# DISTRIBUTION, CONTROL AND MEASUREMENT OF IRRIGATION WATER ON THE FARM: A CASE STUDY OF TUNGAN KAWO IRRIGATION SCHEME

BY

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*A PROJECT REPORT SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, IN PARTIAL ...LFILMENT OF THE REQUIREMENT FOR THE AWARD OF ...TGRADUATE DIPLOMA (PGD) IN AGRICULTURAL ENGINEERING ... AND WATER OPTION)*

FEBRUARY, 1999

# CERTIFICATION

LADAN, Gbongbo, a Postgraduate Diploma Student in the Department of Agricultural Engineering with Reg. No. **PGD/AGRIC/24/97/98** has satisfactorily completed the requirements for the course and Project works for the award of Postgraduate Diploma (PGD) in Agricultural Engineering.

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

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DEACON O. CHUKWU

HEAD OF DEPARTMENT

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ENGR. (DR) M. G. YISA

# DEDICATION

To my family.

# ACKNOWLEDGEMENT

I wish to express my profound gratitude to my Project Supervisor Deacon O. Chukwu; Course co-ordinator Engr. (Dr.) D. Adgidzi, Head of Department (Agric. Engineering) Engr. (Dr.) M.G. Yisa and all other members of the Academic Staff, Department of Agric. Engineering, Federal University of Technology Minna, for all they have done in seeing to the successful completion of this work. I am also grateful to the staff and student colleagues of the Department of Agric. Engineering for the support I got from them while working on the project. The moral support and encouragement I received from my parents, brothers, sisters and the entire members of my family is appreciated. I must not also forget to thank Engr. A. Adewole (Senior Manager; Planning and Design of UNRB&RDA) for making available to me some of the relevant materials on the project area.

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**MINNA**

**FEBRUARY, 1999** **LADAN, GBONGBO**

# ABSTRACT


The Tungan Kawo Irrigation Project covers a total land area of approximately 900 hectares. The irrigation distribution system on the scheme comprise a 0.72 Km length main canal, 10.64 Km secondary canal, 0.9 Km tertiary canal and 27 km length field channels. The distribution control structures put in place to ease irrigation include, the intake bifurcation, escape, drop, turnouts, checks and control gates. The water measurement devices for estimating water on the scheme are weirs and pipe outlets.

The project has been operating at a very low capacity due to structural defects, poor operation and maintenance and above all, improper planning. Most conveyance canals have been eroded and in some cases blocked by siltation or animal interference. The bed level of some sections of the canals falls below the field level thereby creating negative head. The control gates required replacement. Poor canal maintenance is evident resulting to differential access to water.

To correct the defects observed in the distribution network., it is recommended that the secondary canal's embankments be raised and lined, additional checks be constructed, turnout pipes in some of the blocks be changed to bigger sizes, land levelling be carried out and finally allocation rules for water delivery to the farm be introduced and enforced.

# TABLE OF CONTENTS

**TITLE** **PAGE**

# LIST OF FIGURES

# LIST OF TABLES

**TABLE** **PAGE**

# CHAPTER ONE

## 1.0 INTRODUCTION

## 1.1 BACKGROUND TO THE STUDY

The necessity for increasing agricultural production in Nigeria has long been recognised particularly to meet the demand of the fast growing population and to cut down the import of grains and other food items. For this purpose it was deemed necessary to utilize the land and water resources available in the country to their optimum capacity. Realising the importance of the development of irrigated agriculture, the Federal Government has embarked on the development of medium - to large - scale projects related to irrigation development nationwide. One such area is the Tungan Kawo Fadama which lies at a distance of about 7km on the South-East of Wushishi Town in Niger State.

This fadama has long been utilized for growing rice during the wet season. The areas however faced some problems due to early flooding of the basin from two streams namely:- Ubandawaki and Bankogi passing through it. This has resulted to the destruction of rice crops in its early stages. Besides, early cessation of rainfall sometimes resulted in the failure of crops towards its maturity. Taking these problems into consideration, the defunct Northern Regional Government during the year 1955 came up with proposal to establish an irrigation scheme in the area to provide flood protection and supplementary irrigation. Necessary investigations were carried out during the year 1956.

Following the creation of the defunct North Western State, the project was transferred to it in early 1976. The Government of the defunct North Western State commissioned a firm of consultants, Messers Associated Engineers and Consultants to undertake "necessary investigation and design works of the project". The Niger State Government inherited the project as a result of state creation in 1976. The project was eventually transferred to the Niger River Basin Development Authority for execution in 1978. The same consultants were commissioned by the Authority in February 1982, with the award of contract to two indigenous contractors at a cost of =N=16,347,857.87. The irrigation, flood and drainage structures were completed in 1984 but the head works were completed only in early 1988.

## 1.2 OBJECTIVES OF THE STUDY

The objectives of this study are to:

(1) Examine the procedures and approaches in the distribution, control, and measurement of water in the field with particular emphasis on Tungan Kawo Irrigation Farm site.

(2) To identify the various defects in the operation of the irrigation system

(3) To recommend suitable measures to correct the defects.

## 1.3 IMPORTANCE OF THE STUDY

A greater part of the consideration for the study takes its root ahead of the fact that the project which is grossly under utilized due to certain operational lapses and defects in the distribution and controlling system has abundant water and land resources capable of producing 2,322 and 300 tonnes of rice per year during the rainy and dry seasons respectively while the production of cowpeas, onions, maize and vegetables is estimated respectively at 242.4, 5050, 393.6 and 144.0 tonnes annually.

Farmers operating on the project are known to be accustomed to irrigating with a copious supply of water especially when irrigating their rice crops. This practice results not only in loss of large volume of water but also loss of soil nutrients into the drainage system. An efficient distribution and control of this valuable resource has to be adopted if a higher productivity and preservation of soil fertility is to be achieved. An efficient management of water will, apart from the aforementioned ensure:

i) Most economical use of available water resulting in a greater benefit per unit of water per unit area and per unit time.

ii) Reliable and efficient service to the users of water i.e. farmers so that the irrigation water is made available to them as and when required in a quantity to meet demand

iii) Protection and management of irrigation works so that the life of the scheme can be prolonged and supply can work efficiently during period in which it is required.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

The interest to develop irrigated agriculture is not limited to Nigeria, not even to the third countries. Between 1950 and 1980, there was more or less a three-fold increase in the total area of irrigated agriculture throughout the world (Cernia, 1985). If there was any increase in food production at all, particularly in the third world countries such an increase has been closely linked with the expansion of irrigated land. However, the development of new high-yielding varieties as well as agricultural inputs cannot be ignored. India, Indonesia, Pakistan, Philippines, Sri-Lanka, Thailand are examples of areas where irrigated agriculture has thrived and quite successfully too (Dhawan,1988; Chambers,1988; Ostrom,1990)

The growth of irrigation contributed between 50% and 60% of the massive increase in agriculture output of the developing countries from 1960 to 1980 (Crosson and Resenberg, 1989). Interest in expanding irrigation is shown not only by host countries; international financial organizations too have made significant inputs to developing irrigated agriculture. For example, the World Bank recorded that between 1947 and 1985, $11 billion were given to foster irrigation and drainage schemes in developing countries. Another $7.5 billion was also given out as loans to finance area development projects, which on most occasions, included significant irrigation project (Ostrom, 1990). Of all the loans issued by the

Asian Development Bank in the 1970s, 13% were closely related to irrigation project (GAO, 1983). There were also individual irrigation schemes but they were very expensive ventures. For example, the Rahad Irrigation Scheme in the Sudan cost the donor agencies and the Sudanese government over $4,000 million. The "enormous" Mahaweh project in Sri-Lanka was designed to develop and improve water supply to 9 million acres (3,600,000 hectares) of land for over 200 new settlers (Ostrom, 1990).

Though these irrigation projects were considered as being successful schemes in their own right, they were still faced with serious management – related problems. This observation is correct because "many large – scale irrigation projects have not been sustainable in the sense that the net flow of benefits after the projects were completed did not exceed the net costs" (Ostrom, 1990). Economic sustainability can be determined by assessing whether the economic rate of return is equal to, and if possible greater than the opportunity cost of capital (Cernia 1987). Using this standard (IBRD) discovered in 1985 that many large scale irrigation projects have generated "disappointing operational results. The example of Gal Oya Scheme in Sri, lanka immediately comes to mind. Here the cost benefit evaluation made of the original scheme revealed that discounted costs exceeded discounted benefits by 277 million rupees (Harriss 1984). In very many other projects, actual costs have exceeded projects costs and this has made economic sustainability quite difficult to achieve. In India for example, the irrigation work for Jamina irrigation project amounted to 69.80 million rupees

(Ascher and Healy, 1990). It was discovered in many Asian irrigation projects that there is a dis-equilibrium between the area that projected plans assumed would be irrigated and the actual areas that were irrigated after the completion of irrigation projects. The actual area irrigated was more often less than the projected area. There were over estimated agricultural yields when projects were completed. There has been also a very poor maintenance culture in many of these schemes (Bamidele, 1991).

This short review of irrigation schemes especially in Asian countries is relevant to our study of Upper Niger River Basin and Rural Development Authority (UNRB&RDA) managed irrigation project and in fact, in the examination of other RBDA's projects in Nigeria in the following ways.

In the first instance, irrigation programmes to increase agricultural yield is not peculiar to Nigeria. Similarly irrigation projects in Nigeria face management problems as in other areas of the world, though the scope of these problems differs.

Most irrigation schemes in Nigeria are developed and managed by either the State or Federal Governments. In all designs, the government owns the water impounding and distribution structures while the farm lands could be owned by either the government or the farmers or both. The government has been very benevolent in operating and managing schemes. The interaction between the farmers and government could be classified as benevolent client relations. The government especially at the federal level has partially withdrawn from providing funds and services since 1988 and the managing agencies are expected to be self-sufficient and self-sustaining. The dwindling operating funds over the years and the governments' abrupt withdrawal have contributed to the serious deteriorations of most systems' structures and have resulted in the low-level performance of many schemes (Bamidele, 1991).

# CHAPTER THREE

## 3.0 THE STUDY AREA

## 3.1 LOCATION AND GENERAL DESCRIPTION

The Tungan Kawo Dam and Irrigation project is one of the several projects owned and maintained by the Upper Niger River Basin and Rural Development Authority. The project is located at a distance of 8km from Wushishi on the South Eastern direction in Wushishi Local Government Area of Niger State. The reservoir provides controlled facilities for the down stream irrigation of a gross area of 900 hectares as well as flood and drainage control for about 1,215 hectares.

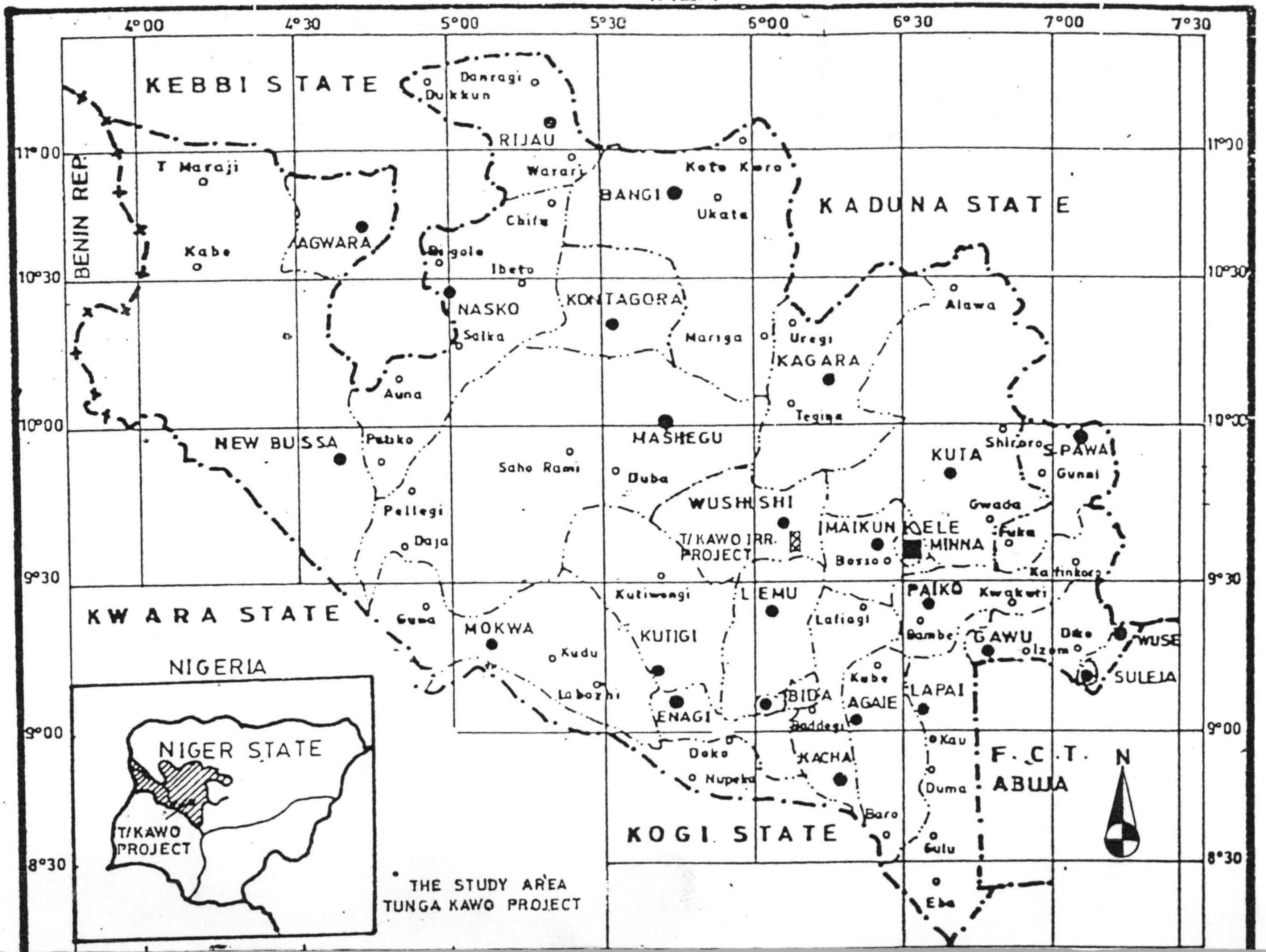
The principal features of the project consist of the following elements:

i) An irrigation system comprising of 0.72km length of lined main canal, 10.64km length of unpaved secondary and tertiary canals to feed he field lots.

ii) An escape structure located at 0.65km of the main canal which is of RCC box culvert type provided with a sliding gear at the upstream end.

iii) A drainage sluice located at the out fall end of the main collector drain comprising of 6No corrugated steel pipes with flap gates at the downstream end. This will cater for a maximum flow of 23.24 cubic meters of water per sec.

AREA



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THE STUDY AREA
TUNGA KAWO PROJECT

iv) A 6.70km length of flood protection earth embankment against flood water from Ubandawaki River.

v) A drainage system comprising of 7.5km long Bankogi drain to convey flood water from Bankogi River and a 3.2km long main collector drain.

## 3.2 TOPOGRAPHY

The land surface is fairly elevated and undulating throughout the project area. The elevation varies from 83m to 103m above mean sea level.

## 3.3 CLIMATE

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

The normal rainfall ranges between 1200mm and 1300mm. Temperature varies from 37.5oc max to 18oc minimum. The hottest period is the months of February, March and April of every year.

## 3.4 HYDROLOGY/HYDROGEOLOGY

Rivers Kaduna and Ubandawaki (Gabuko) are the two main streams in the vicinity of the project area. Rivers Ubandawaki and Bankogi on which the dam is located have a catchment area in the order of 166sq km at the dam site. The river has several tributaries which ultimately discharge into River Nigi which in turn joins Kaduna River on the downstream end of the project area.

The project is situated more or less on the border of the basement complex and Nupe sandstones. The basement complex consists mainly of metamorphic rocks with local granite and basic intrusions (Wushishi) while the Nupe sandstones consist of fine sandstones sometimes overlain by pliuthite (ironstone and laterite).

## 3.5 SOILS

Five different soils were recognised within the project area and are classified according to d'Hoore classification for the soil map of Africa. They are:-

i) Ferruginous Tropical Soil on sandy parent material

ii) Ferralsols dominated by fine sand

iii) Vertisols

iv) Mineral hydromorphic soils

v) Mineral hydromorphic soils of Topographic depressions

The dominant soil type is vertisols comprising of roughly 50% of the survey area followed by the hydromorphic soils and ferralsols. The ferruginous tropical soils mainly surround the survey area.

# CHAPTER FOUR

## 4.0 METHODOLOGY AND PROCEDURE

### 4.1 METHODS OF INVESTIGATIONS:

The report is based mainly on day-to-day experience acquired in the operation of the facilities at the project area under review. Although quite a number of reports on the project were consulted, an attempt to get information was also made through oral interviews with the present operators of the scheme and farmers alike. All these afforded us the opportunity of having an indepth knowledge of the operation of the scheme and problems associated with the system

### 4.2 DISTRIBUTION OF WATER ON THE FARM

Irrigation .water are conveyed from its source through a system of canals, pipelines, or structures to the individual furrow, border or sprinkler head. For projects or group systems, or canal usually delivers the required flow to the farm head gate the furrow. The conveyance system must have the capacity to deliver water to the field that is adequate to meet the largest size of stream required for the irrigation methods planned for the field and to meet the consumptive use of the crops to be grown, making provisions for the expected irrigation efficiency.

Some wastes result when transporting water from head gate or pump to the field. If the water is carried in burried or surface pipelines, the loss may be negligible. In lined ditches the loss will also be minimal depending

Fig. 3: Upstream view of Tunga Kawo Dam with slide gate.

Fig. 4: Bifurcation structure on main canal with Left and Right Bank Secondary Canals.

upon the type of lining and its condition. Water conveyed in open, unlined ditches may have considerable loss, sometimes 15 to 40% per kilometer or more in permeable soils. When unlined ditches are used, the farm requirements it equal to the field requirement plus the amount of the ditch loss.

### 4.2.1 WATER DISTRIBUTION SYSTEM

The water distribution system of the area under study comprised a lined main canal through which water is conveyed to the unpaved secondary canals and subsequently to the tertiary canals and field channels:-

i) Main canal:- This is a 0.72km lined concrete canal with a discharge capacity of 3.42 $m^3$/sec. The canal conveys water from the reservoir intake down to the bifurcation structure at the terminal end of the canal.

ii) Secondary canals:- The bifurcation structure at the end of the main canal bifurcates the main canal into two secondary canals named IL and IR which diverts the flow proportionately to the areas commended by each of them. The division of the canal into two was found necessary due to the position of the main collector drain which divides the area into two district portions. One on its left and the other on its right side. The total areas served by the secondary canals IL and secondary canal IR estimated at 297 hectares (734 acres) and

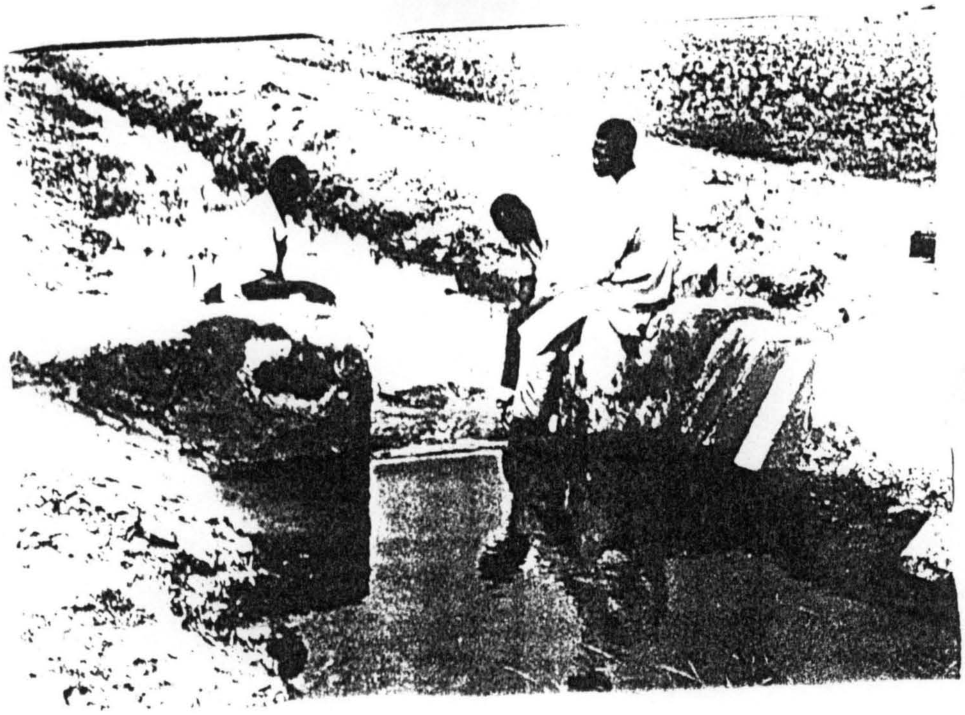

Fig. 5: A typical check structure on Left Bank Secondary Canal.

Fig. 6: A field channel being disilted by farmers

477 ha (1,178 acres) respectively. The designed capacities of the two canals are respectively $1.32m^3/sec$ and $2.12m^3/sec$ on the basis of the area to be commanded.

iii) Tertiary canals:- Tertiary canals have been provided to serve some of the areas which cannot be conveniently served by the secondary canals directly. There are three of such canals, one taking off from the secondary canal IL on its right and two taking off from secondary canals IR on its right and left sides.

iv) Field channels:- There are a total of 63 field channels taking off from secondary or Tertiary canals. The lengths of the field channels vary from a minimum of 280m to a maximum of 720m.The sizes of blocks served by the channels also vary from a minimum of 5.5ha to a maximum of 20 hectares. Most of the blocks sizes were kept within the range of 11-15ha so that the discharge of the field channels does not exceed 0.06$m^3$/sec(2 cusecs).

### 4.2.2 WATER APPLICATION METHOD

Check flooding is the predominant method of irrigation practiced in the area. It is accomplished by turning water into relatively level plots, or checks surrounded by levees. The checks are filled with water through pipe outlets installed along the field channels at a fairly high rate and allowed to stand until the water infiltrates.

The quantity of water applied varies with irrigation season. During rainfed supplementary irrigation cropping season, planting of rice is usually delayed and as a result irrigation activities spills over to around November of each year when rains have completely stopped. Farmers insist on continuous flooding of the entire area at the same time thereby resulting into loss of large volumes of water. The water demand becomes higher compared to the dry season period when less water demanding crops are planted and less area covered.

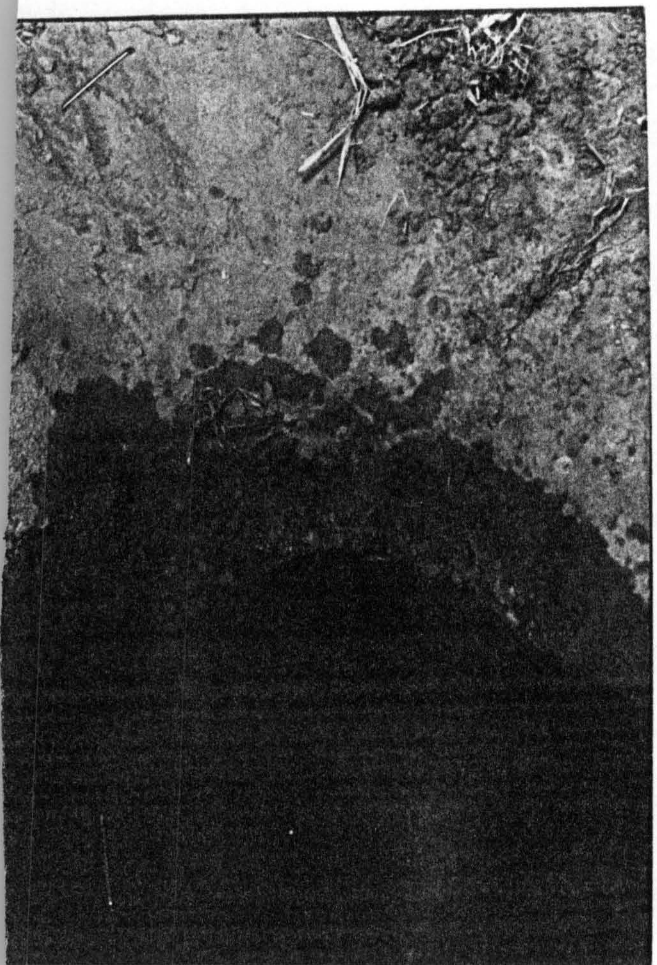

Fig. 7a. Upstream view of Pipe Outlet installed on field channel.

Fig. 7b. Downstream view of the Pipe Outlet.

### 4.2.3 UNIFORMITY OF WATER APPLICATION

The method adopted by farmers operating on the scheme to determine whether their plots have received adequate irrigation water during dry season is by checking the soil moisture condition a day after irrigation. Soils are dug at sensitive location to see if the root zone has been brought up to field capacity; if dry areas or layers are found, irrigation was not complete or the water was not spread uniformly.

### 4.2.4 WATER SUPPLY SYSTEM:-

There is no any organized water scheduling plan for the scheme at the moment. All efforts made by the Authority to introduce one proved abortive. The supply system presently practiced on the scheme is the continuous flow (flooding) and rotational/on demand systems. Since water demand during dry season period vary considerably from field to field depending on crop and soil, limitations set by the canal infrastructure and requests from the farmers themselves, the pattern of turns within one lateral channel becomes complicated. The pattern evolves during irrigation season since water demand gradually increases with changes in climatic condition and crop stage if shortages of water occur during this period some will have to irrigate in the day time while others in the evening.

## 4.3 CONTORL OF WATER ON THE FARM

A properly designed distribution system will make irrigation easy and efficient. Several types of structures are used to control irrigation water on the farm. Water control and diversion structures are necessary for an effective control of irrigation water on the farm Good control will not only reduce the labour required to irrigate but also check and save water loss.

### 4.3.1 DISTRIBUTION CONTROL STRUCTURES:-

For proper distribution of water and to control the flow at the time of fluctuation in water supplies, some control structures have been provided. The intake, off take, division and drop structures on canals are used for this purpose. Where such structures do not exist within a reach of 600m, necessary provision was made for check structures. The list of all such structures are as given in fig 1. Other auxiliary structures have also been put in place to ease irrigation activities.

i) Intake structure:- For supplying water from the reservoir to the main canal, the outlet works was provided. These include intake structure of internal diameter dimensions of 3.0m by 3.0m with the provision of trash rack and grooves for stop logs to be dropped in emergency. For supply to the main canal, are cast in situ reinforced concrete conduit pipe of 120 cm internal diameter was provided. The upstream innert of the pipe was kept at El. 105.00 and the down stream at 105.25m giving a longitudinal slope of 0.01 with the above mentioned arrangement the water way of the conduit pipe passes a discharge of 3.44m$^3$/sec with a minimum water level of 107.5m on the up stream side. The flow through the pipe is being controlled by vertical lifting sliding gate.

ii) Bifurcation structure:- This structure as earlier described is located at the terminal end of the main canal. Its main purpose is to divide or direct the flow of water proportionately to the two secondary canals. It is equipped with gates to furnish the necessary flows to the canals.

iii) Escape structure:- This is located at 650m down stream of the main canal. The structure is essentially a safety valve for the canal. It serves the following purposes.

- Protection of the canal against possible damage
- Emptying of the canal for repairs and maintenance
- Removal of a part of the sediment deposited in the canals
- The sudden rise in water level in the canal due to leakage from the main intake gate during the off season are disposed off through the escape structure. The escape is provided with sluice gate.

iv). Drop structures:- The drop structures are used to control the canal's velocity by lowering the water abruptly from one level to another. The water is lowered over drops and conveyed down slope in a stair step manner. The energy of the falling water is thus dissipated to prevent erosion of the down stream channel or undercutting of the structure. The list of all such structures except for those that were later constructed are as shown in fig 2.

v) Turnouts:- These are structures located in the bank of both the secondary and Tertiary canal for controlling the flow of water from the canal into the field channels. The structures are equipped with wooden gates for regulating the flow.

vi) Checks:- Check structures are placed in the canals to control the elevation of water surface above the structure. The water levels are raised as necessary so that it can be diverted from the ditch. The checks are equipped with stop logs for adjusting the upstream elevation of the water surface.

### 4.3.2 CONTROL GATES:-

Steel plate and stop logs are used as stops for the control gates. Stop logs provided for the turnouts are inserted into the slots provided in the structure. Although these are leaky devices, farmers often shovel earth around them to reduce leakage.

The metal gates are provided at the intake escape, bifurcation and tertiary canal structures to provide water tight checks.

## 4.4 MEASUREMENT OF WATER ON THE FARM

### 4.4.1 NEED FOR IRRIGATION WATER MEASUREMENT

Water is the most valuable asset of irrigated agriculture. Accurate measurement of irrigation water permits more judicious use of this valuable natural resource, such a measurement reduces excessive waste and allows the water to be distributed among users according to their needs and right. Systematic water measurement properly recorded, interpreted and used constitutes the foundation upon which increasing efficiencies of water conveyance, application and use must be based. Accuracy in water measurement is therefore of prime importance in the operation of any water distribution system.

### 4.4.2 WATER MEASUREMENT DEVICES

Several devices are commonly used for measuring irrigation water on the farm. They can be grouped into four major categories:-

i) Volumetric measurement;

ii) Velocity – area method;

iii) Measuring structures;

iv) Tracer method.

In farm irrigation practice, the most commonly used device for measuring water are the weirs, parshal flumes, orifices, spiles, siphons and metergates. In these devices the rate of flow is measured directly by making a reading on a scale which is a part of the instrument and computing the discharge rate from standard formulas. The discharge rate can also be obtained from standard tables or calibration curves prepared specifically for the instrument. The choice between one or the other depends on the expected flow rate and site conditions. For the purpose of this study, a more detailed description of the devices used on the scheme to measure the flow in the channels and into the field is made.

### 4.4.3 WATER MEASUREMENT IN THE STUDY AREA

Weirs and pipe outlets are used to measure flow of water in the study area.

1 Weirs:- are used to measure flow in an irrigation channel. It is a notch of regular form in which irrigation stream is made to flow weirs may be divided into weirs with end contraction and those without end contraction. End contractions are produced when crest length or width of the notch is less than the channel width on suppressed weirs, the crest extends across the full width of the channel, and no contractions are produced. When the water surface downstream from the weir wall is far enough below the crest so that the end has access around the nappe, the flow is said to be free, otherwise, it is submerged.

The discharge through a weir notch is proportional to the head on the crest and is affected by the condition of the crest, the contraction, the velocity of the approaching stream and the elevation of the surface down stream from the weir.

The discharge through a rectangular weir may be computed by the Francis formula stated below:-

i) For suppressed rectangular weir

$Q = 0.184LH^{3/2}$ (Michael, 1985)

Where Q = discharge in lit/sec

L = Length of crest (cm)

H = Head of weir (cm)

ii) For contracted rectangular weir (with end contraction)

$Q = 0.184\ (L-0.2H)H^{3/2}$ (Michael 1985)

Since nearly all the weirs on the farm are of the contracted rectangular type, the equation of the contracted rectangular weir is used to estimate discharge. Table 1 presents the values of discharge through contracted rectangular weirs with contractions at both ends of the weirs under different widths and operating conditions.

2 Pipe outlets- These are the main devices used in estimating the quantity of water directly applied to the field. The pipes are of the PVC type placed in the bank of the field channel to convey water from the channel into the field. The discharge depends on the size of the pipe and the pressure head over the centre of the pipe.

The discharge into the field is estimated using the following equation:-

$$Q = Ca.\sqrt{2gH} \qquad \text{(Michael, 1985)}$$

Where Q = Discharge in lit/sec

C = coefficient = $0.61 \times 10^{-3}$

a = Sectional area of pipe in $Cm^2$

H = Pressure Head over Centre of pipe Cm

g = acceleration due to gravity (981 $Cm/Sec^2$)

Such calculations have been made for the 10cm diameter pipe used in the channels at different heads and the result presented in table 1. Table 3 above shows discharge of pipe outlets of various sizes at different heads.

Although an up-to-date record of water delivered to each plot is not kept on a regular basis at the site, the available one shows that for a rice variety tried on the scheme during the 1994 dry season farming activities, a total of 12,591.6 $m^3$ of water was applied to the 1 hectare plot throughout the growing period. Although it is unrealistic to draw a conclusion from only this single datum, the result gives one an idea of the total water required to be applied to 1 hectare plot under the same condition.

Estimating flow in an open channel is done in the same manner as that through pipe to the field since there are no measuring structures on the field channel. It should be noted that most field channels have submerged outlets and in estimating flow, the head difference between the water level in the canal and that of the field channel is determined and the equation of the pipe flow applied to estimate flow

# TABLE 1: -

**DISCHARGE THROUGH CONTRACTED RECTANGULAR WEIR, LITRES PER SECOND**

| HEAD OVER WEIR Cm | WIDTH OF WEIR | | | |
|---|---|---|---|---|
| | 30 Cm | 40 Cm | 50 cm | 60 Cm |
| 1 | 2 | 3 | 4 | 5 |
| 5.0 | 5.97 | 8.0 | 10.6 | 12.2 |
| 5.5 | 6.9 | 9.3 | 11.6 | 14.0 |
| 6.0 | 7.8 | 10.5 | 13.1 | 15.9 |
| 6.5 | 8.4 | 11.8 | 14.9 | 17.9 |
| 7.0 | 9.7 | 13.2 | 16.6 | 20.0 |
| 7.5 | 10.7 | 14.5 | 18.3 | 22.1 |
| 8.0 | 11.8 | 16.0 | 20.1 | 24.3 |
| 8.5 | 12.9 | 17.6 | 22.1 | 26.7 |
| 9.0 | 14.0 | 19.0 | 24.0 | 28.9 |
| 9.5 | 15.2 | 20.7 | 26.0 | 31.2 |
| 10.0 | 16.3 | 22.2 | 28.0 | 33.8 |
| 11.0 | 18.2 | 25.3 | 32.0 | 37.7 |
| 11.5 | 19.9 | 27.1 | 34.3 | 41.4 |
| 12.0 | 21.3 | 29.0 | 36.7 | 44.4 |
| 12.5 | 23.5 | 30.7 | 39.0 | 42.1 |
| 13.0 | 23.7 | 32.3 | 40.9 | 49.5 |
| 13.5 | 24.8 | 34.0 | 43.0 | 52.2 |
| 14.0 | 26.2 | 35.8 | 45.5 | 55.2 |
| 14.5 | 27.7 | 37.9 | 48.2 | 58.5 |
| 15.0 | 28.8 | 39.5 | 50.3 | 60.9 |
| 16.0 | 31.6 | 43.3 | 55.2 | 67.0 |
| 17.0 | 34.3 | 47.2 | 60.1 | 73.0 |
| 18.0 | 37.0 | 51.0 | 65.3 | 79.0 |
| 19.0 | 39.8 | 55.0 | 70.2 | 85.3 |
| 20. | 42.8 | 59. | 75.8 | 88.8 |

## Table 2

**DISCHARGE THROUGH A 10CM PIPE OUTLET AT DIFFERENT HEADS**

| H Cm | Q Lit/Sec | H Cm | Q Lit/Sec | H Cm | Q Lit/Sec | H Cm | Q Lit/Sec |
|---|---|---|---|---|---|---|---|
| 1.0 | 2.12 | 11.0 | 7.04 | 21.0 | 9.72 | 31.0 | 11.82 |
| 1.5 | 2.60 | 11.5 | 7.21 | 21.5 | 9.84 | 31.5 | 11.92 |
| 2.0 | 3.00 | 12.0 | 7.35 | 22.0 | 9.95 | 32.0 | 12.00 |
| 2.5 | 3.40 | 12.5 | 7.50 | 22.5 | 10.01 | 32.5 | 12.11 |
| 3.0 | 3.68 | 13.0 | 7.65 | 23.0 | 10.18 | 33.0 | 12.20 |
| 3.5 | 3.97 | 13.5 | 7.81 | 23.5 | 10.28 | 33.5 | 12.28 |
| 4.0 | 4.24 | 14.0 | 7.94 | 24.0 | 10.41 | 34.0 | 12.37 |
| 4.5 | 4.5 | 14.5 | 8.08 | 24.5 | 10.50 | 34.5 | 12.46 |
| 5.0 | 4.75 | 15.0 | 8.22 | 25.0 | 12.55 | 35.0 | 12.55 |
| 5.5 | 4.98 | 15.5 | 8.35 | 25.5 | 10.72 | 35.5 | 12.64 |
| 6.0 | 5.21 | 16.0 | 8.49 | 26.0 | 10.82 | 36.0 | 12.73 |
| 6.5 | 5.41 | 16.5 | 8.62 | 26.5 | 10.92 | 36.5 | 12.82 |
| 7.0 | 5.62 | 17.0 | 8.79 | 27.0 | 11.03 | 27.0 | 11.91 |
| 7.5 | 5.81 | 17.5 | 8.87 | 27.5 | 11.13 | 37.50 | 13.10 |
| 8.0 | 6.00 | 18.0 | 9.00 | 38.0 | 11.23 | 38.50 | 13.11 |
| 8.5 | 6.19 | 18.5 | 9.13 | 28.5 | 11.32 | 28.0 | 13.17 |
| 9.0 | 6.31 | 19.0 | 9.25 | 29.0 | 11.43 | 39.0 | 13.35 |
| 9.5 | 6.54 | 19.5 | 9.37 | 29.5 | 11.53 | 39.50 | 13.34 |
| 10.0 | 6.71 | 20.0 | 9.49 | 30.0 | 11.62 | 40.0 | 13.42 |
| 10.5 | 6.88 | 20.5 | 9.61 | 30.5 | 11.71 | 40.5 | 13.51 |

## TABLE 3

**DISCHARGE OF PIPE OUTLETS OF VARIOUS SIZES AT DIFFERENT HEADS.**

| HEIGHT OF WATER OVER CENTRE OF PIPE (Cm) | DISCHARGE RATE LITRE/SECOND | | |
|---|---|---|---|
| | DIAMETER OF PIPE | | |
| | 2.5Cm | 5.0Cm | 7.5Cm |
| 1.0 | 0.13 | 0.53 | 11.2 |
| 1.5 | 0.16 | 0.64 | 11.4 |
| 2.0 | 0.19 | 0.74 | 1.2 |
| 2.5 | 0.21 | 0.81 | 1.8 |
| 3.0 | 0.23 | 0.91 | 2.1 |
| 3.5 | 0.25 | 0.99 | 2.2 |
| 4.0 | 0.26 | 1.15 | 2.4 |
| 4.5 | 0.20 | 1.20 | 2.5 |
| 5.0 | 0.30 | 1.21 | 2.7 |
| 5.5 | 0.31 | 1.23 | 2.8 |
| 6.0 | 0.32 | 1.30 | 2.9 |
| 6.5 | 0.33 | 1.134 | 3.0 |
| 7.0 | 0.35 | 1.39 | 3.1 |
| 7.5 | 0.36 | 1.45 | 3.3 |
| 8.0 | 0.38 | 1.50 | 3.4 |
| 8.5 | 0.39 | 1.53 | 3.5 |
| 9.0 | 0.40 | 1.60 | 3.6 |
| 9.5 | 0.41 | 1.62 | 3.7 |
| 10.0 | 0.42 | 1.70 | 3.8 |
| 10.5 | 0.43 | 1.72 | 3.9 |
| 11.0 | 0.44 | 1.75 | 3.9 |
| 11.5 | 045 | 1.80 | 4.0 |
| 12.0 | 0.46 | 1.83 | 4.1 |

# CHAPTER FIVE

## 5.0 RESULTS AND DISCUSSIONS

### 5.1 OBSERVATIONS FROM THE FIELD SURVEY

1. A greater part of the unpaved IL canal and some field channels have had their embankment eroded while in some areas siltation have partially blocked the ditches thereby reducing the carrying capacity of such canals. The activities of cattle rearers aggravated the problem and some field channels illegally turned as cattle routes have been made completely out of use.
2. The bed level of the IL secondary canal in some areas falls below the field level thereby creating negative head. The effect of this is the inability of such canals to deliver water to the adjacent field channel. The result of the recent survey carried out reveals that few negative heads have been developed between chainages 0 +000 to 3+ 430 along the IL canal. In areas where positive heads were developed, less flow is also expected because of the low canal embankment height relative to the field channel bed level.
3. The pipe sizes used in some of the turnouts produced discharges not commensurate with the area commanded by such turnouts.
4. Check structures which are supposed to head up water are non-existent for upward of 3km in some areas
5. Many cases of illicit behaviour of cutting or breaking canals by the users to divert flows to farm plots or fishing ponds were observed.

6. Nearly all the control gates are in various stapes of disrepair. The main intake gate is only being managed at the moment. The sliding gate spindle and gear accessories for the bifurcation, escape and off take structures at the tertiary canals are worn out making them extremely difficult to operate. The wooden logs used as turnout gates also serve very little purpose of water control.

7. Poor canal maintenance is evident shrubs and weeds have overtaken the two secondary canals. The untidy state of these canals has negative effects on the water flow and the carrying capacity of these canals.

8. There is differential access to water and land by the farmers operating on the scheme. Some farms are well leveled while others are not. Some have good access to water while the irrigation channel delivering water to others is obscured. The people occupying poor and degraded lands with severe water shortages end up with low production levels. The head enders receive more water than the tail enders. There are always more crop failures reported in the tail end areas than in the head reaches.

9. Not much attention is paid to record keeping of the quantity of water delivered to the farm at the site.

## 5.2 PROPOSED REMEDIAL MEASURES

1 The negative head developed along the canals with respect to the field can be corrected by raising the embankment to give the water in the canal enough head relative to the field.

2 The two unlined secondary canals should be lined to check the seepage losses, erosive activities and frequent maintenance often required of earth canals. Unlined earth canals generally are very susceptible to erosion. To check the erosive activities resulting from human and animal interference, the lining of these canals would be a permanent solution to embankment failures. The main canal was lined with concrete in 1983 and since the completion and commissioning of the project in April 1988, the concrete section has continued to remain intact and never abused as it is the case with the unlined secondary canals.

3. Additional check structures should be constructed along the secondary and Tertiary canals where they are considered necessary. Similarly head regulators equipped with adjustable gates should be provided on Secondary canals at the Tertiary canals off takes.

4. The existing pipe sizes used in some of the turnouts produced low discharges relative to the field demand. Such pipe should be replaced with those of bigger diameters to match up the field demand with the supply.

5. Flow in the field channels go directly to the main drain via the collector drains. No attempt has been made by the Authority to check this at the end of the channel. Checking the flow at the tail end results in head build up. The native materials being shoveled by farmers to check the flow at the end of the channel appears not to be effective. The provision of suitable structures equipped with an overflow device is imperative. Some of the field channels requiring attention should be reconstructed.

6. The intake, bifurcation, escape and tertiary canal gates require serious rehabilitation. It will also be necessary to provide spares of their accessories for replacement any time the need arises.

7. Isolated ponds and depressions found on the scheme should be properly graded for uniformity of water distribution.

8. Allocation Rules for water delivery to the farm should be introduced and enforced. The present practice whereby farmers draw water into their farms as at and when required does not augur well for even water distribution.

9. Spiles i.e. pipe outlets currently used to convey water from the field channels to the field cover just a fraction of the entire command area. Other areas uncovered by this facility should also be provided for or in the alternative farmers in these areas should be trained and encouraged on the use of siphon tubes to convey water from the field channels instead of the present practice of breaking such channels to convey water to their plots.

# CHAPTER SIX

## 6.0 CONCLUSION AND RECOMMENDATIONS

6.1 **CONCLUSION:-** It is quite evident that the project has been operating at a very low efficiency. There are structural defects, poor operation and maintenance and above all weak planning for water delivery.

6.2 **RECOMMENDATIONS:-** The operation of the scheme can be improved upon by better physical structures and technologies the key problem concerns the incentives facing officials and farmers. If these individuals are not motivated to operate and maintain the irrigation system effectively, the project will continue to perform ineffectively for several decades. The most important consideration in irrigation development will be integrating farmers participation with effective institutional development while irrigators organization can potentially play an important role in the operation and maintenance of this project. It is important to involve farmers themselves in crafting their own operational and collective choice rules in the governance and management process of the project.

To reduce uncertainty and conflict among irrigators, it is hereby recommended that fixed time slots be adopted as the sole distribution procedure on the scheme. Assigning irrigators fixed time slots may be an economical way of distributing water. If all irrigators know their own time slots, each shows up and diverts water to his or her own plot from certain outlets when his/her time begins. This arrangement is self-enforcing and requires minimal supervision. The officials of the project should as a matter of policy keep an up-to-date record of the daily water delivery to each plot. This will in no small way help in the management of the valuable resource and planning for future work.

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