotted on an ordinary co-ordinate paper, give a parabolic curve. When line data are plotted on a log-log paper, a linear relationship is indicated.

But some data on the initial stage of the experiment usually fall along a straight curve. Since the constant b rectifies this slight deviation from the linear log-log relationship, equation 15 where can be used to express the accumulated infiltration - time relationship. The value of a, α & b usually range between 0 and 1.

The infiltration rate at any time t is obtained by differentiating equation 15 as follows.

$Y = at^{\alpha} + b$ ....(16)

$\frac{dy}{dt} = axt^{\alpha-1}$ ....(17)

2.7.4 MEASUREMENT OF INFILTRATION

Three methods of estimating infiltration characteristics of soil for the design of irrigation systems have been recognized.

They are:

(a) The use of cylinder infiltrometers.

(b) Measurement of a subsidence of free water in a large basin

(c) Estimation of accumulated from the water front advance data.

The use of cylinder infiltrometer method is use in this research work.

2.7.5. CURVE FITTING

The functional relationship between y and t is best represented by the equation $y = at^{\alpha} + b$. The values of the constant a, α & b may be determined by the method of averages using the procedure suggested by Davis (1943). This first step is to plot y against x and choose two points ($X_1$and Y_1) (X_2 Y_2) on and near the extremities of the smooth curve representing the data.

Now a point $X_3 = \sqrt{X_1 X_2}$ is chosen, Y_3 is read against X_3

The Value of b is determined by using the following equation.

$B = y_1 \; y_2 - y^2_3$

$= y_1 + y_2 - {}^2y_3$ ....(18)

2.7.5. WATER QUALITY

In general the purer the water, the more valuable and useful it is for reverine ecology and for abstractions to meet human demands such as irrigation, drinking and industry. Conversely, the more polluted the water, the more expensive it is to treat to satisfactory level.

A sound knowledge of the quality of the water used and its suitability for the crops grown and the soil being used is of extreme necessary.

Irrigation water quality can be lowered with hazardous substances such as chemical fertilizers, pesticides, sewage or industrial effluent, these factors can make water unsuitable for irrigation. The suitability of water can be judged by a umber of parameters principally among whom are:- its electrical conductivity.

, sodium absorption ration and boron content, others are its PH, Ca, K, N03 P04 and faecal coliform density FC.

CHAPTER THREE

3.0 METHODOLOGY

3.1 LOCATION AND CLIMATE

The project was carried out at Tungan Kawo Dam at Wushishi Local Government Area of Niger State of Nigeria. The Tungan Kawo Dam is built across the flood plains of Rivers Ubandawaki and Bankogi. It is located at 7.5km from Wushishi town, 50 km away from Minna which is the nearest meteorological station to the project area at latitude 9^0 N and attitude 848m. The annual rainfall ranges between 1200mm and 1300mm and the temperature varies from 37.5^0C maximum to 18^0C minimum. The hottest period being the months of February, March and April of every year but the dry season starts as from the month of November to March which is the irrigation period.

3.2 MATERIALS AND METHODS

The analyses were basically carried out to ascertain whether the water and soils would have any detrimental effect on the crops grown especially the wheat production.

The sampling exercise covers all the project area. Samples were collected and labeled to identify each sampling point. All sample collected were delivered to the laboratory within 24 hours of collection for investigation.

3.3 SOIL ANALYSES

The objectives of the survey were to collect for analysis composite surface (0-15cm) soil samples for analysis, to evaluate the fertility status of the soil with respect to the elements related to the determinants being considered, and to determine whether or not the soil of the study area requires additional macro-elements (fertilizers).

3.4 SAMPLING

The sampling was grided by pre-determined irrigation structures and layout at a depth of 0-15cm at each sampling point. Samples were collected at random point within the project area.

Four (4) samples were collected at the project area. Samples were collected by means of soil augers.

3.5 PRE -TREATMENT

As soon as samples were obtained in the field, they were taken for pre-treatment. The pre-treatment involves air drying them for 2-3 days, after which they were grinded with a porcelain motor and pestle.

3.6 LABORATORY ANALYSIS

3.6.1 SOIL PH

The Ph of the soil was determined in a $1{:}2^1/_2$ ratios of soil to solution suspension ratios of water and IN KCL respectively. The PH was read using the glass electrode PH meter.

3.6.2 AVAILABLE PHOSPHORUS

The available phosphorus was determined using Bray-1 method that employs a mixture of IN NH_4F (Ammonium fluoride) and O.SN HcL (Hydrochloric acid). The colour absorbency was read colorimetrically on the spectrophotometer.

3.6.3 TOTAL NITROGEN

This was analysed using micro-kjeldahe method of Bremmer Black (1965).

3.6.4 EXCHANGEABLE POTTASIUM CATION

IN NH_4, OAC (ammonium acetzte) at PH 7 mixture was used to determine the concentration of potasium with the acid of a flame photometer.

3.6.5 SOIL PARTICLE-SIZE DISTRIBUTION AND TEXTURE.

Particle – size analysis was carried out on previously air-dried soil samples that had been sieved through a 2mm – mesh sieve. Hydrometer method as describe by Boryoucus (1954) was used and neutral sodium hexameta phosphate (colgon) used as dispersing agent.

3.7 WATER ANALYSIS

The analyses were basically carried out to ascertain whether the water would have any detrimental effect on the soil or crops grown. The sampling exercise covers the study area. Samples were collected in labeled sampling bottles to identify each sampling point. All samples collected were delivered to the laboratory within 24 hours of collection for investigation.

3.7.1 PRE -TREATMENT OF WATER SAMPLES

Water samples collected in bottles were kept under a room temperature which did not exceed 25^0C on arrival from each field trip, the idea was to reduce microbial activities to the bearest minimum.

3.7.2 LABORATORY ANALYSIS

Water quality measurement programme usually involves mainly laboratory analysis. The solution of measurement methods were based on:-

a. Total number of analysis.

b. Frequency and scope of measurement.

c. Sensitivity and detection limits.

d. Constraints on accuracy and precision.

In recent advances in technology automated technique for water pollution characterization was adopted.

A C – 100 series multi parameter Bench spectro photometer was used for the concentration in water of all the determinants.

3.7.3 PRINCIPLE OF OPERATION

The colour of every object we see is determined by a process of absorption and emission of the electromagnetic radiation (light) of its molecules. Colorimetric analysis is based on the principle that specific compound react with others to form a colour the intensity of which is proportional to the concentration of the substance to be measured. When a substance is exposed to a beam of light intensity to, a portion of the radiation is absorbed by the substance molecules and radiation of intensity I, lower than Io, is emitted. The quantity of radiation absorbed is given by the Lambert – Beer law.

$\text{Log}\ {}^{I_o}/_{I} - \Sigma Tcd.$

Where $\text{Log}\ {}^{I_o}/_{I}$ = Absorbance (A)

ΣT = Molar extinction coefficient of the substance at wave length T.

c = molar concentration of the substance

d = optical distance light travels through samples.

Therefore, the concentration 'C' can be calculated from the colour intensity of the substance determined by the emitted radiation I as the other factors are known.

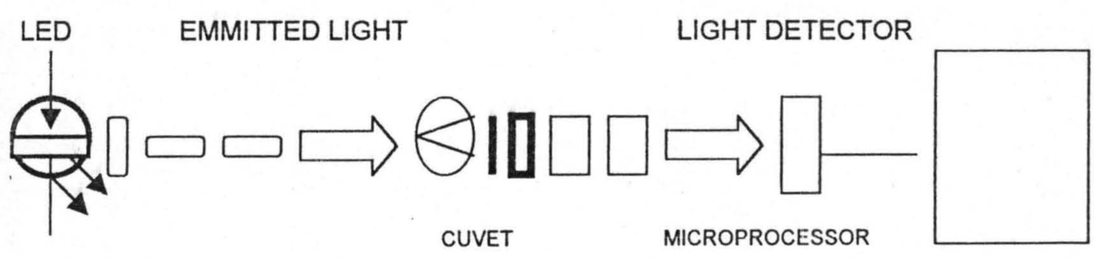

FIG. BLOCK DIAGRAM OF A SPECTORPHOTOMETER

A mochromatic LED (light emitting diode) emits radiation at a single wave length, supplying the system with the intensity Io. Since the substance absorbs the colour complimentary to the one it emits, Hauna spectrophotometer uses LED that emits appropriate wavelength to measure the sample. The photoelectric cell collects the radiation I that is not absorbed by the sample and converts it into an electric current, producing a potential in the MV range. The microprocessor uses this potential to convert the incoming value into the desired measuring unit and display it on the LED.

3.7.4 MEASUREMENT OF INDIVIDUAL ELEMENTS

3.7.4.1 PH.

SPECIFICATIONS

Range = 4.9 to 8.5 PH.

Accuracy = ± 0.1 P.H.

Light Source = Light Emitting Diode at 5.55mm.

Method = Adaptation of the phenol red method.

The reaction with the reagent causes a red tint in the sample.

3.7.4.2 PHOSPHATE

SPECIFICATIONS

Range = 0.0 to 30.0 mg/L

Accuracy = ± 1 mg/L ± 4% of reading.

Light Source – Light emitting diode at 470mm.

Method – Adaptation of the standard methods for the examination of water and waste water (WHO, 1996, 18 edition) Amino acid method:- The reaction between phosphate and the reagent causes a blue tint in the sample.

3.7.4.3 NITRATE

SPECIFICATIONS

Range – 0.0 to 85mg/L

Accuracy - ±0.5 mg/L ±0% of reading.

Light Source – Light emitting diode at 555mm.

Method – Adaptation of the cadmium reduction method. The reaction between nitrate nitrogen and the reagent causes an amber tint in the sample.

3.7.4.4 DISSOLVED OXYGEN

SPECIFICATIONS

Range – 0.0 to 10.0 mg/L (ppm)

Accuracy - ±0.4mg/L ±3% reading.

Light Source – Adaptation of the standard methods for the examination of water and waster water (18th edition) azide modified winkler method. The reaction between dissolved oxygen and the reagent causes a yellow tints in the sample.

3.7.4.5 POTTASSIUM

SPECIFICATIONS

Range – 0.0 to 20.0 mg/L

Accuracy - ±0.1 mg/L, ±2% reading.

Light Source – Light emitting diode at 768mm.

Method – Adaptation of the standard methods for the examination of water and waste water (18 edition). Flame emission spectrophotometer I method.

3.7.5 ELECTRICAL CONDUCTIVITY (EC MS/cm)

The salt concentration in any irrigation is easily measured by determination of EC, it measures the ability of any water to conduct electricity and is expressed as Mhos/cm = 0.1 s/m (0-1.0Ms/cm). From the result of water analysis carried out, the EC values for all samples range from 0.05 to about 0.09Ms/cm, meaning they could safely be used to irrigate. Most crops on most soils in the field with little or no likelihood that soil salinity will develop.

3.8 INFILTRATION TEST

The main objective of this test was to determine the sample size necessary to estimate the means and standard deviation of infiltration parameters at desired levels of confidence.

Four field tests were conducted on the Study Area using cylindrical infiltrometers method.

3.8.1 TEST METHOD

Two cylindrical infiltrometers with different diameters were used. The inner cylinder, from which the infiltration measurements were taken, was 30cm is diameter and outer cylinder which was used to form the buffer pond was 60cm in diameter. The cylinders were installed about 12cm deep in the soil. This was accomplished by marking the outside of the cylinders at the 12cm level and driving the cylinders up to the mark. This was done by a falling weight type hummer striking on a wooden plank placed on top of the cylinder to prevent damage to the edges of the metal cylinders. The water level was read with the field type point gauge. The point rod was set of the desired level to which water is to be added.

A stopwatch was used to note the instant the addition of water begin and the time the water reaches the desired level. The total quantity of water added to the inner cylinder was determined by counting the number of full containers of water and the fractional volume in the Jar, which is added last. The difference between the quantity of water added and the volume of water in the cylinder at the instant it reaches the desired point was taken as the quantity of water that infiltrates during the time interval between the start of filling and the first measurement.

After the initial reading, point gauge measurements were made at frequent intervals to determine the amount of water that has infiltrated during the time interval.

The average depth of water maintained was 7 to 12cm, which is approximately equal to the water level expected in the borders or basins during irrigation.

3.9 DESIGN SYSTEM AND METHODS

In any modern irrigation method has both advantages and disadvantages which govern the decision of the choice of the system by the designer. It is therefore imperative to evaluate the project and choose the most appropriate method suitable to a given local condition.

Since the land surface is fairly elevated and undulating throughout the project area as revealed by the topographical survey, the volume of water available for irrigation is very limited, the viable method of irrigation to be adopted is the sprinkler system.

Sprinkler system design consists of selecting system of pipe work to transmit water to the sprinkler at a suitable pressure. The items required in design are.

i. The layout of the system

ii. Selecting of the sprinkler and nozzle size.

iii. Design of the sprinkler lateral and the number required

iv. Design of the main pipeline system

v. Pump selection

3.9.1 DESIGN PROCEDURE

The design procedure involve the following.

(i) Calculation of gross water application (m)

(ii) Calculation of setting time (hours)

(iii) Calculation area to irrigated in a (ha)

(iv) Determination of sprinkler discharge (L/s)

(v) Determination of the discharge in the lateral (L/s) and size of lateral pipe (mm)

(vi) Determination of the mainline and its size (mm)

(vii) Determine pump capacity.

3.9.2 DESIGN DETAILS

- Crop: Wheat.
- Area: - 1 ha ($10,000m^2$)
- Peak consumptive use (cu) = $31m^3$/day.
- Depth of root Zone = 1.6mm
- Water holding capacity 170mm/m
- Soil type = Sandy loam – clay loam.
- Application efficiency Ea = 75% (Sprinkler System).
- Soil intake rate (Si) = 13.2mm/hr.
- Moisture extraction level = 40%.

3.9.3 CALCULATIONS

(a) Depth of application is the gross depth of water required per irrigation.

$$\Rightarrow d = \frac{(Psa)\,D}{E_a} \qquad \text{...}(19)$$

Where

D	=	gross depth application (mm)
P	=	fractional – moisture extraction level.
Sa	=	moisture holding capacity of the soil (mm/m)
D	=	depth of root zone (mm)
Ea	=	application efficiency (75%)

3.9.3.1 IRRIGATION INTERVAL

This is the number of days allowed between one irrigation and another. It is the ratio of the gross depth of application to the peak consumptive use.

Ie. $\frac{d}{Cu.}$ ....(20)

d = Gross depth of application (mm)

Cu = peak consumptive use M^3/day.

3.9.3.2 IRRIGATION PERIOD.

This is the time required to completed one irrigation in hours. It is the ratio of gross depth to the soil intake rate i.e. $T = \frac{d}{Si}$ ....(21)

Where

T = Irrigation period (hrs)

d = gross depth of application (mm)

Si = Soil intake rate (mm/hrs)

3.9.3.3 VOLUME OF WATER REQUIRED FOR ONE HA

$V = \frac{Ad}{Ea}$ ....(22)

Where

A = Area to be irrigated (m^2)

d = Depth of application (mm)

Ea = application efficiency (fraction)

3.9.3.4 DETERMINATION AVAILABLE STORAGE/ RESERVOIR VOLUME

V = Ad ....(23)

Where A = Reservoir (m^2)

d = depth of storage (mm)

3.9.3.5 CAPACITY REQUIREMENT

This depend on the size of the area to be irrigated, the gross depth of application at each irrigation and the net operating time allowed to apply the depth.

i.e. $Q = \frac{453AD}{FH}$ (F.A.O 1984). ....(24)

Where

Q	=	Discharge capacity (L/S)
A	=	Area to be irrigated (ha)
D	=	gross depth of application (mm)
F	=	number of days allowed for completion of one irrigation.
H	=	Number of actual operating hours per day.

3.9.3.6 SELECTION OF SPRINKLER SIZE. DISCHARGE AND OPERATING PRESSURE.

This can be determined using the Homograph or with the following equation by F.A.O. 1984.

$q = \frac{S_i \times . S_m \times I}{96.3}$ (F.A.O. 1984) ....(25)

Where

q	=	Sprinkler discharge (L/S)
S_i	=	Sprinkler spacing (m)
S_m	=	Lateral Spacing (m)
I	=	Optimum application rate (mm/hr).

3.9.3.7 LATERAL DESIGN

This is based on lateral level ground. In this case the allowable pressure was due to friction in the lateral line = 20% of the operating pressure for sprinkler.

3.9.3.8 MAIN LINE

The allowable loss in the main line is given by the equation.

Pm = Pa + ¾ (pf + pr) ....(26)

Where

Pm = pressure required to lift water in the risers/sprinkler.

Pa = operating pressure (psi)

Pf = Actual pressure loss due to fraction (psi)

Pr = pressure loss due to riser pipe (psi)

¾ = factor use to provide for the average operating pressure (pa) at the centre of the line.

3.9.3.9 PRESSURE REQUIREMENT

To select a pump and power unit that would operate the system efficiently it is necessary to determine the total pressure losses in the system or the total dynamic head against which water must be pumped.

(a) Static Head.

This is the difference in elevation between the water source and the point of discharge or the vertical distance the water must be raised or lowered.

(b) The total dynamic head (TDH) is the sum of total of:-

i. pressure head required to operate the lateral line (HL)

ii. Frictional loss in the mainline/sub-main (HF)

iii. Frictional losses in fitting and valves (hf)

iv. Total static head including suction lift (Hs)

:. $T\Delta H = HL + HF = hf + Hs$ hf is negligible and can be ignored.

:. $T\Delta H = HL + HF + Hs$. ……………………………………..(27)

3.9.3.0 SELECTION OF PUMP AND POWER UNIT.

Having determined the total dynamic head, pump size can be computed by the use of the equation.

$$\text{Pump size} = \frac{QH}{100E} \qquad (28)$$

Where

Q = Maximum discharge (L/S)

H = Total head (m)

E = Pump efficiency (%)

100 = Constant.

CHAPTER FOUR

4.0 DESIGN CALCULATIONS AND ANALYSIS

4.1 DESIGN CRITERIA

There are some design criteria to be taken into consideration when designing an sprinkler irrigation system since the design of an irrigation system is very complex and not readily subjected to quantitative analysis. For this project, the following design criteria are taken into consideration.

(1) To store required water into the root zone of the crops. The amount of water to be stored varies with the type of crops to be grown and the month of the growing season.

(2) To obtain a reasonably uniform application of water system that will provide satisfactory control under all conditions.

(3) To minimize the soil erosion since the quantity of irrigation water can be controlled to one's desire.

(4) To minimize the run-off of irrigation water from the field not as surface irrigation that sizeable quantity of water are wasted in the field.

4.2 DESIGN PROCEDURE

In design procedure, the following parameters are determined.

i. Capacity requirement (gross water requirement).

ii. Depth of application, irrigation period and irrigation interval.

iii. Sprinkler discharge, size, spacing and the operating pressure.

iv. Lateral design – discharge, size and head loss.

v. Mainline design – discharge, since and the total pressure required.

vi. Total dynamic head.

vii. Pump capacity and power unit.

4.3 DESIGN DETAILS

The size of project area is one hectare (1ha) located at 7.5km from Wushishi town in Wushishi local government area of Niger State. The project area is in Tungan Kawo dam built across the flood plains of Rivers Ubandawaki and Bankogi. A semi permanent small overhead sprinkler irrigation system is adopted for the design of the project, the mainline is semi-permanent while the laterals and the sprinkler are portable.

The following are the design details of the project which are either – calculated or obtained from standard irrigation charts or tables.

a.	Type of Crop	=	wheat.
b.	Soil type	=	Sandy clay loam.
c.	Size of the farm	=	One hectare (10,000m^2)
d.	Source of water	=	From channel.
e.	Topography of the field	=	0% slope
f.	Depth of root zone	=	90cm = 0.9m.
g.	Infiltration rate	=	13.2mm/hrs.
h.	Application efficiency	=	75%
i.	Application rate	=	0.4cm/hr.
j.	Water holding capacity	=	10cm/m. (100mm/m)
k.	Peak rate consumptive (cu)	=	31m^3/day (3.1mm/day)
l.	Operating hours	=	8hr/day.
m.	Moisture extraction level	=	50%

4.4 DESIGN CALCULATIONS

a. Water holding capacity (ch) = 100mm/m.

b. Roof zone depth (dr) = 90cm.

c. Peak rate of consumptive (cu) = 3.1mm/day

d. Irrigation is started at 50% moisture depletion, MAD = 50%.

e. Water application efficiency (Ea) = 75%

f. Operation hour = 8hour/day.

g. Available moisture content (Oa).$= \frac{chXdr}{100}$

where

0a = total moisture content (cm)

ch = moisture holding capacity

dr = root zone (cm)

$$= \frac{10 \times 90}{100} = 9cm$$

:. Oa = 9cm.

h. Net irrigation depth $Dn = \frac{Oa \times MAD}{100}$

where,

Oa = total moisture content (cm)

MAD = moisture depletion (%)

Dn = Net irrigation depth (cm)

$$:. Dn = \frac{9 \times 50}{100} = 4.5cm$$

i. irrigation depth. $Dg = \frac{100Dn}{Ea.}$

Where Dg = irrigation depth (cm)

Dn = Net irrigation depth (cm)

Ea = irrigation efficiency (%)

-; $Dg = \frac{100 \times 4.5}{75} = 6cm$

j. Irrigation frequency or interval (days)

$$= \frac{\text{Net depth of application}}{\text{peak rate.}}$$

$$= \frac{4.5}{0.31} = 14.5 \text{ day} = 15 \text{ days}$$

k. Irrigation period = $\frac{\text{depth of application}}{\text{Soil intake}}$

$$= \frac{6}{1.32} = 4.5\text{hours} = 5\text{hrs}$$

L. System capacity (Q)

One of the parameters of the sprinkler system which need to be evaluated is its capacity requirement. The required capacity of the sprinkler system depends on the size of the area to be irrigated, the gross depth of the application of each irrigation and the net operating time to apply the depth.

If is determined by the use of the equation.

$$Q = 2780 \frac{A \times d}{F \times H \times E}$$

Where

Q = discharge capacity of the pump, L/S

A = area to be irrigated, hectares.

d = Net depth of water application, cm.

F = Number of days allowed for the completion of one irrigation.

H = Number of actual operating hours per day.

E = Water application efficiency, percent.

$$Q = \frac{2780 \times 1 \times 4.5}{15 \times 5 \times 75} = \frac{12510}{5625} = 2.2 L/S.$$

4.5 SELECTION OF SPRINKLER

The selection of sprinkler is based largely upon design information furnished by the manufacturers of the equipment. The choice depends mainly on the diameter of coverage required, pressure available and sprinkler discharge.

The required discharge of an individual sprinkler is a function of the water application rate and two way spacing of the sprinkler. This may be determine by the following formula.

$$q = \frac{S_l \times S_M \times I}{360} = \text{(A.M. Micheal)}$$

where

q = sprinkler discharge (L/S)

Si = sprinkler spacing (m)

S_M = Lateral spacing (m)

I = optimum application rate mm/hr.

Therefore in this design, the selection is based from the sprinkler irrigation design summary night rain 300 series sprinkler type no 30-72, full circle twins nozzle.

(a) Infiltration rate = 13.2mm/hr.

(b) Sprinkler spacing = 15m x 10m.

$$\therefore Q = \frac{15 \times 10 \times 13{,}2}{360} \quad \frac{1980}{360} = 5.5 m^3/hr$$

$$= 5.5 \times 0.278 \text{ L/S}$$

$$= 1.5 \text{ L/S.}$$

From operating figure of some rotary sprinkler – model 5, two nozzles, the discharge of 1.5L/S will have:-

(a) Nozzles size = 6.3mm x 5.56mm

(b) Wetted diameter = 37.8m

(c) Pressure = 3.0kg/cm^2 = 30m head.

(d) Discharge = 1.5L/S per sprinkler

(e) Total discharge = 70 x 1.5 = 105 L/S.

(f) Number of sprinkler = 100/15 = 6.6 = 7 sprinkler

(g) Number of lateral = 100/10 = 10 Laterals.

(h) Total number of sprinkler = 7 x 10 = 70 sprinklers.

(i) Length of Lateral = 70 x 10 = 700m.

(j) Length of the main = 108m.

(k) Nos of pipes on the main = 108/6 = 18pipes.

(l) Nos of pipes on the lateral = 100/6 = 16.6 = 17 pipes.

(m) Total lateral pipes on the field = 17x10 = 170 pipes.

4.6 DESIGN OF LATERALS

The design is based on laterals on level ground. In this case, the allowable loss/100m length of pipe should not exceed 20% of the operating pressure =

$$\frac{20 \times 30}{100} = 6m.$$

According to the allowable rule loss per 100ft. $= \dfrac{0.20 \text{ pa} \times 2.31}{L/100 \times F}$

In this design,

L = 700m = 3.28 x 700 (ft) = 2296 ft.

F = 0.419 (for 7 outlet)

Pa = 3kg/cm2 = 42.9PSI

$$\text{Allowable loss} = \frac{0.2 \times 42.9 \times 2.31}{\frac{700}{100} \times 0.419} = \frac{19.8198}{2.933}$$

$$= 6.76 \text{ ft}$$

$$\frac{6.76}{3.28}$$

$$= 200\text{mm}$$

∴ Discharge per lateral = discharge per sprinkler x Nos of sprinkler per lateral.

= 1.5 x 7 = 10.5 L/S.

From the Appendix C table C.2 on head loss coefficients for circular pipe flowing full S.I Unit on soil and water conservation Engineering by:-

1. Glenn .O. sehwab
2. Delmar .D. Fangmeier
3. William .J. ,Elliot
4. Richard .K. Frevert

Fourth edition page 474 with the head loss of 2m (200mm) and the discharge of 10.5L/S, the corresponding inside diameter of lateral pipe = 102mm (4in).

4.7 DESIGN OF THE MAINLINE

The design of the mainline, Scobey's (1930) equation for friction or head loss in pipes was used.

$$Hf = \frac{KLQ^{1.9}}{D^{4.9}} \quad (4.10 \times 10^6)$$

Where

Hf = total friction loss in main, in, ^{m}

K = scobey's coefficient of retardation

L = Length of the pipe in m;

Q = Total discharge in L/S.

D = Diameter of the pipes in mm.

Allowable loss/100, length of pipe should not exceed 40% of the operating pressure $= \frac{40 \times 30}{100} = 12m.$

∴ Hf= 12m

L = 108(m)

K = 0.4

Q = 105 (L/S)

D = ? (mm)

$$\therefore D = \frac{KLQ^{1.9} \quad (4.10 \times 10^{6})}{Hf}^{4.9}$$

$$D = \frac{0.4 \times 108 \times (105)^{1.9} \times 4.10 \times 10^{6}}{12}^{4.9}$$

= 1.226108.

$$= \frac{1.226 \quad 4.9}{12}$$

= 8.8m

= 9m

= 900mm.

4.8 BILL OF QUANTITIES

S/NO	DESCRIPTION OF ITEMS	QTY	RATE	AMOUNT
1.	Main line pipes	18	N3,500.00	N63,000.00
2.	Lateral line pipes	170	3,000.00	510,000.00
3.	T. Joint	18	1,500.00	27,000.00
4.	Lateral stopper	18	1,000.00	18,000.00
5.	Main line stopper	1	2,000.00	2,000.00
6.	Riser pipes	70	1000	70,000.00
7.	Sprinkler head	70	400.00	28,000.00
8.	Roof rest	70	200.00	200.00
9.	High pressure pump (water pump) Kubota GS 160 engine, KGP 206 model maximum head 35m, maximum capacity 530L/Min, H.P 2.8 psi.	1	150,000.00	150,000.00
	TOTAL			**N868,200.00**

4.9 DISCUSSIONS OF RESULTS

4.9.1 Soil Characteristics

As from the result of soil analysis in table 1 which shows the soil characteristic; it is suitable for wheat production and other crops like rice, tomatoes and maize /using sprinkler irrigation system.

Table I: Soil Analysis

DEPTH OF SAMPLING/m	SAND (%)	CLAY %	SILTY %	TEXTURAL CLASS USDA	PH 1:2.5	Organic carbon %	Organic Matter	Total nitrogen %	Pottasium meg/100g	AVALABL PHOSPHORUS
0-15	23	39	39.0	SCL	4.7	1.3	2.0	0.16	0.30	7.3

4.9.2 Chemical Analysis of Water.

The results of water analysis presented in table 2 shows that the water is suitable for irrigation as it falls under class 1 water.

Table II: Water Analysis.

Ec mhos/cm	PH	Br Mg/L	No_3 Mg/L	$Po\text{-}_4$ Mg/L	K+ Mg/L	CL- Mg/L	So_4- Mg/L	Hco_3- Mg/L	Na Mg/L	TDS Mg/L	Mg mg/L	Ca mg/L	Fc/ 100m
0.09	7.5	0.0	0.7	0.2	2.3	4.4	15	49	2.1	290	6.5	16.2	0.0

CHAPTER FIVE

5 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSIONS

With the experience gained from this research work, it is observed that:-

1. The soil and water analysis results show that sprinkler irrigation system may be achieved for wheat production.
2. The design calculations and costing show that the project is viable and therefore farmers can practice sprinkler irrigation system in the Area.
3. With the availability of roads, market and source of irrigation water, the sprinkler irrigation system can be achieved.

5.2 RECOMMENDATIONS

The following recommendations are made with the experience gained from this research work.

i. The Niger River Basin Development Authority with the conjunction of Niger State Government should try to encourage the local farmer to produce wheat using sprinkler irrigation system in the area.

ii. Because of the high cost of the system, the government should try to give soft loan to the farmers to enable them increase their farm sizes. The farmers should also form co-operative societies to enable them obtain loan from the government.

iii. To encourage the farmers, the authority should try to establish a sprinkler irrigation system in the areas to produce wheat and other crops like rice, maize, tomatoes e.t.c.

iv. Sprinkler irrigation system should be encouraged because of the general soil characteristics of the project area and also to minimize water wastage.

v. Finally their should be more research work on sprinkler irrigation system for wheat production and other crops like rice, tomatoes and vegetables.

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