ECONOMICS OF SUB-IRRIGATION SYSTEM

(A CASE STUDY OF MUSA INLAND VALLEY BADEGGI NIGER STATE.

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE.

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CERTIFICATION OF SUBMISSION

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A project submitted in partial fulfilment of the requirement for the award of the post Graduate Diploma in Agricultural Engineering (PGD)

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DEDICATION

The project work is dedicated to the entire B.O.A. Akinrinola's family

ABSTRACT

From the research findings, when one hectare of maize field was subjected to sub-irrigation system (High water table (57cm-83cm below ridge surface), the yield recorded was 1944.1kg/ha which is quite promising with improvement in this technology more yield will be harvested, the yield that of low water table condition was 345kg/ha which will require more effort, while that of rainfed plot that was subjected to the same condition yielded 2928.6kg/ha. From this finding, rainfed condition is much more better in terms of production (yield)table 4.4. In terms of economic benefit (profit) rainfed system of production is the best (table 4.5).

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CHAPTER FIVE

Conclusion and Recommendation

INTRODUCTIONS:

1.1 Water is natures` greatest gift to mankind. The foods that the soil produce depends upon water for their growth and nutritive value. Out of the total water consumed for human needs in the world about 80% is used for raising crops varshney etal (1983) . In areas where rainfall is not adequate or is too low to support either plant growth or to ensure a high rate of production of good quality produce, water may be applied artificially to supplement the soil moisture by a process called irrigation. Man`s dependence upon irrigation can be traced to earliest biblical references. Irrigation in very early times was practiced by the Egyptians, the Asians and the Indians of North America. (Michael 1980). For the most part, water supplies were available to the people only during periods of heavy runoff. Modern concepts of irrigation have been made possible only by the application of modern power sources to deep well pumps and by storage of large quantities of water reservoirs.

Hansen etal (1980) defines irrigation as an artificial means of preventing deficiencies in the moisture content of soil. Soil-water plant relationship relates to the properties of soil and plants that affects the movement, relation and use of water. Soil provides room for water to be used by plants through roots present in this medium. Water as such also as a carrier of large amount of nutrient is required in a large volume for the successful growth of crop. Due to in adequate and uneven distribution of rainfall during the growth span of crop, it becomes essential to study various way through which water will be available for plant use (as it is required by plants continuous metabolic activity).

At anytime, only a small portion of soil water lies in the immediate neighbourhood of the absorptive surfaces of plant root systems, more over, an immense amount of water is needed to offset transpiration by vigorous growing crops. Two phenomena seems to account for the acquisition of this water; the capillary movement of soil water to plant root is one of the source and other source is the growth of roots into moist soil.

The upward movement of ground water by capillary form the water table into the root zone can be a major source of water for plant growth and maturity. To be most effective without seriously restricting growth ground water should be near but below the depth from which the major portion of the plants needs are extracted. If ground water is too near the surface, the land`s ability to economically produce most crops becomes almost nil, Anthony (1986) Hitherto, a water table within the lower portion of the root zone may supply a considerable amount of water and thereby reduce the cost of irrigation more than it offsets the loss of production. The optimum depth of water table is that depth which gives the maximum economic return (57cm-83cm below ridge surface).

1.2 STATEMENT OF OBJECTIVES

(1) To compare the yield of rainfed (maize) crop with that of irrigated crop (Sub-Irrigated).

(2)To determine the best method in terms of yield production.

(3)To enlighten people more about the significance of irrigation.

CHAPTER TWO

LITERATURE REVIEW

2.1 WATER RESOURCE

Water is vital to life and development in all parts of the world. The paramount influence of water in agriculture in general and crop production in particular is fairly well established. Water infact appears to be the most important natural living factors in world food production. It is evident therefore that water as an environment variable has received and will continue to received major attention in the global need to increase food production.

Water availability depends on water balance, a difference between intake and outflow for much of agriculture these imply rainfall and evaporation. Although humid regions by definition receive rainfall in excess of evapotranspiration, short term variations in the distribution of the first factor result in periods of negative water balance and moisture stress on crops during the growing season. These periods vary in length and frequency according to subregion or zone. They tend to be rather accentuated in the transitional zone between the humid and sub-humid tropics. A knowledge of the water use by crops within this area is therefore required for better planning of the cropping cycles to reduce the risk of crop failure and to increase production vaughn and Glen (1980).

Water requirements has been defined as the quantity of water required by a crop, regardless of it's source in a given period of time for it's normal growth under field conditions. It includes consumption use of water by the crop and other unavoidable losses associated with the delivery and application of water in the field.

2.1.2.

2.1.3. THE FUNCTIONS OF WATER TO PLANTS

Considering the many phenomena of nature in which water plays an important role, he recognise that from the view point of mainkind the functions of water can be beneficial or detrimental.

(1) Waterfeeds plants

(2) Water helps to create soil and to differentiate it into horizons

(3) Water brings plants nutrient elements into plant – available form.

(4) Water supports microbial fauna and flore that make nutrient elements available to plants.

(5) Water carries dissolved oxygen into the soil.

(6) Water keeps soil from getting too hot or too cold especially in temperate regions.

DEFECTS OF WATER ON PLANTS

(1) Water can drown plants

(2) Water helps to destroy soil, by erosion and obviates existing horizons by removing their components.

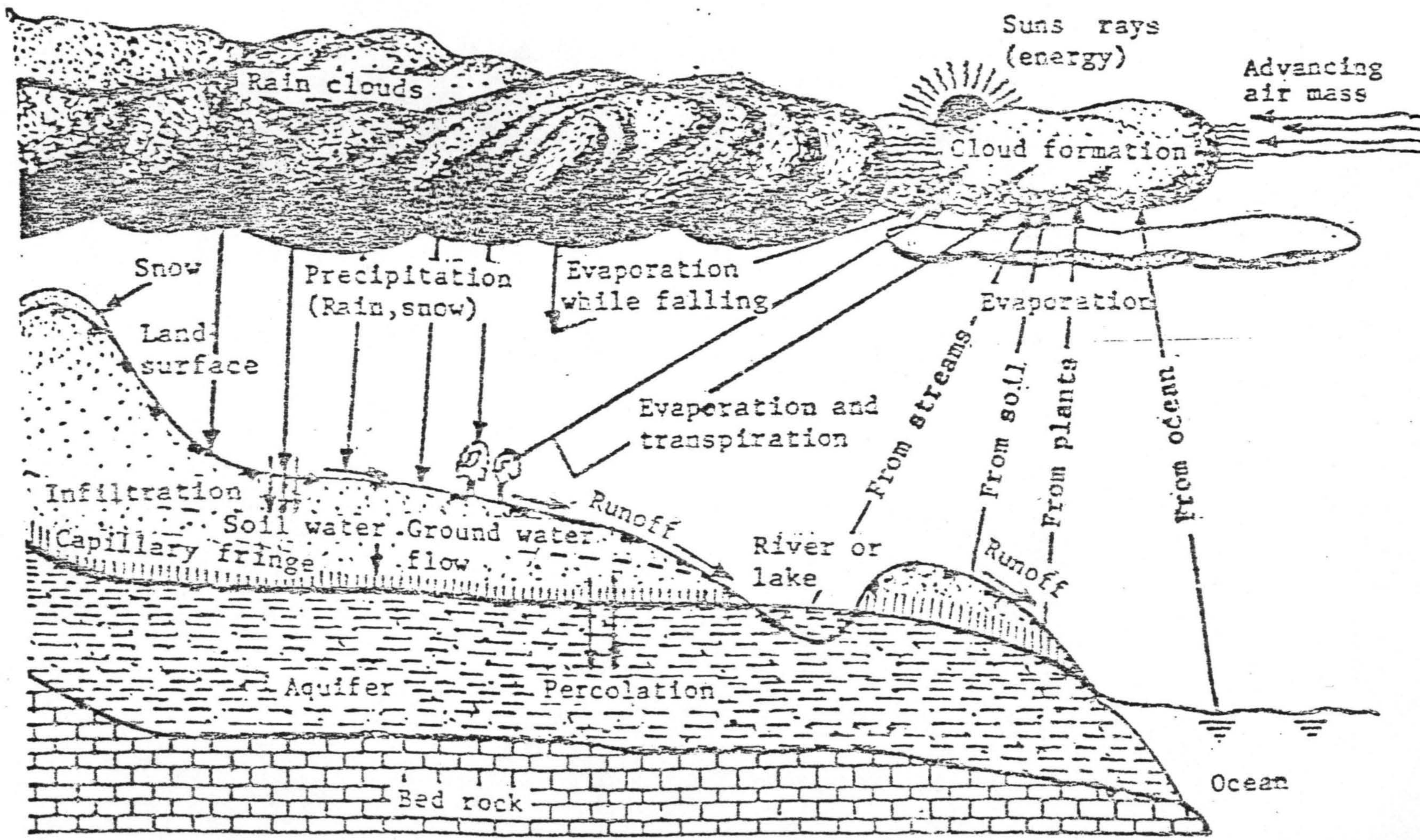
(3) Water leaches out plant nutrient elements.

(4) Water prevents entrance of air into the soil.

About four –fifths of water used for all purposes (exclusive hydroelectric power and navigation) comes from streams and lakes

2.13 HYDROLOGICAL CYCLE

Long ago king Solomon observed that "All streams flow into the sea, yet the sea is not full though the streams are still flowing". (Ecclesiates 1.7) The explanation for these enigma is so well known today to the role played by evaporation and precipitation is far from obvious.



Suns rays
(energy)
Advancing
air mass
Rain clouds
Cloud formation
Snow
Precipitation
(Rain,snow)
Evaporation
while falling
Evaporation
Land
surface
Evaporation and
transpiration
From streams
From soil
From plants
From ocean
Infiltration
Runoff
Soil water
Ground water
flow
Capillary fringe
River or
lake
Runoff
Aquifer
Percolation
Bed rock
Ocean

Water evaporated from the ocean is transported over the continents by moving air masses when this moisture bearing air is cooled to its dewpoint temperature, forming fog or cloud. The cooling occurs when the moist is lifted to higher elevations. Since air pressure decreases with elevation, the air expands as it is lifted and cooled in accordance with the ideal gas Law.

$$PV/T = \text{Constant} \quad \ldots\ldots 2.1$$

Where

P = pressure, V = volume, T = Temperature

About two thirds of the precipitation that reaches the land surface is returned to the atmosphere by evaporation from water surface, soil and vegetation through plants transpiration. The remaining third of the precipitation returns ultimately to the ocean through surface or underground channels.

2.13.1 **PRECIPITATION:-** It includes all water that falls from the almosphere to the earths surface. Precipitation occurs in a variety of forms, ligerial precipitation (rainfall) and frozen precipitation.

2.1.3.2 **EVAPOTRANSPIRATION:** Evapotranspiration of the water that is precipitated on the earth, a large amount is returned to the atmosphere as vapour, through the combine action of evaporation, transpiration and sublimation. These are in essence three variations of single process due to the energy of the solar engine that keeps the hydrological cycle running .

Evaporation or vapourization is the process by which molecules of water at the surface of water or moist acquire enough energy through sun radiation to escape the liquid and pass into gaseous state.

Transpiration is the process by which plants loose water to the atmosphere.

2.1.3.3 **RUN OFF:** The term run off is usually considered synonymous with stream flow and is the sum of surface runoff and ground – water flow that reaches the streams. Surface runoff equals precipitation minus surface retention and infiltration the passage or movement of water through the surface of the soil. Surface runoff = water gains – water losses – water storage. Water gains = precipitations, condensation and absorption. . Water losses = percolation, evaporation and transpiration. Water storage = Interception storage, surface storage.

2.3.3.4**GROUND WATER:** It is the tension- free continuos mass of water below the soil surface. It fills all the pores of the material in which it occurs. The surface of ground water is called the ground water table. It can be found by drilling a hole in the soil and observing the surface level of the water that will fill up the hole. In some cases two or more ground water level exist above each other, where extensive layers of impervious materials occurs.

The upper ground water masses are called perched ground. The ground water level changes with the season. It is high in the spring and sink, during the summer. The capillary fringe of ground water is held by the soil under tension and is therefore soil moisture and not ground water. By capillary fringe is ment the water in the layer of soil or subsoil into which ground water enters due to capillary rise. The direct value of ground water to plants depends on whether roots can reach the cappillary fringe. Whether this be the case or not is determined by the depth of the water table, the rate and extent of cappillary rise, the aeration of the solid and the nature of the crop.

2.2. PHYSICAL PROPERTIES OF SOILS

The soil is a complex mechanical system. For a soil to be in good physical condition for plant growth, the air, water and solid particles must be in the right proportions at all times Donehuse (1958). Every centimeter of soil that is expected to support plant life must be:

1. Open enough to permit the right amount of rain water or irrigation water to enter the soil, but not so open as to allow excessive loss of water and plant nutrients by deep percolation.

2. Sufficiently retention of moisture to supply roots with all the needed water, but not so retentive as to create undesirable suspended water tables.

3. Well enough aerated to permit all plant root cells to obtain oxygen at all times, but not excessively aerated to the point of preventing a continuous contact of roots with moist soil particles.

2.2.1. MOISTURE CONTENT

Measurement of water stored in soils and capacity of soils to store water are important some solid produce crops despite the lapse of many days and sometimes weeks, between periods of rainfall is evidence of their capacity to store available water, since all growing plants require water continuously.

In irrigated regions, the capacity of soils to store available water for the use of growing crops is a special importance and interest, because the depth of water to apply in each irrigation, and the interval between irrigation's are both influenced by storage capacity of the soil.

Knowledge of the capacity of soils to retain available irrigation water is also essential for efficient irrigation. If the irrigation applies more water than the root zone soil reservoir can retain at single irrigation, the excess is wasted. If it applies less than the solid will retain, the plants may wilt from lack of water before the next irrigation unless water is applied more frequently than otherwise could be necessary.

It is important to find the available water capacity for different solids i.e the field capacity less the moisture content at the permanent wilting point.

2.2.2 POROSITY:- It can be defined as the ratio of the pores to the total soil volume. It is an index of the relative volume of pores. It is influenced by the textural and structural characteristics of the soil. Michael (1980).

The porosity of sand soil usually ranges from 35 to 50% while that of clay soils from 40 to 60%. The more finely divided are the individual soil particles, the greater the porosity.

2.2.3 WATER HOLDING CAPACITY

The Moisture content of a sample of soil is usually defined as the amount of water lost when dried at 105^{o}c, expressed either as the weight of water per unit weight of dry solid or as the volume of water per unit volume of bulk soil. Although such information is not a clear indication of the availability of water for plant growth. Th differences exists because the water retention characteristics may be different for different soils Michael (1980).

About half a soil volume is pore space which is occupied by varying amounts of air and water depending on how wet the soil is. Water is held in the pore spaces in form of films adhering to the soil particles. The smaller pores in the soil are called micropores; the larger ones are called macropore, Micropores don't hold water well because the water films become too thick to adhere well to the surrounding soil particles. It is note worthy that drainage takes place within Macropores and water holding capacity within micropores.

2.2.2 HYDRAULIC CONDUCTIVITY:- Permeability and conductivity are frequently used interchangeably. The characteristic, that determines how fast air and water move through soils describe what is known as permeability. The rate water moves through a soil is determined in the least permeability horizon. Plough plans or natural clays plans reduce the permeability of a soil. Past management practices also determines permeability. Continues tillage reduces permeability while growth of deep rooted grasses, Legumes and trees increases permeability.

The permeability of a soil is defined as the velocity of flow caused by a unit gradient, and this is an important point of difference between permeability and infiltration. Permeability is influenced by most physical properties. For unsaturated soils the moisture contents is one of the dominant factors influencing permeability Vaughn etal (1950).

2.3.1 INFILTRATION:- The rate at which water can enter soil when not limited by the rate of supply is measured in the field with water either pounded on the surface on falling on it as artificial or natural rain at a rate sufficient to cause runoff. It is expresed in (m/s) or some convenient multiple of these units and is called infiltration capacity or infiltrability. It is a potential rate that is characteristic of the soil under specified conditions. In particular, it varies with time during a test and with initial water content

FACTORS AFFACTING INFILTRATION RATE

The movement of water into the soil by infiltration may be limited by any restriction on the flow of water through the soil profile. The major factors affecting the infiltration of water into the soil are: The initial moisture content, condition of the soil surface, hydraulic conductivity of the soil profile, texture, porosity, degree of swelling of soil colloids and organic matter, vegetation cover, duration of ponding water, irrigation or rainfall and viscosity of the water.

Infiltration rate are generally lower in soils of heavy texture than on soils of light texture. The influence of water depth over soil on infiltration rate was investigated by many workers. It has been established that in surface irrigation depth increases initial infiltration slightly but the head has negligible effect after prolonged irrigation.

The high rate of infiltration in the tropics under otherwise comparable soil conditions is due to low viscosity of warm water.

2.4 **SOIL TEXTURE:** The relative proportion of sand silt and clay determined the soil texture. Texture is designated by using the names of the predominant size tractions and the word "Loam" whenever all three major size fractions occurs in sizeable proportions. Thus the term "Silty clay" describes a soil in which the clay characteristics are outstanding and which also contains a substantial quantity of silt. A 'silty clay loam' is similar to silty clay except that it contains sand in a sizeable proportion. Sandy soils are classified coarse-textured, loam soils, medium textured and clay soils as fine texture.

2.5.1 WATER MOVEMENT ALONG SOIL-PLANT ATMOSPHERE SYSTEM

Almost every plant process is affected directly or indirectly by the water supply. Water constitutes about 80 to 90 percent of most plant cells and tissues in which there is active metabolism. It forms a continuos liquid phase through the plant from the root hairs to the leaf epidemis. Plant roots take up water and transfer it through the root tissues to the conductivity vessels of plant.

FACTORS INFLUENCING THE WATER RELATIONS OF PLANTS

i. ***Soil factors:-*** Soil moisture content, texture, structure, density, Salinity, fertility, Aeration, Temperature and drainage.

ii. ***Plant Factors:-*** Type of crop, density and depth of rooting, the rate of root growth, are dynamic roughness of the crop, drought coherance and varietal effects.

iii. ***Weather Factors:-*** Sunshine, Temperature, Humidity, Wind and rainfall.

iv. ***Miscellaneous Factors:-*** Sort volume and plant spacing soil fertility and crop and soil management.

WATER MOVEMENT ALONG SOIL PLANT ATMOSPHERE SYSTEM

The complete path of water from the soil through the plant to the atmosphere forms a continuous system which may be analysed by excluding the potential difference between soil and atmosphere in contact with roots leaf respectively The Path of water may be divided into four sequential process as follows: The supply of liquid water to the root surface, the entry of water into the root, the passage of water in the conducting elements; and the movement of water vapour through and out of the leaves.

2.5.2 ROOTING CHARACTERISTICS AND MOISTURE USE OF CROPS

The Amount of soil moisture that is available to a plant is determined by the moisture characteristic of soil, the depth to which the plant roots extend and the proliferation or density of the roots. Soil moisture characteristic such as field capacity and wilting percentage are peculiar to a soil and are functions of the texture and organic matter.

EFFECTIVE ROOT ZONE:- Is the depth from which the roots of an average mature plants are capable of reducing soil moisture to the extent that it should be replaced by irrigation . It is not necessarily the maximum root depth for any given plant, especially for plants that have a long tap root.

2.5.3 WATER REQUIREMENT OF CROPS

The estimation of the water requirements (WR) of crops is one of the basic needs for crop planning on the farm and for the planning of any water budget. Water requirement may be defined as the quantity of water, regardless of its source, required by crops for their normal growth under filed conditions at a place.

Water requirement includes contribution from any of the sources of water. The major sources being irrigation water (I_R), effective rainfall (P_E) and soil profile or ground waters contribution (G_W)

$W_R = I_R + P_E + G_W$ 2.2

2.5.4. **FIELD WATER BALANCE**

The water balance of a field is an itemized statement or algebraic summation of all gains, losses and changes of storage of water occurring in a given field within specified boundaries during a specified period of time. The task of monitoring and controlling the filed water balance is vital to the efficient management of water and soil.

A knowledge of the water balance is necessary to evaluate the possible methods to minimize loss and to maximize gain and utilization of water which is so often the limiting factor in crop production. The water balance equation may be stated as follows.

(Gains) + (Losses) = (Changes in storage)

Gains:- of water in the filed are generally due to precipitation and irrigation.

Losses:- Includes surface runoff (R_0) deep percolation Pc and evaporation (E_{to})

$(P_E + I_R) - (E_{To} + P_c + R_o) = -D_s$ or $+D_s$ 2.3

The negative sign of the Ds value indicates an upward direction of the ground water flow and positive sign indicate a downward direction of the ground water flow its amount refers to the ground water table contribution (G.W.C) and is a source of water supply.

Hence, the approximate total water requirement (TWR) of Maize can be calculated as

$TWR = P + I + D_s = E_{To} + Pc + Ro$ 2.4

2.5.5 FIELD CAPACITY

Field capacity of soil is the moisture content after drainage or gravitational water has become very slow and the moisture content has become relatively stable. It is the moisture content beyond which water drain freely under influence of gravity. This situation usually exist one to three days after the soil has been thoroughly wetted by rain or irrigation. The term field capacity, field carrying capacity, normal moisture capacity and capillary capacity are often used synonymously. The field capacity is the upper limit of available moisture ranged in soil moisture and plant relations. The soil moisture tension at field capacity varies from soil to soil, but it generally ranges from 1/10 to 1/8 atmosphere.

2.5.6 PERMANENT WILTING PERCENTAGE

The permanent wilting percentage, also known as permanent point or wilting coefficient, is the soil moisture content at which plant can no longer obtain enough moisture to meet transpiration requirement; and remain wilted unless water is added to the soil.

2.6 ORGANIC MATTER CONTENT

Soil organic matter comes from dead plant and animals. These plant and animals residues are in various stages of decomposition by the soil Microorganisms. Organic matter takes up a very small fraction of the soil but it is very important component because it influences the structure of soil, provides plant food and is good source of three important element Nitrogen, Phosphorus and Potassium. It is responsible for the loose, friable condition of loam soil. It increases the water holding capacity of soil and proportion of water available to plant roots for good growth.

2.7 PERMEABILITY

Qualitatively, is the characteristic of the pervious medium relating to the readiness with which it transmits fluids.

Qualitatively, it is the specific property governing the rate of readiness with which a porous medium transmits fluids under standard conditions. According to this definition, equations used for expressing flow, which takes into account the properties of the fluid should give the same soil permeability value for all fluid which do not utter the medium Michael (1980)

2.8 HYDRAULIC CONDUCTIVITY

The earliest quantitative description of water flow through a porous medium was that given by Henry Darcy (1956) who reported on the infiltration of water flowing through a sand bed for an improved supply.

Darcy's experiment shows that the flow of water is the difference in hydraulic head at the ends of the column. This is known as Darcy's Law expressed as:

$$V = K\frac{(h_1 - h_2)}{L} \quad \ldots\ldots 2.5$$

Where:- V= Velocity of flow, m^3 lday

K= hydraulic conductivity depending on the properties of sand and liquid.

h_1-h_2 = difference in hydraulic head

L = Distance along the flow path between points h_1 and h_2 (m)

By defination, the quotient $(h_1-h_2)/L$ along the flow path is the hydraulic gradient thus

$V=Ki$

The quantity of flow may be of greater Interest than the velocity; hence interms of quantity of flow, Darcy's law may be expressed

$$Q = av\text{-}kia \quad \ldots\ldots 2.6$$

Where Q = Volumes of water discharged in saturated length of time usually expressed as m^3 /day

a= Cross-sectional area through which water moves in M^2

The value of K can be determined or obtained from laboratory test of the sample formation by constant head parameter;

2.9 WATER RELATION OF THE SOIL

Soil serves as the storage reservoir for water, only the water stored in the root zone of crop can be a major source and utilized by it for its transpiration and building up of plant tissues.

2.9.1 SOIL WATER

When water is added to a dry soil either by irrigation or rain, it is distributed around the soil particles where it is held by adhesive and cohesive forces, it displaces air in the pore spaces and eventually fill the pores. Soil water relationships are very important in agriculture for several reasons and these are:-

Water is needed by green plant to meet their transpiration and most of this water came from soil. Nutrients in the soil are dissolved in soil water making up the soil solution from which plants absorb essential nutrients (element) soil moisture helps to control soil air and temperature for essential plant growth, water is the principal raw material for photosynthesis. Water exist in the soils in different forms.

2.9.2 CAPILLARY WATER

Capillary water is that which rises above the water table in the soil and is held in fine and medium pores of soil particles by surface tension. Capillary water moves as a liquid in any direction from more saturated to less saturated regions. The finer the pores, the greater is the force binding the water (surface tension) and the higher is the capillary tension, this result in a higher rise of water.

Surface tension is the force which exists a combination of cohesive force between water molecules and adhesive. It is the force which makes water drops spread on the surface of the soil particles.

Capillary water can further be classified into capillary suspended water, capillary back water and soil moisture at the capillary break-up point.

CAPILLARY SUSPENDED WATER:- Is the water retained in soils when they are wetted from the top (by irrigation or rain waters), with this kind of moistening the moisture of soil decreases with depth.

CAPILLARY BACK WATER

This fills the capillaries of a soil when the water migrates from the bottom up from ground water. This moisture of a soil in this case decreases towards the surface where it evaporates.

SOIL MOISTURE AT THE CAPILLARY BREAK UP POINT:- This is the threshold of soil moisture at which the water in soil capillaries breaks up and terminates its upward migration.

Capillary rise is affected by temperature and solutes since they affect surface tension.

Capillary water is held by forces of surface tension and continuous films around soil particles and in capillary spaces. Capillary water is held between tension of about 31 atmosphere and 15 atmosphere, capillary adjustments is sluggish comparatively, easy movement does not occur until the water film thickens and pressures near one third atmosphere are reached. As a result of its energy relations, the capillary water is the only fluid water bearing solutes, that remains in the soil for any length of time, if drainage is satisfactory. Thus , it functions physically and chemically as the soil solution. The principal factors influencing the amount of capillary water in soils are the structure, texture and organic matter particles. The finer the texture of the mineral soil the greater is likely its capillary capacity. Granular soil structure produces higher capillary capacity. Presence of organic matter increases the capillary capacity.

2.9.3 HYGROSCOPIC WATER

Hygroscopic water is that which is absorbed on the surface of soil particles atmospheric water-vapour. The colloidal components of the soil such as clay and humus have a strong attraction for water molecules, binding to their surface by surface energy force. The amount of water absorbed from the atmosphere is always in equilibrium with atmospheric moisture.

2.9.4 GRAVITATIONAL WATER

Gravitational water is that which can drain from the soil under the influence of gravity. It is available to plant but it is often pulled down by gravity beyond the reach of plant roots.

2.9.5 GROUND WATER

Ground water is the tension-free continuous mass of water below the soil surface. It fills all the pores of the material in which it occurs. The surface of the ground water is called the ground water table. It can be found by drilling a hole in the soil and observing the surface level of the water that will fill up the hole.

The Upper ground water masses are called perched ground. Ground water changes with the season.

2.9.6 RECHARGE

Critical shortages of ground water due to limited natural recharge, small storage capacity and over use here stimulated efforts to recharge ground water reservoirs with surface water. Flood flows which would otherwise have been lost are diverted and applied to the land, thus providing water to seep into underground reservoir.

Full conservation and use of available water supplies requires a integrated use of surface and subsurface water and storage facilities. Water percolates into the ground water reservoir to be stored until needed for irrigation.

2.10 MAIZE

Maize is widely grown in the country, maize comes closet to being a staple food crop, it provides the daily bread for the population of the poorer rural areas. Much of the first rains crop is eaten as boiled or roasted fresh ears during the " hungry gap" when it is the first food to come to harvest.

2.10.1. CLIMATE AND SOIL REQUIREMENT

Being a water loving crop, maize demands a constant supply of moisture throughout the growing period. The demand for water is greatest during the silking and tarsseling stage. Acute moisture shortage during this period will produce poorly filled wars. Maize does not grow well in areas with rainfall over 2,000mm per year with soil P_H below 5 and low sunlight. Deep permeable fertile sandy soils give the best result. Well drained loamy soils with plenty of organic matter give best result.

2.10.2 CULTIVATION AND MANAGEMENT

PLANTING PATTERN: Planting patterns have direct effect on yield, solar energy capture and evaporation and thus an indirect effect on water use efficiency. Two important planting pattern practices are plant density and row spacing. For maize production, the agronomical density and spacing are 75cm x 25cm or 90cm x 20cm at the rate of 55,000 plants per hectare. Widely spaced crop rows are avoided. A narrowing of rows generally means a uniform distribution of plants over a given area. Thus making the plant canopy more effective in intercepting radiant energy and shading weeds. An added advantage is the reduction in rain drop impact on soil structure in the surface layer. In general, dwarf varieties of crops benefit more from narrow rows than tall, late maturing varieties.

PLANTING DATE:- Planting date is extremely important cultural practice in efficient water use. The main reason for choosing the optimum dates for sowing is to ensure good germination by placing the seed in the optimum moisture zone. After the seeds germination, the moisture should be optimum for root growth and root penetration to envelope maximum soil volume for nutrient up take. The dates also indicate right type of climate for the shoot growth and optimum utilization of moisture by the roots under normal rainfall conditions major yield can be obtained by making the best use of the interaction between plant breeding, agronomy and meteorology by sticking to the optimum planting time for particular crop and its variety.

2.10.3 ***WEED CONTROL:-*** One of the main management means of obtaining more efficient water use is the elimination of weeds in crops. Weeds complete with crops for soil nutrient, water and light. Except in hight rainfall areas the primary concern is the water factor because the water requirement of weed compared to nutrient requirement is greater than that of crop plants (Michael 1980). The competition for light is primarily operative when the weeds species is as tall as or taller than the crop and density is high. Competition for water begins when the root systems of the weed and crop overlap. Suitable technology for efficient weed control, both mechanical and chemical have been developed which should be availed in increasing water use efficiency of maize.

2.10.4 ***DISEASE AND PESTS:*** An often overlooked means of increasing water use efficiency falls in the lot of entomologists, plant pathologists and plant breeders, plant breeders are included because the development of resistant varieties is perhaps the most effective economical and long lasting control for diseases and insects. Plant breeders seeks to prevent crop damage by selectively changing the genetic make up of the plant. Efficient crop and water management also includes the use of chemical pesticides. By proper use these can prevent insects and pests from disturbing the balance of nature in producing a healthy crop plant.

2.10.5TILLAGE

Tillage influences crop yields and water use efficiency. The principal effect of tillage are the preparation of seed bed conducive for the germination of seed and growth of seedling, conservation of soil moisture in un-irrigated areas by its influence on infiltration characteristics of the soil and providing adequate soil depth for optimum root growth, proper placement of seeds and fertilizer in the soil and intercultivation of weed control.

2.10.6 FERTILIZER APPLICATION

Fertilizer are applied to increase yield, it increases water use efficiency. An increase in crop yield produced by increasing soil fertility does not produce a corresponding increase in evapotranspiration. Some of the practices essential for the efficient use of fertilizers are

1. Soil test to evaluate the nutrient deficiency in the soil and use of the proper quantity.
2. Placement of fertilizers in the soil properly.
3 Split dose application of the fertilizer at suitable time intervals rather than bulk application at one time.
4 Controlled application of water to avoid leaching of fertilizers in deep percolation below crop root zone . Recommended rate of fertilizer for

maximum yield :- 75-120kg N, 30-60kg P_2O_5 and 30-60kg k_2O per hectare and from compound fertilizer 6-12bags of 20-10-10 per hectare and 2-4 bags of sulphate of ammonia per hectare.

4.10.2.1 HARVESTING

Maize are harvested as soon as the grains are dry enough (90-130) days after planting depending on variety.

2.11.1 ENVIRONMENTAL REQUIREMENT OF MAIZE

Badeggi meets favourably the environmental requirements of maize. It requires a lot of light. Its mechanism for assimilating carbon give it considerable scope for synthesizing starch, provided that it is not short of solar energy. Badeggi has a fairly high temperature required by maize to germinate. The influence of temperature on the length of the growth cycle is considerable. Badeggi is not renowned with severe wind storms. As maize is particularly sensitive to wind damage because of the size of the plant and the width of its leaves. The soil is naturally rich of mineral elements required by maize for its growth and life. Such mineral elements as : Nitrogen, (N), Phosphorus (P_2), Potassium (K_2), Calcium , magnessium (Mg) etc. With little rational fertilization "farming activities prosper. At Badeggi rainfall is plentiful and reliable and land is used fairly intensively, individual rights to land being strong under rental tenancy agreement with the authority or management of the institute.

2.11.2 INPUTS ANALYSIS FOR MAIZE CULTIVATION

For the purpose of this project which aims at comparing the input and yield of rainfed and sub-irrigation of maize; the inputs required by an ideal " maize farm settlement " will be classified as follows and briefly discussed.

(a) Financial input

(b) Man power input

(c) Agricultural input

(d) Land input

(e) Irrigational input

(a) Financial input involves all monetary reasources or values expanded on both capital and revenue of agricultural projects and operations of a maize plantation. For example capital expenditure involves in the purchase of fixed assets. Purchases of land, buildings, machinery, vehicles, furnitures and irrigational projects.

Revenue expenditure will include the following:

I. Direct growing costs:- seeds, fertilizers, harvesting etc.

II. Indirect growing costs:- field roads maintenance, general works operating costs, water pump maintenance etc.

III. Overhead costs:- Manager salary, administration, telephone, marketing, finance, charges, insurance, rents, electricity, repairs, wages and salaries.

MAN POWER INPUT:- Represents the labour input. Requisite labour is necessary in order to obtained the final product-productive labour represents reality in this category are included land clearing, hoeing, ploughing, sowing, weeding, brushing, felling , burning and clearing, pest scaring, harvesting.

In maize farming for instance, labour activities include hoeing, planting, weeding, fertilizer application, harvesting. The above stated labour input are carried out in non mechanised agricultural practices which is the level of study of this researcher.

Labour can be both measured and aggregated, that is, that we can both assume that time spent at some task is a consistent INDICATOR of the labour applied and that say hours spent weeding can be meaningfully added to hours spent sowing seeds.

Irrigated maize farm may budget on an operational basis as follows:- Cultivation, irrigation, field maintenance, harvesting, transportation. Within each operation, there will be costs for labour, materials and machinery usage.

Summarily, the labour input on the farm land which the experimental study was carried out required the following expenditures to produce maize in addition to the rental charges payable.

1. Land preparation
2. Burning of trash
3. Ridging
4. Fertilizer application
5. Planting
6. Weeding
7. Harvesting

Required physical calculation of the resources used. Money, materials, labour give the total cost.

(a) **LABOUR COST:-** There is variance in labour cost because of difference in the amount of labour used or the price per unit of labour, the wage rate.

(b) **WAGE RATE VARIANCE:-** Labour of a different grade are used for the task e.g. using more juvenile or female labour or due to working overtime at a higher rate-

(c) **LABOUR EFFICIENCY VARIANCE:-** Occurs where the actual time expended is higher or lower than the standard labour hours specified for the particular activity. This could arise for a variety of reasons: Some within the control of management (waiting for materials, waiting for instruction) and some outside its immediate control ,(weather, machine, breakdown or tiredness.

Labour therefore refers to human services in terms of man-hours or man – days except decision making.

(d) AGRICULTURAL INPUT:- Is taken to mean all agricultural materials used for cultivation, farm maintenance, harvesting and preservation or storage of maize. Examples are seeds, fertilizers, herbicides, pesticides, chemicals etc.

These stock resources "used – up" entirely in the production process. Weed killers, fungicides, insecticides, improved and certified seeds etc.

(e) LAND INPUT:- Land is used economically here to mean all free gifts of nature. This include soil, air, heat, water, rain, agents of pollination, earthworm, solar energy etc.

(f) _IRRIGATIONAL INPUT: - The provision of water requirement for crop at the right time in the right quality and quantity, exclusive of precipitation, to be supplied by artificial means. Irrigational requirement are dependent not only on water evapotranspiration but also on water application efficiency. Water supplied by percolation, by capillary movement from the ground water and by effective rainfall- like sprinkler etc.

Irrigation could be surface or sub-surface

CHAPTER THREE

MATERIALS AND METHODS

This chapter focuses on the method by which this project work was carried out. Desk research oral interview sub-irrigation as well as rainfed system, used for the production of maize.

3.1. ***DESK RESEARCH:-*** The organised knowledge of some authors (see References) were used to explain and buttress the practical work carriedout on the production of maize plant.

3.2. ***ORAL INTERVIEW:-*** At the project area, oral interview was conducted. The senior and intermidiary staff of NCRI were interviewed regarding the cultivation of the crop and method of irrigation used in the study area.

3.3. ***SUB-IRRIGATION:-*** In this aspect the work of Ndagi Baba (1998) regarding the topic in question was reviewed to determine the yield of maize per hectare when ground water (sub-irrigation system) was used in producing maize.

3.3.1 EXPERIMENTAL LAYOUT

He cultivated three plots that were located at three different portion along the slope of the land presumably that the water table depth would decrease down the slope and denoted as low water table plot (>100cm), medium water table plot (50-60cm) and high water table plot (0-20cm). These depths are within the maize root zone. A piezometer was installed in each plot by using hand driven anger of length 1.5m and screw diameter of 5cm to drilled the well to depth of 100cm. The pipes were buried with their perforated end below the ground surface. The piezometers were made from P.V.C pipes of diameter 4.5cm and has a total length of 150cm and they were radialy perforated at 5cm apart a cross 100cm length. At the neck of the pipe on the ground surface the clearance between the well and the pipe was sealed up to disallow the vertical flow of water into the well by surface run and off precipitation.

3 (1mx1m) ridges with depth of 0.6cm were constructed in each of the three plots. To intercept effect of surface run off, each plot was surrounded by compacted ridge of 50cm high.

Two rows of maize (TZER.W) were planted on each ridge at 7.5cm x25cm interrow and interrow spacing respectively. Two seeds were planted per hole, about 2.5cm deep and thinned to one plant per stand 20 days after planting 45g of N.P.K 20-10-10 was applied per square meter 20 days after planting according to the prevailing practice (450kglha). Weeding and modification of soil structure took place 20 days after planting. Each plot covered a total area of fifteen square metres.

3.3.2 YIELD

The farm plots that was cultivated on the 2nd September, 1998 yielded 573.2g at 90 days after planting. In conversion to hectare, the high water table yielded 1944.1kg/ha while the low water table yielded 345kg /ha.

3.4 RAINFED SYSTEM

Under this system, an experienced farmer was interviewed regarding the mode of farming system carriedout. He explained that he has a hectare of farm which was rented and the plot was used mainly for planting maize. Family labour was employed for all the farming activities and N.P.K. 20-10-10 was applied to the farm. He stressed further that the yield of 2928.6kg/ha was recorded.

3.5.1 LOCATION OF AREA OF STUDY

The headquarters of the institute (NCRI) is located on the outskirts of Badeggi village on kilometre 143 on the Bida-Suleja Highway in Niger State. Situated in the Southern Guinea zone of the Savannah region in Lat.9^0. $^07^1$ North and long 6^0. 08^1 East. The headquarters is centrally placed in relation to all major grain producing areas of Nigeria.

The research work was conducted at Emilugi farmers Participatory Technology Evalution valley located on the out skirts of National Cereals

Research Institute Badeggi at 9km from Bida along Bida-Suleja road in Niger State of Nigeria with geographical location of latitude 9^{O} 45^{1}N and longitude 6^{0} 7^{1}E at 70.57m above the sea level seasonal rainfall commenced in March with may, July, and August as the wettest.

3.5.2 CLIMATE

The annual rainfall at Badeggi averages1219mm. The wettest months are June, July, and August. There is however, a tendency for the rainfall to be rather irregular.

The dry season (November-March) is several with less than 39mm of rainfall. The first four months are usually without rain.

The mean Relative Humidity at 0900 G.M.7 ranges from eighty percent (June-Sept) to 60%. (Jan-Feb) at times drop to 42% if the North-easterly harmattan wind prevails for any length of time.

Mean Temp are fairly regular throughout the year and range from 26.1^{0}c (June-Feb) to 30.2^{0}c (March-April) Mean max Temperature 32.2^{0}C in the period of Oct. to May rising to 36.7^{0}C throughout March and April.

A South-Westerly wind prevails during the rains while the North easterly harmattan blows during the period Nov. to Sep. in the dry season.

3.5.3 GEOlOGY & PHYSIOGRAPHY

The Badggi irrigation scheme is sited in cretaceous Rock of mesozoic origin. The sand store is generally known as Nupe sand stones of the Niger-Kaduna-Gabko river system.

Physiographycally the site is located in the Gbako flood plains. The soils of Badeggi irrigation scheme are considerably complicated. This is due to the fact that at Badeggi the frequent changes in course of River Gbako have caused the various textures of recent alluvium to be laid down in an intricate pattern of sandy alluvium where the river flooded fairly rapidly, clayey where it is sluggish or stagnant & very clayey where it was left in Lakes as the river course changed (Moss, 1954). In addition the older alluvium (is clayey & was probably laid down a considerable time ago by a river flowing in the present Gbako basin during a previous period of geological time) is often only covered by about a meter of the more recent alluvium & sometimes protrudes through it.

The soil series found in the scheme vary in texture from pure sand through clayey sand & sandy clay soils in the surface layer & through the profile. These differences in texture determine their suitability for cropcultivation in terms of $H_2 0$ retention & ease of drainage & land preparation.

3.5.4. THE EXISTING FARMING SYSTEMS

Most farmers have both upland & wetland farms varying in site from 0.4ha to 2.0ha in the wetland & from 1.2 ha to 4.0ha in the upland. According to ward (1983) the average farm size of farmers using fertilizer was 0.83ha and the average size for farmers using fertilizer was 0.83ha and the average size for non-users was 0.39ha in 1980. Land ownership in the area is based on the liel' holder system where land rights are not heritable. Tenants pay rents or tributes to land owners are only symbolic. The principal crops grown in the area are sorghum, millet, rice, maize, sweet potato groundnut, melon, cassava and yam intercropping is the most common farming practice for most crops except rice which is a sole crop 100% of the time and yam 84% of the time.

Crop production practices depend largely on manual labour and use of land tools such as hoes and cutlasses. Farm labour consists of family labour and hired labout Hired labour contributes a high proportion (40%) of total labour used. This situation makes labour shortage a common occurrence during peak periods of land preparation, planting weeding and harvesting

CHAPTER FOUR

4.4. RESULTS AND DISCUSSION

This chapter discuss the result of findings which includes the costs of input and output of cultivated maize subjected to three different conditions viz:- High Water Condition, Low Water Condition (Sub-irrigation system) and rainfed system of cultivation per hectare.

From the maize produced using sub-irrigation system, 1944. Kg/ha was harvested from a high water table condition while on the low water table condition 345kg/ha was realised.

From the cultivation practiced carriedout between the high water table condition and the low water table condition, it was observed that the cobs obtained from low water table plot have missing kernels or ears and some have no kernels or eras at all. This is due to inadequate moisture in this plot during dry period of the cropping season and capillary rise (Capillary back water) could not reach their effective root zone.

Generally, to bring about high production of the maize in this field there is need for irrigation at the upper part of the field (low water table areas.) especially during dry cropping season and provision of drainage system (s) at lower party (high water tables areas) to drain excess water during wet cropping seasons.

On the other hand, the rainfed crops was able to maximize the available rainfall and yield realised was 2928.6kg/ha which has a remarkable difference from the sub-irrigated plot in terms of kernel formation, they are well formed except for very few cobs.

From the input cost analysis table for sub-irrigation (high water table) table 4.1 the cost of production per hectare was N23,850.00, the cost of production per hectare for low water table (Sub-irrigation) was N19,950.00 per hectare (table 4.2) while that of rainfed was N28,140.00.

The cost of site preparation and ridging for sub-irrigation was high because of the intensive labour involved in making the beds to the required depth. On the other hand the cost of fertilizers was higher during the raining season because of competition by farmers.

The yield realised from rainfed crop was 2928.6kg (59 bags) while 1944. lkg (39 bags) was realised from sub-irrigation (high water table) and 345Kg (7bags) was realised from (low water table) table 4.4.

Generally, to bring about high production of maize in this field adequate conservation of the soil is paramount because of the high nutrient requirement of maize.

TABLE 4.1 **INPUT COST ANALYSIS FOR SUB-IRRIGATION FARM (HIGH WATER TABLE 57CM –83CM BELOW RIDGE FOR ONE HECTARE**

NATURE OF WORK	COST PER HECTARE (N)
1. Site Preparation and Ridging	N4,000.00
2. Labour employed in sowing	N1,500.00
3. Labour employed in Weeding	N2,000.00
4. Cost of Seeds hybrid (20Kg at the rate of N100.00 per Kg.	N2,000.00
5. Cost of N.P.K Fertilizer (9bags at the rate of N1,000.00 per bag)	N9,000.00
6. Harvesting Cost	N1,600.00
7. Labour employed in shelling and bagging of 39bags (1944.Ikg) at the rate of N30.00 per bag	N1,170.00
8. Cost of empty bags at N20.000 per bags (39bags) (1944.1Kg)	N780.00
9. Transportation Cost (Plus loading and off loading of Goods	N1,800.00
TOTAL	**N23,000.000**

Total cost of production for high water table (57cm-83cm below ridge surface) per hectare was N23,850.00.

The yield harvested per hectare was 1944.1Kg

TABLE 4.2 **INPUT COST ANALYSIS FOR SUB-IRRIGATED FARM (LOW WATER TABLE) FOR ONE HECTARE**

NATURE OF WORK	COST PER HECTARE (N)
1 Site Preparation and Ridging	N4,000.00
2 Labour employed in sowing	N1,500.00
3 Labour employed in Weeding	N2,000.00
4 Cost of Seeds hybrid (20Kg at the rate of N100.00 per Kg.	N2,000.00
5 Cost of N.P.K Fertilizer (9bags at the rate of N1,000.00 per bag)	N9,000.00
6 Harvesting Cost	N800.00
7 Labour employed in shelling and bagging of 7bags (345kg) at the rate of N30.00 per bag	N210.00
8 Cost of empty bags at N20.000 per bags (7bags) (345Kg)	N140.00
9 Transportation Cost (Plus loading and off loading of Goods	N300.00
TOTAL	**N19,950.000**

Total cost of production for high water table per hectare was N19,950.00.

The yield harvested per hectare was 345kg

TABLE 4.3 **INPUT COST ANALYSIS FOR RAINFED MAIZE FARM PER HECTARE**

NATURE OF WORK	COST PER HECTARE (N)
1 Site Preparation and Ridging	N3,800.00
2 Labour employed in sowing	N1,600.00
3 Labour employed in Weeding	N1,800.00
4 Cost of Seeds hybrid (20Kg at the rate of N100.00 per Kg.	N2,000.00
5 Cost of N.P.K Fertilizer (9bags at the rate of N1,200.00 per bag)	N10,800.00
6 Harvesting Cost	N1,800.00
7 Labour employed in shelling and bagging of 59bags (2928.6KG) at the rate of N40.00 per bag	N2,300.00
8 Cost of empty bags at N20.000 per bags (59bags) (2928.6Kg)	N780.00
9 Transportation Cost (Plus loading and off loading of Goods	N2,800.00
TOTAL	**N28,140.000**

Total cost of production for rainfed maize per hectare was N28,140.00. The yield harvested per hectare was 2928.6kg

TABLE 4.4 **OUTPUT COST ANALYSIS FOR HIGH WATER TABLE, LOW WATER TABLE AND RAINFED MAIZE PER HECTARE**

Cultivation System	Cost of Production Per Hectare	Yields Per Hectare
1. High Water Table	N23,850.00	1,944.1kg
2. Low Water Table	N19,950.00	345kg
3. Rainfed	N28,140.00	2928.6kg

Table 4.5 **PROFIT AND LOSS ANALYSIS TABLE FOR SUB-IRRIGATED AND RAINFED MAIZE FARM PER HECTARE**

S/no	Cultivation system	Cost of production per hectare	Yields per Hectare	Sales	Profit per Hectare	Loss per Hectare
1.	High water table	N23,850.00	1,944.1kg	N34,993.80	N11,143.80	
2.	Low water table	N19,950.00	345kg	N6,210.00	-	N13,740.0
3.	Rainfed	N28,140.00	2928.6kg	N49,786.20	N21,646.20	

NB: The selling price for sub-irrigated farm was assumed to be N900.00 per 50kg while rainfed price was assumed to be N850.00 per 50kg this was due to seasonal variation in prices of commodities.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

For highest yield of maize, rainfed practices is recommended from the comparism made in table 4.4, highest yield was recorded from this practices. It requires less labour and could be practised by first timers. In case of sub-irrigation method (high water table) this could still be practised inorder to meet the food demand of the populace but with things being equal, rainfed practise is much more advisable, and economical (table 4.5).

From the table of input cost analysis (Table 4.3), the cost of fertilizer was higher because of the seasonal demand and this tends to increase the production cost.

In conclusion if much is cultivated, enough could be obtained to last till the next rainy season. This is done in advance countries with Conventional storage devices and facilities.

5.2 RECOMMENDATION

For maximum yield of Maize:-

1. Rainfed system of farming should be adopted
2. Adequate extension services should be intensified to boast production.
3. High yielding varieties of maize should be planted and farmers should be enlightened on selection of most appropriate variety.
4. Since maize needs adequate water, proper timing of planting should be taken into consideration.
5. More research should be carried out on ground water contribution to boast production especially high water table condition.
6. Proper drainage should be carried out where necessary and surface irrigation were need be.
7. Effort should be intensified towards improvement of the existing varieties.

8 - CLIMATOLOGY REPORT AT EMILUGI (PROJECT SITE) 1998, LAT. 09"45' NORTH, LONG. 06°07' EAST
ALT 70.57m

Month	Rainfall	Max. Temp. °C	Min. Temp. °C	Relative humidity %	Mean Monthly Temp. °C
Jan	0.0	35	17	52	26
Feb	0.0	39	21	43	30
Mar	0.0	40	23	33	31.5
Apr	67.1	39	27	68	33
May	213.2	34	25	82	29.5
Jun	75..5	33	24	82	28.5
Jul	239.7	32	24	85	28
Aug	145.5	30	24	84	27
Sep	153.7	31	23	85	27
Oct	103	33	24	82	28.5
Nov					
Dec					

Source: NCRI Badeggi Meteorological Department