

TECHNICAL AND ECONOMIC COMPARISON OF PERFORMANCE  
BETWEEN FARMER AND GOVERNMENT MANAGED IRRIGATION SCHEMES  
IN TANZANIA: A CASE STUDY OF KAPUNGA IRRIGATION PROJECT

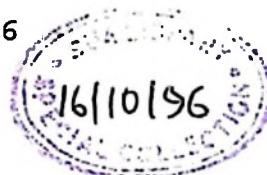
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**ABSTRACT**

This study compares the performance of government-managed irrigation schemes (GMIS) to farmer-managed irrigation schemes (FMIS) at Kapunga rice irrigation project in Mbeya region in Tanzania. The specific objectives were to evaluate: (i) organisational structure of the two systems; (ii) water management aspects of the two systems; (iii) productivity and economic performance of the two systems. Appropriate indicators have been used to quantify performance of the two types of management of irrigation.

Results of the study show that the farmer-managed scheme performed better than the government-managed scheme in attaining scheme irrigation efficiency, productivity, economic, and financial profitability. Applicable indicators for the farmer-managed irrigation schemes are quantified as shown below. Those of the government-managed scheme are indicated in brackets. Its overall irrigation efficiency was 61% (29%); average productivity was 3.2 ton/ha (2.2 ton/ha); economic profitability: internal rate of return was 3.2% (5%), benefit/cost ratio 0.6 (0.14); while its financial profitability: internal rate of return was 3.9% (5.1%), benefit/cost ratio 0.6 (0.13). The organisation of both the government and farmer-managed irrigation schemes were appropriate, however, both schemes

were weak in irrigation management as the essential operation and maintenance activities were not carried out effectively. Both the government and the farmer-managed schemes had canal maintenance problem. There was a corresponding big error in water adequacy of 86% and 98% respectively arising from improper water control at the secondary canals offtake. Paddy nurseries in the government-managed scheme had undesirable water stress. However, both schemes were able to distribute water equitably, reliably, as well as maintaining a correct field water depth from tillering to flowering and grain formation stages.

DECLARATION

I, DAVID NYAKAMWE CHEMKA, do declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work and that it has never been submitted for a degree in any other university.

Signature : *DCM* -----  
Date : 07/08/96 -----

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DEDICATION

To my wife Constansia, my son Nathan, and my daughter Elizabeth, who were patient with me at the time of undertaking this study.

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## CHAPTER I

## INTRODUCTION

## 1.1 Background information

Tanzania's economy depends mainly on agriculture (Ministry of Agriculture, 1983). However, due to unreliability of rainfall, irrigation in Tanzania has been established to supplement crop water needs. Both the British and the nationalist government with the help of donors rehabilitated many irrigation schemes. To date, 80% of irrigation schemes are farmer-managed while, 20% are government-managed irrigation schemes (Masija and Kagubila, 1994). Government-managed irrigation schemes (GMIS) are those in which principal management responsibilities are carried out by government with farmers playing a subsidiary role. Farmer-managed irrigation schemes (FMIS) are those in which farmers play the principal role with the government playing a subsidiary role. GMIS were established to ensure national food security and economic growth while the establishment of FMIS is aimed at increasing farmers productivity (Ministry of Agriculture, 1983).

According to Mnzavas and Makonta (1994), irrigation development in Tanzania has gone through in three stages.

First, there was imposed smallholder irrigation practice. The second was the large scale (GMIS) practice in which only the government was involved in irrigation development. In all these stages, farmers did not participate in planning, designing and constructing irrigation schemes. Also, responsibilities of farmers for operating and maintaining the schemes were not clearly defined. Therefore, their chances of adopting modern irrigation techniques were limited. Their irrigation practices remained at traditional level. On the other hand, government-managed irrigation schemes received substantive capital, modern equipment and trained manpower. Though a large amount of funding had been allocated to government-managed irrigation schemes in Tanzania, their performance remained low (FAO, 1991). Due to poor performance of the GMIS, the government of Tanzania is currently emphasizing development of farmer-managed irrigation schemes as a means of attaining sustainable irrigation farming.

## **1.2 Purpose and objectives of study**

Though the development of the FMIS is currently emphasized, no study has evaluated the performance of both the farmer and government-managed irrigation schemes in order to assess their performances. Abernethy, (1986) has cautioned that a proper study to identify areas needing improvements

and support should be carried out before any intervention is made.

Consequently, the main objective of this study is to compare technical and economic performance of the GMIS to FMIS at Kapunga rice project. The specific objectives of this study are:

- (a) to evaluate water management aspects of the two schemes.
- (b) to evaluate organisational structure of the two schemes.
- (c) to evaluate productivity and economic performance of the two schemes.

Results of this study have potential to assist the government or irrigation development agencies to decide which type of schemes to promote.

**CHAPTER II****LITERATURE REVIEW****2.1 Introduction**

This chapter reviews the literature including the theories and background of performance of irrigation systems. The background is drawn from engineering (irrigation), agriculture and socio-economic disciplines. This chapter forms a basis for the methods, analysis and conclusions of the study.

**2.2 Performance of Irrigation Schemes.**

There is a general awareness that, irrigation management has been weak in many African farmer-managed and government-managed schemes (Speelman, 1990). Much disappointment exists all over the world with the performance of government-managed irrigation schemes (Sagardoy, 1986). Farmer-managed irrigation schemes in many countries contribute to the production of a significant portion of the subsistence food supply. However, many FMIS do not perform as they could (Manor and Chambouleyron, 1993). Recent studies on the performance of irrigation systems show that in general, the performance of many

irrigation systems has fallen partly due to poor design but predominantly due to problems of organisation and management (Sagardoy et al., 1986). Late release of government funds for operating the farms, unavailability of funds at the time needed, lack of involvement by the government officials in utilising the schemes' potential benefits, and large bureaucracies, are some of the reasons which contribute to poor performance of GMIS. In an attempt to improve irrigation systems' performance, a number of studies are being done in developing countries to compare performance of government-managed irrigation systems against farmer-managed irrigation systems. In northern areas of Pakistan, Hossain (1991) compared farmer and government-managed irrigation schemes using factors such as: (a) number of newly developed schemes; (b) maintenance; (c) equitable water distribution; (d) management of equity of both labour and water and (e) innovation in design. He found that farmer-managed schemes performed better than government-managed irrigation schemes. In hilly areas of Uttar Pradesh, Pande (1991) reported on the comparison made between government and farmer-managed irrigation schemes using indicators such as productivity, cost to the government, farmer-management efficiency, and timeliness to irrigation water supplies. He also considered access to loan and subsidy, cost effectiveness to maintenance, and sustainability.

He reported that a farmer-managed irrigation system under a contract of constructing the system and supplying irrigation water performed better in terms of high productivity and high percentage of irrigated area than a government-managed irrigation system. The farmer-managed scheme for example developed 4000 schemes while the government-managed scheme developed only a handful number of schemes.

In Philippines, Lauraya et. al. (1991), reported on a farmer-managed irrigation systems where the systems are jointly developed by irrigation associations and the National irrigation administration and later handed over to farmers. However, the farmers association was limited to dealing with water distribution activities alone. Now, however, the Philippines National irrigation association is extending responsibilities to farmers association to deal with other services such as providing credit, agricultural inputs and market. In Japan and Taiwan, irrigation management is the responsibility of water users themselves with only a limited role played by the government (Nagata, 1994).

In the process of transferring irrigation management from the government to farmers, the government has to intervene to help farmers conduct irrigation activities in a better

way. Martin et al., (1986) pointed out the need to have basic information before any intervention is undertaken to help farmers. He emphasized on the need to know: how farmers manage their systems; and in what ways they could be helped from outside. He described the above mentioned aspects in the context of activities directly associated with water distribution and organisation of people who manage the irrigation system. He emphasized on the need to evaluate water flow parameters such as efficiency, adequacy, equity, and dependability.

### **2.3 Indicators of Irrigation Scheme Performance**

To know the performance of irrigation schemes, schemes are normally evaluated using the following indicators (Jensen, 1983; Manor and Chambouleyron, 1993);

- (1) irrigation efficiencies;
- (2) water delivery performance;
- (3) soil moisture status;
- (4) organisational form and;
- (5) productivity and economic performance.

#### **2.3.1 Irrigation efficiencies**

The purpose of irrigation is to replenish the available moisture in the root zone depleted by evapotranspiration.

However, in the irrigation process, water losses occur at different levels in an irrigation system (FAO, 1971). Water losses are normally expressed as irrigation efficiencies. These include: conveyance, distribution and application efficiencies.

### Conveyance efficiency

Conveyance efficiency ( $E_c$ ) is the efficiency of water conveyance in the main canal system from the scheme head works to the main canal outlet (secondary canals inlet). It is normally calculated as the ratio of water received at the block inlet to the water delivered at the head works (intake) as in equation (1). It is normally affected by the: canal length, porosity of the canal bed, lined or unlined canal, soil type and rate of evaporation. Conveyance efficiencies in ratio form, in unlined canals range from 1 to 0.7 for areas with effective management and 0.7 to 0 for areas with ineffective management. The conveyance efficiency is normally calculated as:

$$E_c = \frac{(\sum Q_i)}{Q} \quad (1)$$

Where:

$Q_i$  = Discharge in  $i^{\text{th}}$  secondary canal inlet (main canal

offtake)

Q = Discharge in main canal intake

### Distribution efficiency

The field canal distribution efficiency ( $E_d$ ) is the efficiency of water conveyance in the canals within a sector, block or sub-unit. The unit may be the tertiary unit or the quaternary or even the sub-quaternary unit. It is expressed as the ratio of water received at the field inlet to water received at the block inlet and is calculated using the following equation.

$$E_d = \frac{\sum (Q_{outflow})}{\sum (Q_{inflow})} \quad (2)$$

where:

( $Q_{inflow}$ ) = discharge entering the distribution canal

( $Q_{outflow}$ ) = discharge leaving the distribution canal.

According to Abdulmumin et al. (1990), distribution efficiency is classified as adequate if it lies within the range of 1.0 to 0.65, sufficient in the range of 0.65 to 0.55, insufficient in the range of 0.55 to 0.40, and poor below 0.4.

### Application efficiency

Application efficiency ( $A_p$ ) is defined as the ratio of

water required in the field to the water applied in the field. The acceptable application efficiency for basin and level borders range between 0.6 to 1 (FAO, 1971). In basin irrigation, application efficiency is expressed by James (1988) as follows;

$$Ea = \frac{(A*D*100)}{(Q*T)} \quad (3)$$

where:

- A = Area of the irrigated field
- D = Required depth to be applied
- Q = The water flow rate
- T = Total time to irrigate

#### Overall scheme efficiency

Overall scheme efficiency ( $E_p$ ) is expressed as the product of application efficiency, distribution efficiency, and conveyance efficiency. In surface irrigation systems, the overall irrigation efficiency should not be less than 0.45 (Abdulmumin et al., 1990).

#### 2.3.2 Water delivery performance

In the context of irrigation systems, the measure to analyze irrigation performance in terms of supplying water adequately, dependably, and equitably in an irrigation

system is very important (Oad and Sampath, 1991).. For proper monitoring, the amount of water applied into the field should be measured. Such practice will help in judging whether water is being matched with the predicted quantities or whether water is being distributed equally, adequately, and timely among different farmers in an irrigation system. Thampa and Banskota (1991) employed inter-quartile ratio (IQR) as the equity indicator. However, Abernethy (1991) reported that the IQR was not a sufficient indicator of water distribution in an irrigation canal system. The IQR assesses the mode of distribution of irrigation water between the upstream and the tail end irrigators. However, even the irrigators in the middle of an irrigation canal system are actually affected by the water distribution problem.

Oad and Sampath (1991) related the measurement of water distribution parameters of equity, adequacy, and dependability at any irrigation system delivery point using the mean square prediction error theory shown below. This method was observed to be useful in identifying sources and levels of low water management performance in an irrigation system. The mean square prediction error equation is expressed as;

$$\frac{\sum (Q_{r(x)} - Q_{a(x)})^2}{R} = (MQ_r - MQ_a)^2 + (SQ_r - SQ_a)^2 + 2(1-r)(SQ_r)(SQ_a) \dots \quad (4)$$

In the equation;  $MQ_r$  and  $MQ_a$  are arithmetic means of the required and the actual delivered quantity of water at any point (x) in an irrigation system.  $SQ_r$  and  $SQ_a$  are the standard deviations of  $Q_r$  and  $Q_a$ .

$Q_{r(x)}$  is the required quantity of water to be delivered at any point (x) in an irrigation system.  $Q_{a(x)}$  is the actual quantity of water delivered at any point (x) in an irrigation system.

$R$  is the number of points (x) where water is delivered in an irrigation system. 'r' is the correlation of  $Q_r$  and  $Q_a$  and is calculated as:

$$r = \frac{\sum \frac{(Q_r(x) - MQ_r)(Q_a(x) - MQ_a)}{R}}{(SQ_r)(SQ_a)}$$

The statistical mean and standard deviation are calculated following the standard procedures. The term  $(MQ_r - MQ_a)^2$  is an error in water adequacy and is denoted by (Aer). The second term  $(SQ_r - SQ_a)^2$  is the error due to unequal variation between the required and actual amount of water delivered in an irrigation system and is denoted by (Eer). It measures equity of water distribution in an irrigation system. The third term  $2(1-r)(SQ_r)(SQ_a)$  is the error due

to covariance between the actual and required amount of water and is denoted by  $(C_{er})$ . It is a measure of a canal physical condition and management capability to implement an irrigation schedule pattern. The total error is equal to the sum of  $A_{er}$ ,  $E_{er}$ , and  $C_{er}$ , and is equal to one. A zero error shows that the system has the highest order of performance.

### 2.3.3 Soil moisture status

Water being a scarce resource and very important to crop production should be well managed (FAO, 1971). For optimum paddy production, two soil moisture conditions are required. The first soil moisture condition is at the early stage (decades 1 to 4 before transplanting) and last stage (decades 10 to 12 after transplanting) where water ponding is not required. Here, a decade means a 10 days interval. The second soil moisture condition is at an intermediate stage (decades 1 to 9 after transplanting) where a controlled water ponding is required (Halcrow et al., 1993). According to Haque (1986), proper paddy management in Africa requires that water depth of 5 cm be maintained in the paddy field in decades 1 to 6 after transplanting (at tillering), 10 cm in decades 7 to 9 (at flowering). These moisture levels should be maintained. Halcrow et al. (1993) recommends the use of soil moisture balance equation

(see equation 5) to estimate daily soil moisture balance during the paddy nursery stage where water ponding is not required. The soil moisture balance equation can be written as follows;

$$S_e - S_b = d_n + P_e + U_f - ET_{crop} - D_r \quad (5)$$

Where:

- $S_e$  = water in the root zone at the end of the period considered.
- $S_b$  = water in the root zone in the field in mm at the beginning of the period being considered.
- $d_n$  = net irrigation in mm applied during the period being considered.
- $P_e$  = effective rainfall in mm taken as: 0 if  $P_e < 5\text{mm}$ .  
100% if  $P_e < 12.5\text{mm}$ , 80% if  $12.5 < P_e < 15\text{mm}$ .  
50% if  $P_e > 15\text{mm}$  (Thampa and Banskota, 1991).
- $U_f$  = upward flow of water into the root zone from shallow water table in mm.
- $D_r$  = water due to deep percolation in mm.
- $ET_{crop}$  = Evapotranspiration in mm.

Earlier investigations at the Kapunga irrigation project show that:  $U_f = 0$ ,  $D_r$  was low (1 mm/day) (Halcrow et al., 1993). Several models including those of Blaney - Criddle; Jensen - Haise; Pan evaporation and the modified Penman model are available for the prediction of  $ET_o$  which is related to  $ET_{crop}$ . However, the modified Penman model is widely used due to its relative better accuracy (Jensen,

1983). The modified Penman model is represented as:

$$ET_o = C[(W * R_n) + (1 - W) * f(u) (e_a - e_d)] \quad (5.1)$$

where:

$ET_o$  = reference crop evapotranspiration in mm/day.

$W$  = temperature-related weighing factor.

$R_n$  = net radiation in equivalent evaporation in mm/day.

$f(u)$  = wind-related function.

$(e_a - e_d)$  = difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air.

$c$  = adjustment factor to compensate for the effect of day and night.  $ET_{crop}$  is expressed as:

$ET_{crop} = k_c * ET_o$  Where:  $k_c$  = daily crop coefficient varying between 1.1 to 0.95 for rice (Halcrow et al., 1993). For optimum crop production, the soil water balance should not fall below the allowable soil moisture deficit given by:

$$Ad = Rd * MAD * Hc \quad (6)$$

Where:

$Ad$  = allowable soil moisture deficit in mm

$Rd$  = depth of root (estimated from root growth model (Hansen et al., 1979))

$MAD$  = management deficit taken as 0.5

$Hc$  = available water holding capacity of the soil (field capacity moisture content - permanently)

wilting point soil moisture content)

#### 2.3.4 Organisational form.

Organisation of any irrigation system is an important factor that determines its performance. Here, organisation may be defined as the design of any kind of social arrangements between individuals - regardless of whether they are farmers or government officials - to achieve a goal or a set of goals (Sagardoy, 1986). Any organisation has a form or structure. Whatever the form, it must be developed so that each individual has a clear description of the authority, responsibility, and accountability necessary for the intended work to proceed (Kerziner, 1992). According to Manor and Chambouleyron (1993), a well organised irrigation project maintains a good linkage between the top and the bottom management; it carries out operation and maintenance of activities effectively; it ensures that irrigation rules are complied with and that conflicts among farmers are well managed. Questionnaires can be used to assess effectiveness of any irrigation schemes performance.

According to Sagardoy (1986), the qualities of a well organised project include: water distribution activities, system maintenance, collection of water charges or similar

charges, assistance and extension to farmers. Other services would include: finance, agricultural and basic infrastructure. Furthermore, Ostrom and Benjamin (1991) described a theoretical framework that consists of predictors of a well functioning irrigation project. These would be the presence of: clearly defined irrigation project boundaries, fair proportion between the benefits received and the contributions made by each irrigator member, collective decision making arrangements; accountable monitoring, gradual sanctions against rule violations, governmental recognition of farmers to organize and address different functions.

Abernethy (1991) reports that in irrigation schemes where rehabilitations were performed by the government, farmers ability to manage the schemes were reduced, thereby creating dependence on the implementing agency. Organisations which were started by the government were weak especially where they were not properly nurtured towards independence. Other experiences in Ecuador, where indigenous farmers organisations were common, show that water management obeys social rules that do not fit with the actual situation, and that, in many cases prevent any evolution of productive systems (Abenerthy, 1991).

### 2.3.5 Productivity and economic performance

#### Productivity performance

Productivity is normally measured as a rate of production per unit area or per unit volume of water used. The normal rate for the Kilombero rice variety which is grown at Kapunga irrigation project is 5 ton/ha (Halcrow, 1993), while in terms of water used, the acceptable limits ranges from 0.7 to 1.1 kg/m<sup>3</sup> of water (Doorenbos et al., 1986).

#### Economic performance

Economic performance of a scheme refers to whether the scheme renders benefits to a society or a nation as a whole. It is normally expressed in terms of the internal rate of return (IRR) and benefit cost/ratio (B/C). Internal rate of return is defined as the value of discount rate ( $i$ ) that makes the net present value equal to the initial investment cost of the project. The rate should be greater than the opportunity cost of capital. Algebraically, the United Nations Industrial Organisation (1972) defines IRR as the value of  $i$  for which:

$$\sum_{t=0}^{\infty} \frac{B_t}{(1+i)^t} = 0 \quad (11)$$

where:  $B_t$  = Benefit at year t.  
1 is the discount factor at year t which when  $(1 + i)^t$  multiplied by  $B_t$  gives the NPV of the project at year t. The value of IRR ( $i$ ) can be obtained by plotting a graph of net present value (NPV) against discount rates ( $i$ ). Interpolation on such a graph gives the value of IRR or ( $i$ ) as:

$$IRR = A + B \frac{C}{C + E}$$

Where: A = Lower discounting rate  
 B = Difference between the lower and the higher discounting rates  
 C = NPV (Net present value) of the lower discounting rate  
 E = NPV at the higher discount rate.

Note: in summing up C, E negative signs are ignored.

Benefit/Cost ratio is calculated as:

$$\frac{B}{C} = \frac{\sum_{t=0}^t \frac{B_t}{(1+i)^t}}{\sum_{t=0}^t \frac{C_t}{(1+i)^t}}$$

Where:

$B_t$  = The net benefit at year t. It is obtained by subtracting costs from gross sales and then multiplied by an appropriate discounting factor for a given year t.

$C_t$  = Cost at year  $t$ . For a profitable scheme, benefit/cost ratio should be greater than one. If a project is to be sustained, it has to be both financially and economically viable. The flow of resources must be such that benefits exceed costs. Economic viability refers to the benefits the project renders to the government or a society while financial viability refers to whether the project is profitable to the farmer as an individual. FAO (1985) distinguishes between financial and economic profitability. In financial analysis, taxes are considered as costs while grants and subsidies are considered as incomes and market prices are adopted. However, in economic analysis, taxes are considered as transfers and not as costs or income. Subsidies are considered as costs to the society or government and shadow prices are adopted in the analysis. Herrera et al. (1991) assessed the profitability of two Argentinean farmers association using benefit cost ratio and internal rate of return. He found that the association which had an unequitable land ownership had higher benefit/cost ratio. He also found that poor management skills worsened the economic situation of the individual farmer and the association.

**CHAPTER III****MATERIALS AND METHODS****3.1 Introduction**

This chapter presents materials and methods used to obtain results of the study. It contains the background to the area of study and instrumentation used to measure/estimate applicable parameters.

**3.2 Background to Area of Study**

The Kapunga irrigation project consists of the Kapunga smallholder (farmer-managed) rice irrigation scheme of 789 ha and the Kapunga NAFCO (National Agriculture Food Corporation) of 3015 ha rice irrigation scheme (Fig.3.1). The smallholder farmers come from nine villages namely: Igumbilo, Chimala, Mwanima, Matebete, Muwala, Isitu, Mbalino, Ihai, and Itamboleo.

This irrigation project was designed to contribute in raising national economy and food production for farmers. Infrastructures such as: canals and hydraulic structures, canal intake, drainage canals, buildings, rice mill complex, roads, portable water supply, were constructed by the government of Tanzania. Other provisions included

agricultural machinery, transport facilities and support staff.

### 3.2.1 Location

Kapunga rice project is located between  $8^{\circ} 30'$  and  $9^{\circ} 00'$  latitude south and between  $34^{\circ} 00'$  and  $34^{\circ} 30'$  longitude east, north of Chimala town in Mbeya region at the altitude of 1035 m above mean sea level. The project lies between Chimala river and the Great Ruaha river in the Usangu plains (Fig. 3.1)

### 3.2.2 Project layout

Irrigation water for the project is diverted from the great Ruaha river through a main canal intake structure. Irrigation water is then conveyed through an earthen main canal which feeds secondary canal no. 1, no. 2, for the government-managed scheme and number 3 for the farmer - managed scheme. The government-managed scheme is divided into a series of 6 ha fields. Each of the 6 ha field is irrigated by a field canal which takes off from the secondary canal no. 1 or no. 2.

### 3.2.3 Field operations

The Kapunga government-managed scheme is fully mechanized from land preparation to grain storage, while the farmer-managed scheme's operations are carried out by human labour. Cultivation in the farmer-managed scheme is by hired tractors from the Kapunga GMIS and animal power from individual smallholder farmers.

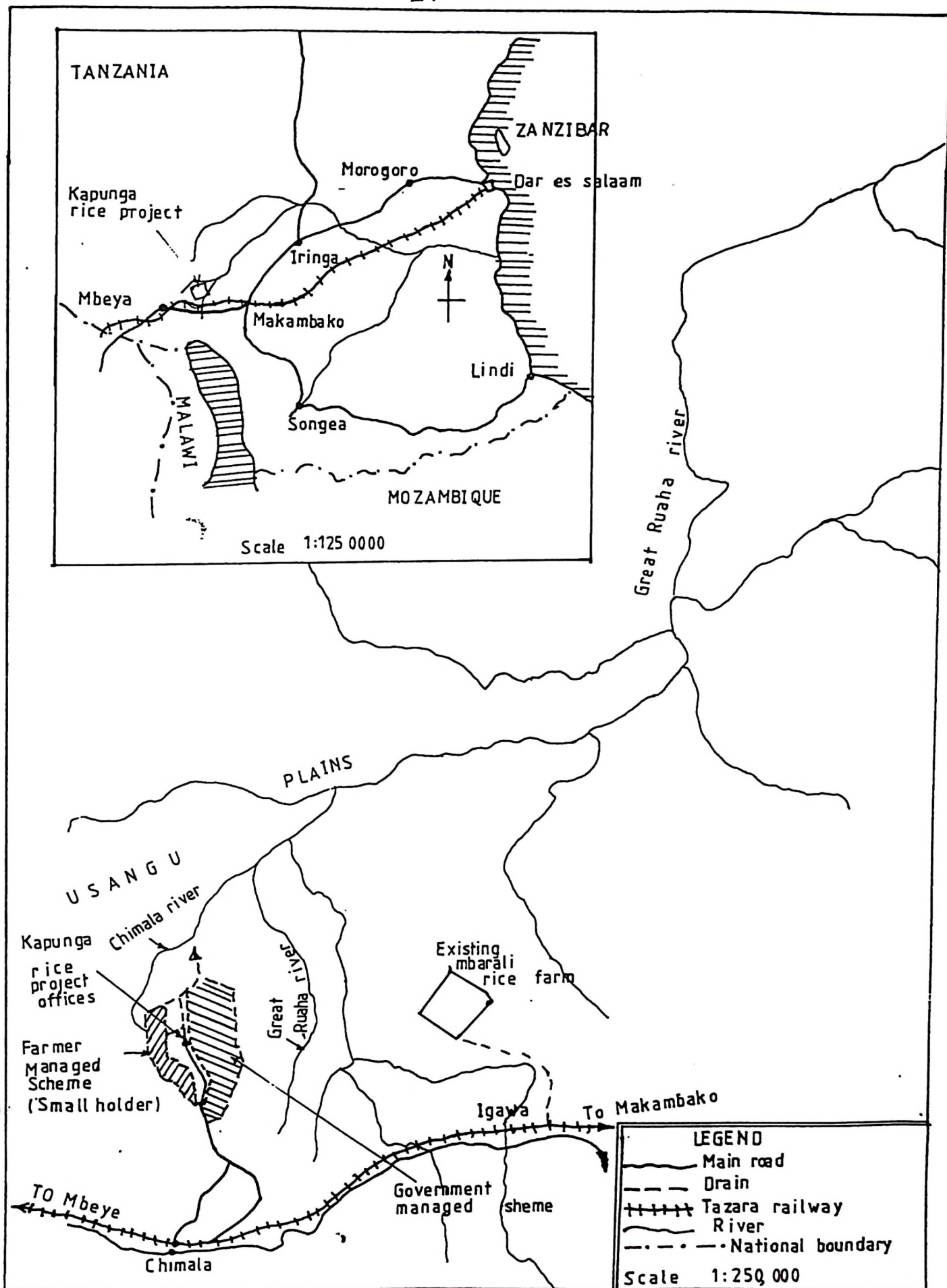


Fig. 3-1 Location map of Kapunga irrigation projection  
 ( Source: NAFCO Kapunga)

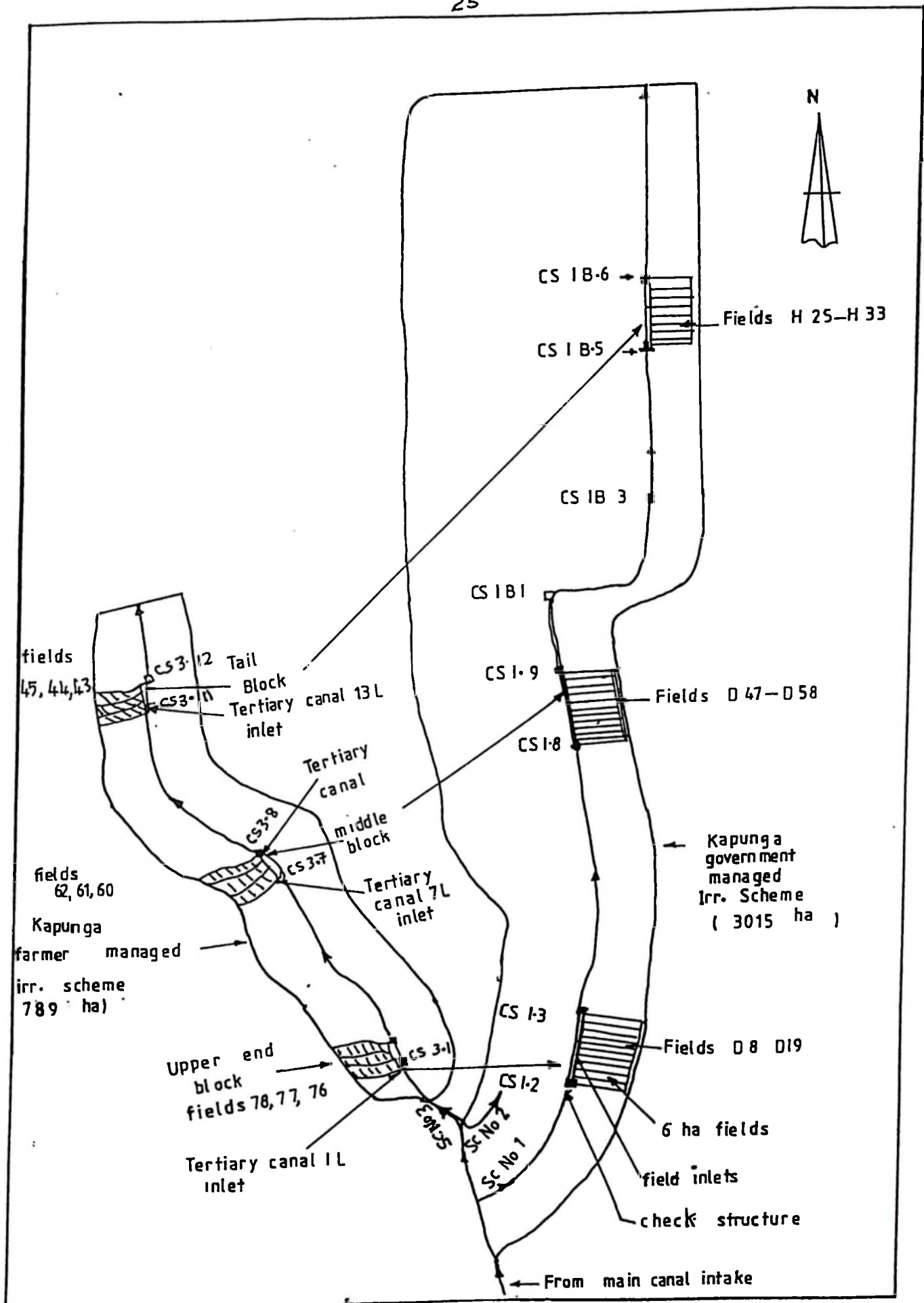


Fig-3-2 Kapunga irrigation project layout )

Source: ( Kapunga Irr. project )

### 3.2.4 Climate

Fig. 3.3 shows an average annual evapotranspiration with 80% probability rainfall at Kapunga irrigation project. The average annual temperature is 21 °C with a minimum of 14.53 °C in July and a maximum of 24.43 °C in November. Mean annual relative humidity is 65.7 percent. It ranges between 79.0 percent in February and 46.4 percent in December. There are 88.3 hours of sunshine a year.

Mean annual rainfall is 430.3 mm; the highest rainfall is in February with 198.76 mm and the lowest in October with 0.4 mm.

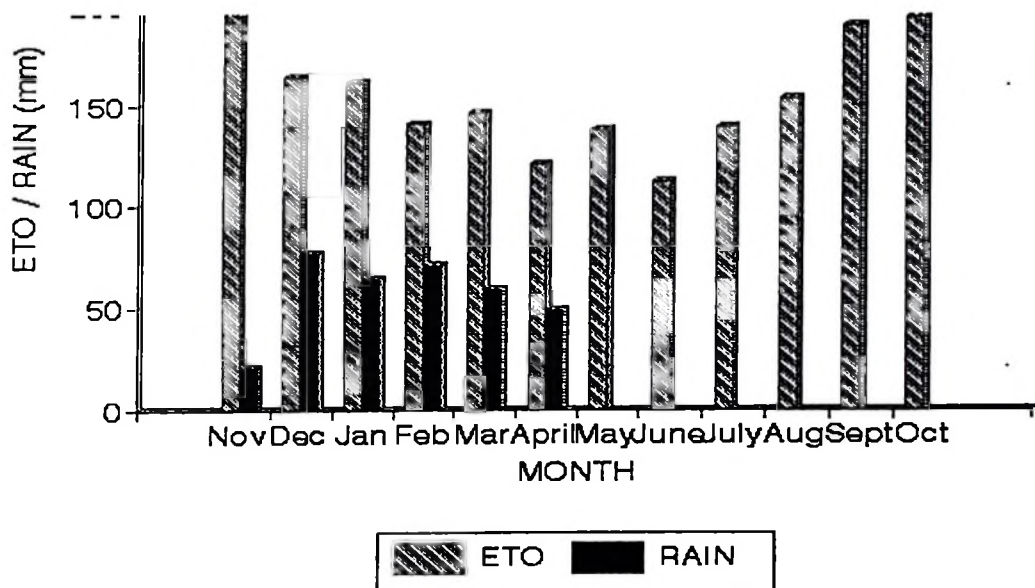


Fig. 3.3 Annual 80% probability rainfall / evapotranspiration

### 3.2.5 Land form and geology

The project area is part of the flood plains which is fed by rivers from the Poroto mountains. The head waters have their source at an altitude of 1 800 - 2 000 meters above mean sea level. The plain clays mainly overlie the pre-cambrian rock material. Coarse textured material have been formed on the steeper pediments and colluvial fans where rivers flow fast.

### 3.2.6 Soils

Soil texture ranges from medium to heavy. The clays are mainly derived from shale. The medium soil is mainly alluvial having been formed by periodic floods. Most project area has pH ranging from 6.5 to 7.5. The organic matter content is in the range of 0.5 to 4%, Nitrogen (N) ranges between 0.05 % to 0.4%, Phosphorus (P) in form of ( $P_2O_5$ ) ranges from 7 to 30 ppm and Potassium (K) varies from 2.06 to 1.05 me/100g. They may thus be considered as soils of medium fertility.

Land suitability survey by Agrar und Hydrotechnic GmbH Consulting Engineers (1979) over the Kapunga rice project area show that: paddy production is suitable over 5 982 ha (53%), it is moderately suitable over 4 474 ha (40%),

it is moderate to marginally suitable over 600 ha ( 5%) while it is not suitable over 275 ha ( 2%).

### 3.2.7 Topography

The area is flat being part of the Usangu plains. It lies immediately north of the Poroto mountains, between the Chimala river and the Great Ruaha river at an altitude of 1035 meters above mean sea level. It is a part of the Great Ruaha flood plains with a general slope of 2/1000 bounded by the Kawetire mountain ranges to the west and the Ruaha national park to the north east.

### 3.3 Instrumentation for Field Measurements.

The following facilities which exist at the Kapunga irrigation project (Fig. 3.2) were used in the data collection. (1) A calibrated flume at the main canal intake, (2) three constant head orifices at the secondary canal no. 1, no. 2, and no. 3 intake (main canal oftakes), (3) check structures (cs): 1.2, 1.3, 1.8, 1.9, 1B.5, 1B.6, 3.1, 3.2, 3.7, 3.8, 3.11, 3.12;, and (4) field canal inlets for fields no: D8-D19, D47-D58, H25-H33, 76-78, 60-62, 43-45. These facilities were used to measure water flow rates. Other facilities included: six cylindrical cores, mallet, a piece of timber, knife and a spade.

These facilities were used to take soil samples for the soil bulk density and soil water holding capacity determination. Twenty eight small holder farmers; two watermen, an extension staff for small holder farmers (from the government-managed scheme) and two functional managers (production and field engineering) were also involved in providing answers to the interview (Table 4.10).

### 3.3.1 Sample fields.

Sample fields D8-D19, D47-D58, H25-H33, Tertiary (fields): 1L (76-78), 7L (60-62), 13L (43-45) were randomly selected in the upper, middle, and tail end regions of the farmer and government-managed irrigation schemes (Fig. 3.2) for the measurement of: the amount of water applied in the field, or water depth, crop yield, estimation of field moisture and interview to farmers.

In order to compare the statistical data between the FMIS (first sample) and GMIS (second sample) in which sample data were less than 30 and the standard deviations were unknown; a T-test was applied. The t-test equation is given by:

$$T = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 + n_2 - 2)} \frac{n_1 + n_2}{n_1 * n_2}}}$$

where:  $S^2_1$  and  $S^2_2$  are the estimated variances of the first and the second samples respectively.  $n_1$  and  $n_2$  are sample populations for the first and second samples, respectively.  $X_1$  and  $X_2$  bar are the estimated averages for the first and second samples, respectively.  $\mu_1$  and  $\mu_2$  are the true mean of the populations for the first and the second samples, respectively. The term  $(n_1 + n_2 - 2)$  represents the degree of freedom.

### **3.3.2 Water flow measurements**

#### **Conveyance efficiency**

The amount of water discharged at the main canal intake was recorded from the flume installed on the canal. The amount of water discharged at the distribution (main canal offtake) on the secondary canal no. 1, 2, and 3 inlets were recorded from the meter gauges installed on the structures. These meter readings were converted to the equivalent water discharge rates using rating Tables (Appendix 3.1).

#### **Distribution efficiency**

Canal discharges were measured between: check structures no. 1.2 and 1.3, 1.7 and 1.8, 1B.5 and 1B.6 for the

secondary canal no. 1. On the secondary canal no. 3, the rate of water discharges was measured between: check structures number 3.1 and 3.2, check structures number 3.8 and number 3.6, and between check structure number 3.10 and number 3.11. Canal offtake discharges along the two corresponding checks were also measured. Distribution efficiencies for secondary canal no. 1 and 3 were determined using equation (2).

#### Application efficiency

The areas of the sample fields D8-19, D47-58 and H25-33 for the government-managed irrigation scheme and fields number: 78,77,76 of the upper block; 62,61, 60 of the middle block and 45, 44, 43 of the tail block for the farmer-managed scheme, were noted down from canal layout maps (Halcrow, 1993). The time of irrigation was recorded from the beginning to the end of irrigation for every irrigation event. The water flow rates through secondary canal no. 1 and no. 3 offtakes were observed on the calibrated offtakes. The corresponding actual flow rates were obtained from corresponding rating Table (Appendix 3.1). To determine the value of water depth that had to be applied at every event, data on mean monthly evapotranspiration, effective rainfall ( $P_e$ ), crop coefficient ( $K_c$ ), and basic irrigation requirements of flooding for rice (BR) which

were used during the project design (Halcrow et al., 1993) were used as shown in Appendix 3.2 to derive the depth (D) of irrigation in every decade. The application efficiency was calculated using equation (3).

#### **Overall scheme efficiency**

The overall scheme efficiency ( $E_p$ ) was calculated as the product of conveyance efficiency, distribution efficiency, and application efficiency.

#### **Water delivery performance**

To assess water delivery performance of the two schemes, the total quantity of water delivered in the sample fields in the Government managed-scheme was collected as explained under the application efficiency section above. For the farmer-managed scheme, water delivery into the sample plots was recorded daily at 1000 hours and at 1700 hours on the tertiary canals numbers 1L, 7L, 13L on secondary canal number 3. These data were collected from land preparation to 20 days before harvest (140 days).

#### **3.3.3 Soil moisture status**

To assess soil moisture levels in paddy nurseries at the

early stage (decades 1 to 4), a representative nursery from each of the fields: D-15 in the upper block, D-52 in the middle block, H-28 in the tail block, in the government-managed scheme and from plots 77-6 in the upper block, 61-4 in the middle block, and 44-5 in the tail block in the farmer-managed scheme was selected for nursery moisture measurements. Two representative soil samples, one for bulk density and the other for soil water holding capacity were taken from these selected fields/plots before cultivation at a mean depth of 10 cm and were tested in the laboratory. The pressure plate test was used for soil water holding capacity determination. Equation (5) and (6) were used to assess the daily nurseries moisture levels.

From decades 1 to 9 after transplanting, water depth over the sample paddy fields were measured on daily basis at 1700 hours using a carpenters ruler. At the end of the cropping season, the average water depths that were maintained within the blocks in decades 1 to 6 and 7 to 9 after transplanting were calculated.

#### 3.3.4 Climatic data used

Daily rainfall, humidity, wind speed and radiation data were collected from the meteorological station located within the project area. These data were used in the Penman equation (5.1) to estimate the daily ETo which was in turn

used for estimating nursery soil moisture balance in Appendix 4.2 and 4.3.

### **3.3.5 Productivity and economic performance**

The 1994/95 season production of the sample plots in the government and farmer-managed scheme was weighed at 18% moisture content. Interviews were conducted to the 28 farmers to obtain their 1992-1994 average yield, benefits and costs per hectare. The government-managed scheme office was used to obtain the 1991 to 1995 yields.

A T-test was used to compare the mean production of the farmer and the government-managed irrigation scheme. The record of production of previous years (1991-1995), costs and benefits of both schemes were collected. Discounted costs and benefits were estimated to assess their economic and financial performance as explained in (section 2.3.5).

### **3.3.6 Organisation**

To assess organisational performance, a review on organisational structure as stipulated in Halcrow (1993) was made. Twenty eight smallholder farmers and the Kapunga irrigation project's functional managers were interviewed.

**CHAPTER IV****RESULTS AND DISCUSSION****4.1 Introduction**

This chapter presents and discusses the results of the study carried out to evaluate and compare the performance of a farmer-managed irrigation scheme and a government-managed irrigation scheme at Kapunga rice irrigation project. The results include: (i) water management aspects of the two schemes; (ii) productivity and economic performance of the two schemes; and (iii), organisational structure of the two schemes.

**4.2 Water Management****4.2.1 Irrigation efficiencies**

Results of irrigation efficiencies for both the farmer-managed and government-managed are given in Table 4.1. The conveyance efficiency of the main canal was found to be 85% for both managements. This is a good performance as it lies within the recommended range of between 80% and 90% (Abdulmumin et al., 1990).

Table 4.1 Irrigation efficiencies (%).

	Block	Farmer managed	Government managed	Required
Application Efficiency	Upper	85	38	63
	Middle	96	43	63
	Tail	91	46	63
	<b>Average</b>	<b>91</b>	<b>42</b>	<b>63</b>
Distribution Efficiency	Upper	80	81	80
	Middle	82	83	80
	Tail	78	79	80
	<b>Average</b>	<b>80</b>	<b>81</b>	<b>80</b>
Conveyance		85	85	90
Overall		61	29	45

Table 4.2 T-test results (irrigation efficiencies)

Degree of freedom $v = 4$		GMIS /	FMIS /	GMIS/
		FMIS	PLANNED	PLANNED
	Test statistic T	0.610	1.060	0.870
Distribution	Critical T at 5%			
efficiency	level of significance	2.777	2.777	2.777
	Critical T at 1%			
	level of significance	4.604	4.604	4.604
	Test statistic T	12.27	8.700	8.800
Application	Critical T at 5%			
Efficiency	level of significance	2.777	2.777	2.777
	Critical T at 1%			
	level of significance	4.604	4.604	4.604

#### 4.2.2 Distribution efficiency

Analysis to compare the distribution efficiency of the GMIS to that of the FMIS (Table 4.1) was made using a T-test. The distribution efficiency of the secondary canal number 1 for the GMIS and number 3 for the FMIS were not significantly different. This is shown by the result of a T-test of 0.61 against a critical T-test of 4.06 at 1% and 2.77 at 5% levels of significance (Table 4.2).

Comparison of the distribution efficiency of the GMIS and the planned distribution efficiency gave a T-test statistic of 0.87 against a critical T value of 4.604 at 1% and 2.77 at 5% levels of significance (Table 4.2), which means that the distribution efficiency of the GMIS was not significantly different from the planned distribution efficiency.

Analysis to compare the distribution efficiency of the FMIS and the planned distribution efficiency (Table 4.1) gave a T-test statistic of 1.06 against a critical T-test of 4.604 at 5% and 2.77 at 1% levels of significance. This shows that the distribution efficiency in the FMIS was not significantly different from the required/planned distribution efficiency.

#### 4.2.3 Application efficiency

Results of a T-test analysis to compare the application efficiency of the government-managed scheme to the planned (desired) value gave a T-test statistic of 8.8 against a critical t values of 4.604 at 1% and 2.776 at 5 % levels of significance, respectively. This shows that the application efficiency of the government-managed scheme differed significantly from planned value at both 1% and 5% levels of significance. The application efficiency in the GMIS was low due to excessive time of water application. According to the scheme design, irrigation water was to be applied in the field for an average of 24 hours for a single irrigation event. It was, however, observed that the time of irrigation ranged from 36 hours to 72 hours.

Application efficiency in the FMIS ranged between 85% and 96%, while the required (design) value was 63%. These results suggest that the application efficiency in the FMIS was different from the planned value. A T-test carried out to compare application efficiency of the FMIS against the planned application efficiency showed that the application efficiency of the FMIS was significantly different from the planned application efficiency. The T-test value was 8.7 against a critical T value of 4.604 at 1% level of

significance and 2.778 at 5% level of significance. Application efficiency in the FMIS was greater than the planned application efficiency.

The average application efficiency in the GMIS ranged between 38% and 48 % which seems to be different to those of the FMIS which ranged from 85% to 96%. Analysis to compare application efficiency between the FMIS and the GMIS showed a T-test statistic of 12.27 against a critical T value of 4.604 at 1% level of significance and 2.776 at 5% level of significance which means that application efficiency in the FMIS was significantly different from that of the GMIS at both 1% and 5% levels of significance. Application efficiency in the FMIS was higher than application efficiency in the GMIS.

#### 4.2.4 Soil moisture characteristic curve

The soil moisture characteristic data are presented in appendix 4.1. The soil water holding capacity of fields D15, D52, and H28, plots: 77-6, 61-4, 44-5, are given as Hc mm in Appendix 4.1. These data were obtained by subtracting the soil moisture content at permanent wilting point ( $pF = 4.2$ ) from the soil moisture content at field capacity ( $pF = 2$ ). The moisture characteristic curve is presented in Fig. 4.1.

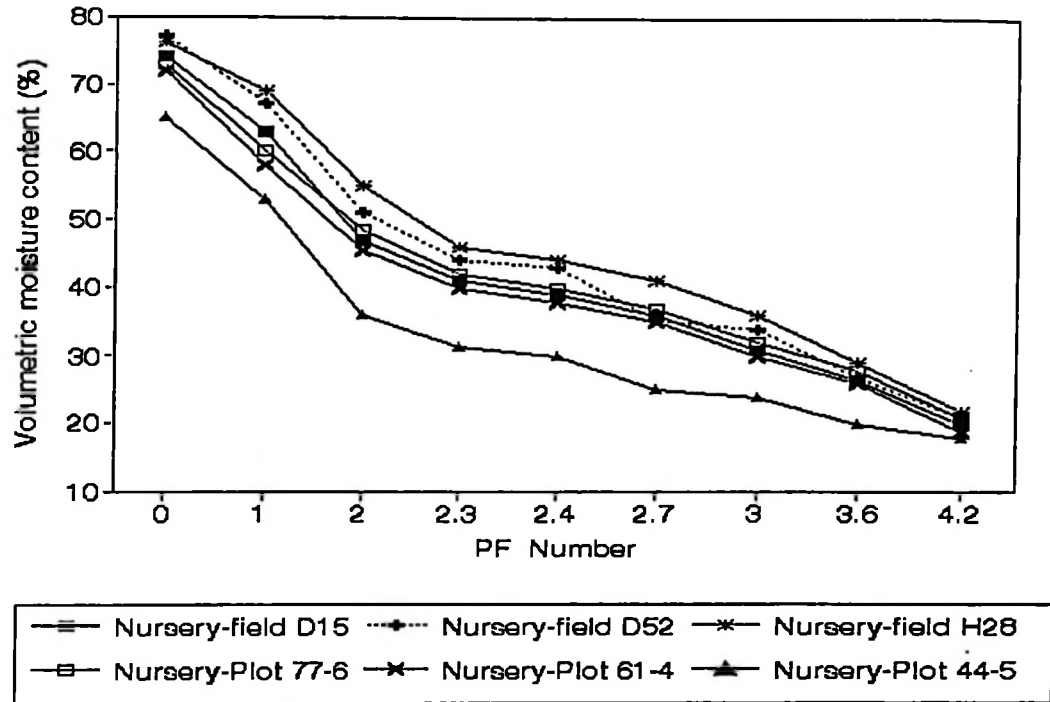


Fig. 4.1 Soil moisture characteristics curves

#### 4.2.5 Paddy nursery soil moisture.

Results of the estimated paddy nursery soil moisture are presented in Appendix 4.2 and 4.3. The analysis of these results are given in figures 4.2 - 4.7.

##### Farmer-managed irrigation scheme

In the farmer-managed scheme paddy nursery, plots: 77-6, 61-4, and 44-5, (Figs. 4.2- 4.4); there was no indication of nursery moisture stress except for three days between the 4<sup>th</sup> and 7<sup>th</sup> of December, 1994 in plot 77-6, where the estimated soil moisture (Se-Sb) falls below the estimated allowable (readily available) soil moisture deficit (Ad). On the 7<sup>th</sup> of December, 1994, for example, the nursery soil moisture was -31 mm while the allowable soil moisture on that day was -18 mm. In plot 61-4, (Fig. 4.3), the soil moisture fell below the allowable soil moisture between the 4<sup>th</sup> and the 7<sup>th</sup> of December, 1994. The soil moisture was -31 mm while the allowable soil moisture was -18 mm. From the 7<sup>th</sup> of December, 1994 to 13<sup>th</sup> January, 1995, the nursery soil moisture was always above the allowable moisture, a condition which is desirable. In plot 44-5 (Fig. 4.4), the nursery soil moisture fell below the allowable moisture on three occasions which are; between the 3<sup>rd</sup> and the 7<sup>th</sup>, the 12<sup>th</sup> and the 14<sup>th</sup> and between the 20<sup>th</sup>

and the 21<sup>st</sup> of December, 1994. On the 7<sup>th</sup> of December, 1994, the soil moisture was -31 mm while the allowable soil moisture was -13 mm. On the 14<sup>th</sup> December, 1994, the soil moisture was -40 mm while the allowable soil moisture was -32 mm. On the 22<sup>nd</sup> December, 1994 the nursery soil moisture was -46 mm while the allowable soil moisture was -35mm. Water was being allocated in the secondary canal no. 3 after 7 days (at every weekend). Therefore, farmers were irrigating at smaller interval. The estimated soil moisture in paddy nurseries showed no water stress to the paddy nurseries (Appendix 4.3 and Fig. 4.1-4.4). The estimated soil moisture balance (Se-Sb) was always more than the readily available moisture (equal to Ad).

#### **Government-managed irrigation scheme**

Nursery fields D8-D19, D47-D58, H25-H33 in the government-managed scheme (Fig. 4.5- 4.7) were stressed beyond the allowable moisture deficit (Ad) before the next irrigation due to long intervals of irrigation of more than 10 days. On the 22<sup>nd</sup> November, 1994, the paddy nursery in plot D15 (Fig. 4.5) in the upper block D8-D19 for example, had an estimated soil moisture of -97 mm against an estimated limiting readily available soil moisture of -34 mm. On the 14<sup>th</sup> December, 1994, the estimated soil moisture was -130 against the estimated readily available soil moisture

of -91 mm. The same result is indicated in the paddy nursery in field number D52 in the middle block (D47-D58, Fig. 4.6) in which, within the 40 days of the nursery stage, only one irrigation was performed. The rest of moisture was supplied by rainfall. In this field, soil moisture level was always below the allowable moisture deficit. These long intervals of irrigation in the government-managed scheme was caused by improper field soil moisture monitoring.

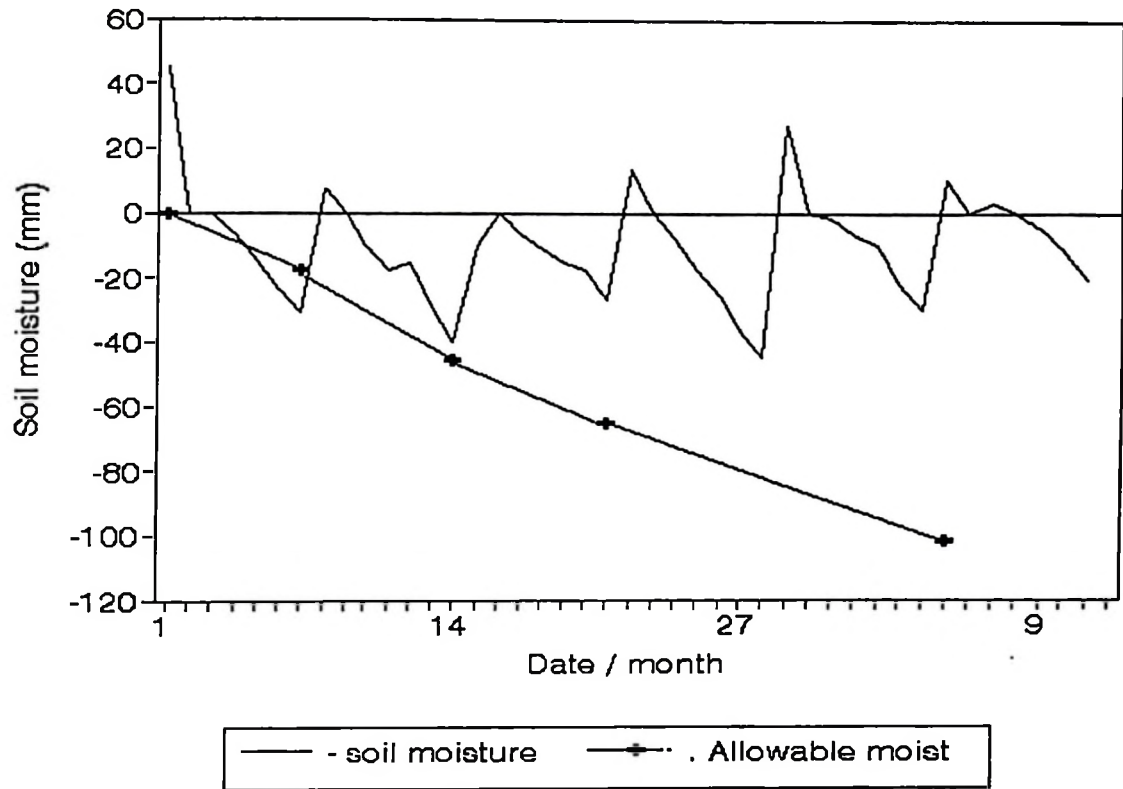


Fig. 4.2. Plot 77 - 6 Nursery soil moisture.  
1st December, 1994 - 11th January, 1995.

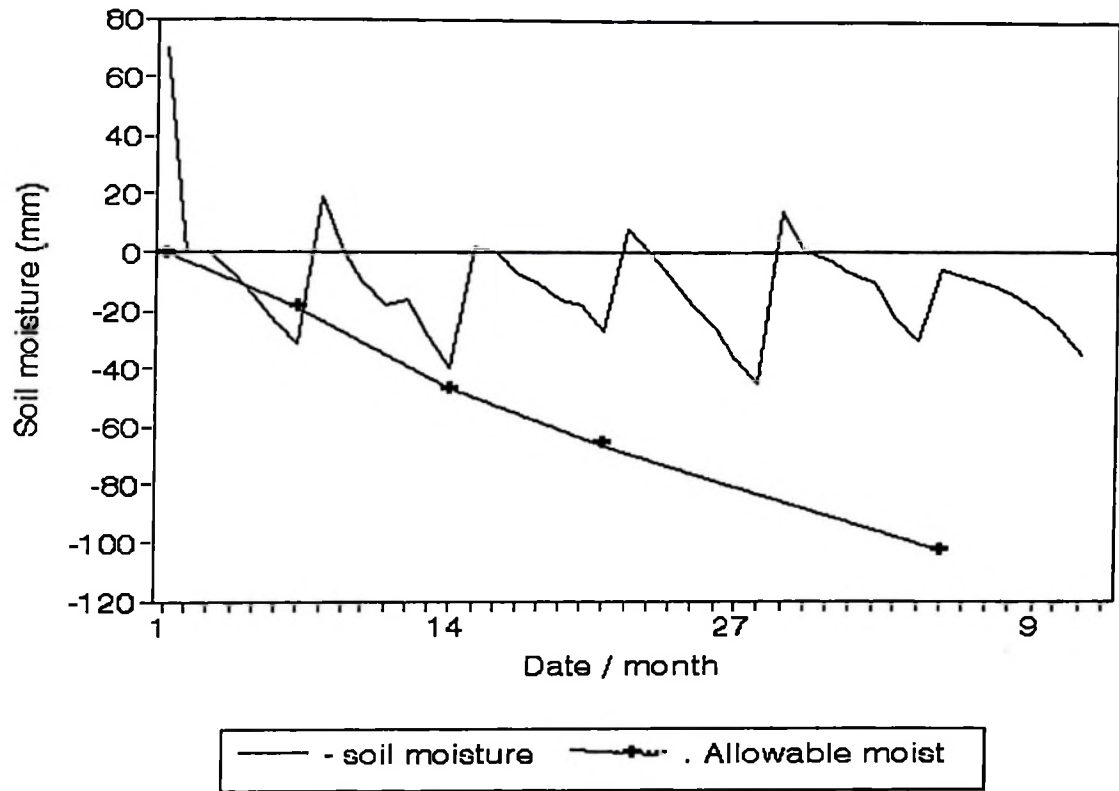


Fig. 4.3. Plot 61 - 4 Nursery soil moisture.  
1st December, 1994 - 11th January, 1995.

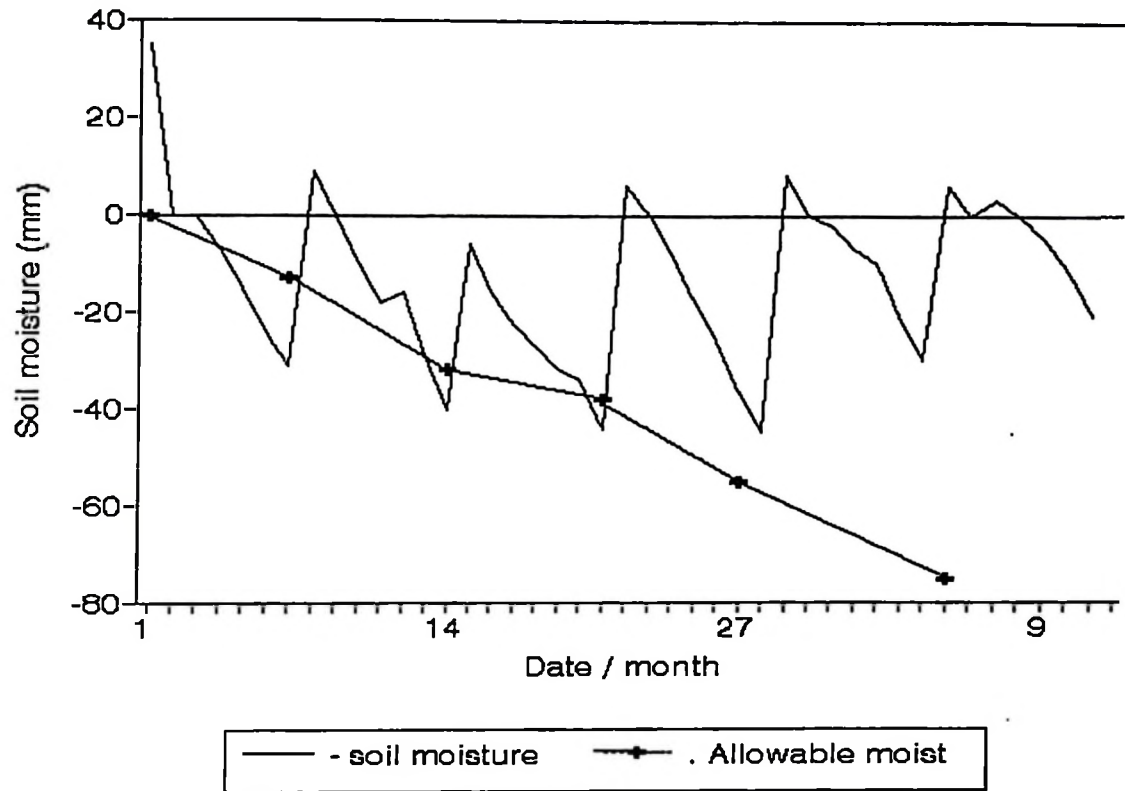


Fig. 4.4. Plot 44 - 5 Nursery soil moisture.  
1st December, 1994 - 11th January, 1995.

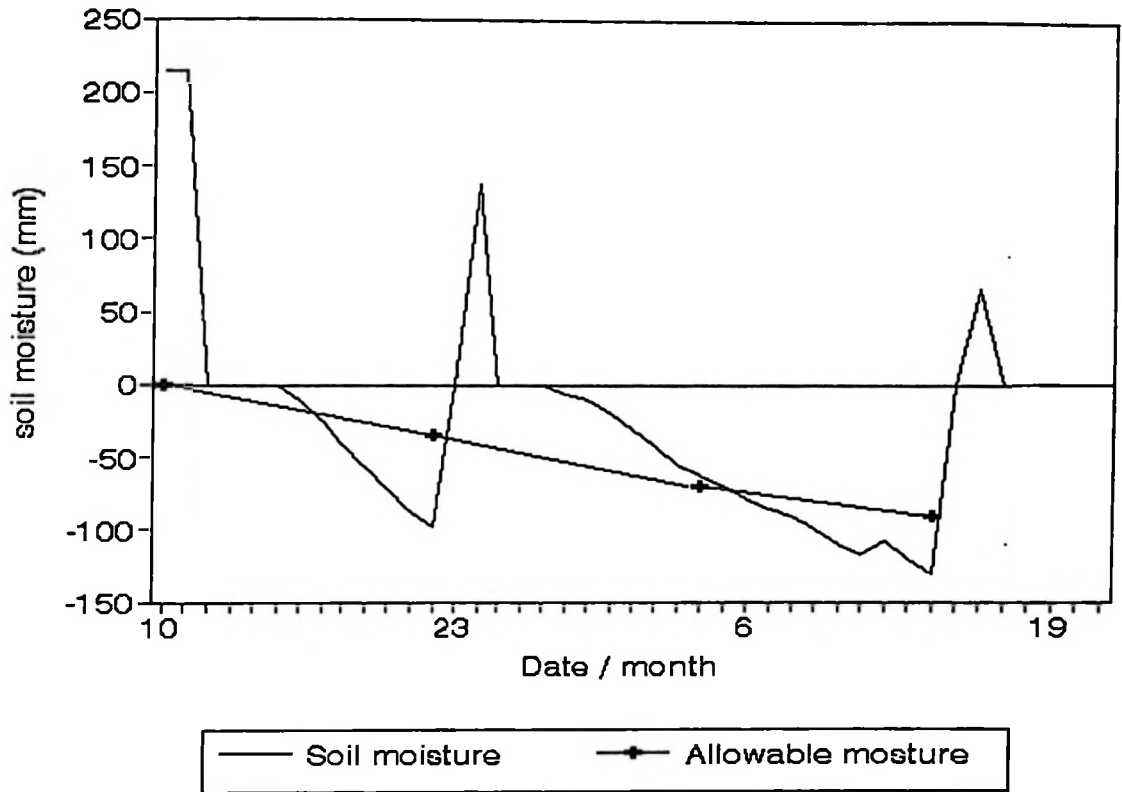


Fig. 4.5. Field D15 Nursery soil moisture.  
10th November, 1994 - 20th December, 1994.

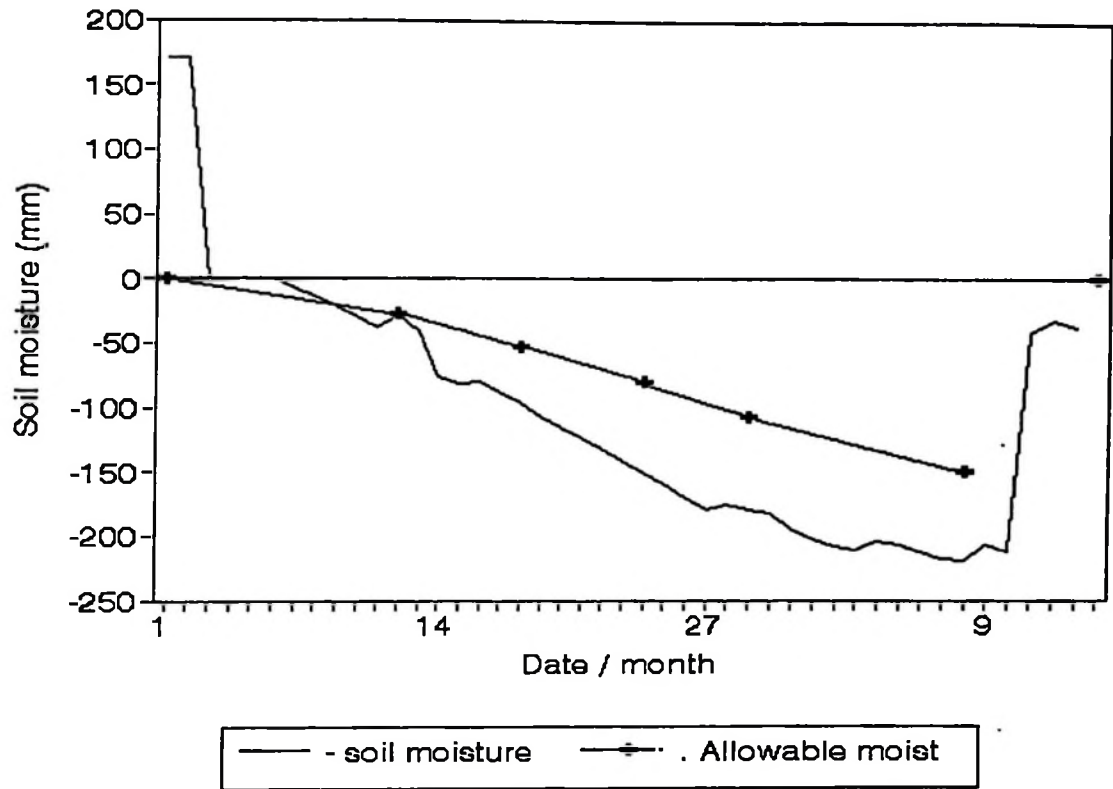


Fig. 4.6. Field D52 Nursery soil moisture.  
1st December, 1994 - 13th January, 1995.

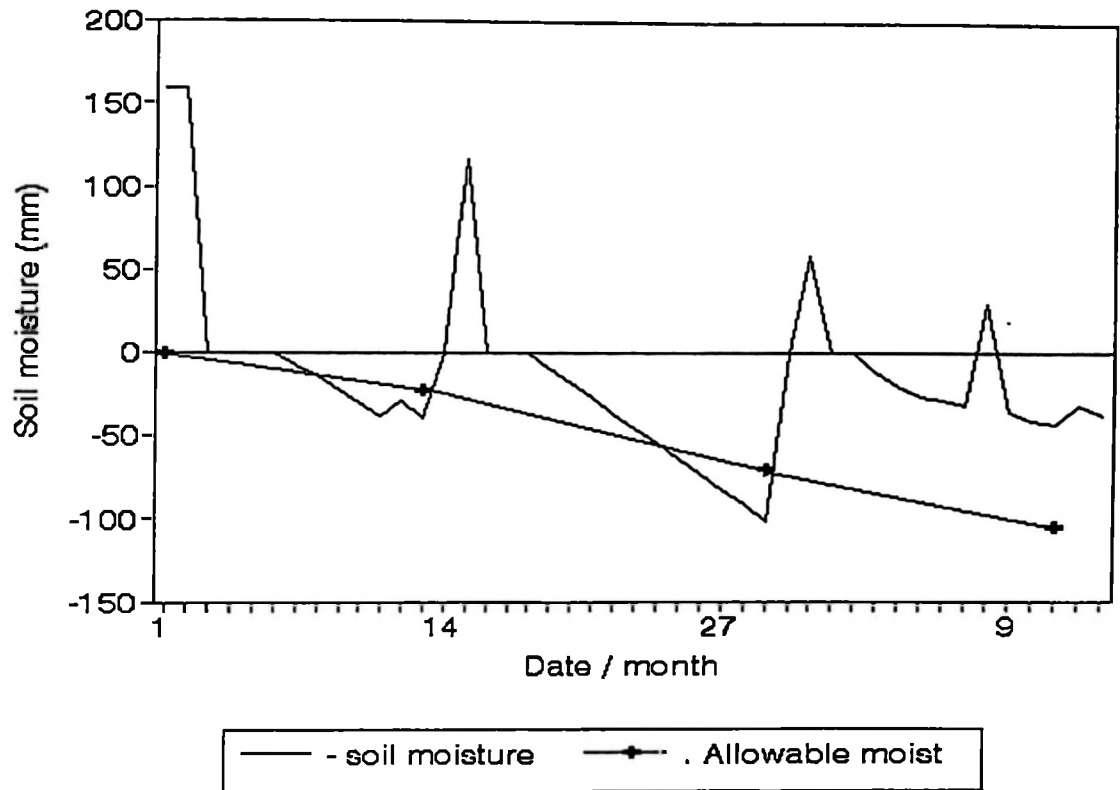


Fig. 4.7. Field H28 Nursery soil moisture.  
1st December, 1994 - 15th Jan.1995.

#### 4.2.6 Water delivery performance.

Analysis of the water delivery performance (Table 4.3) by the Mean square prediction error theory (Oad and Sampath, 1991) is presented in Table 4.4. These results show that both the FMIS and GMIS were not applying water in the fields according to the planned quantities. This is shown by a big water adequacy error of 98% and 86% for the farmer and the government-managed schemes, respectively. The amount of water applied in the FMIS was generally less than the planned quantities. While the GMIS applied much more water than the planned quantities. This is also shown by the low average application efficiencies which amounted to 42% against the planned value of 63% (Table 4.1) in the GMIS, while, in the FMIS, the average application efficiency was high, amounting to 91%. The inadequacy of water in the farmer-managed scheme was due to (i) improper water control at the secondary canal no. 3 offtake, and (ii) farmers were not following rotation rules at the level of the tertiary block.

Both the FMIS and the GMIS had a low error of equity of water distribution of 2% and 11% respectively. The indicated low error of equity showed that water was distributed more or less uniformly in the canal systems. This is due to the fact that the FMIS was designed to discharge water along its canal length automatically by

using fixed duck-bill check structures. The FMIS had the least equity error (Eer) of 2% meaning that water was more uniformly distributed in the FMIS than in the GMIS.

Table 4.3 Seasonal planned and actual quantity of water delivered in the sample blocks.

Name of scheme	Block	Quantity of irrigation water required (mm) at 63% AP <sup>1</sup>	Quantity of irrigation water applied (mm)
Government-managed scheme	Upper (D8-D19)	1360	2250
	Middle (D47-D58)	1240	1800
	Tail (H25-H33)	1240	1700
Farmer-managed scheme	Upper (Fields: 78, 77, 76 )	1240	916
	Middle (Fields: 62, 61, 60)	1240	812
	Tail (Fields: 45, 44, 43)	1240	857

<sup>1</sup> Application efficiency.

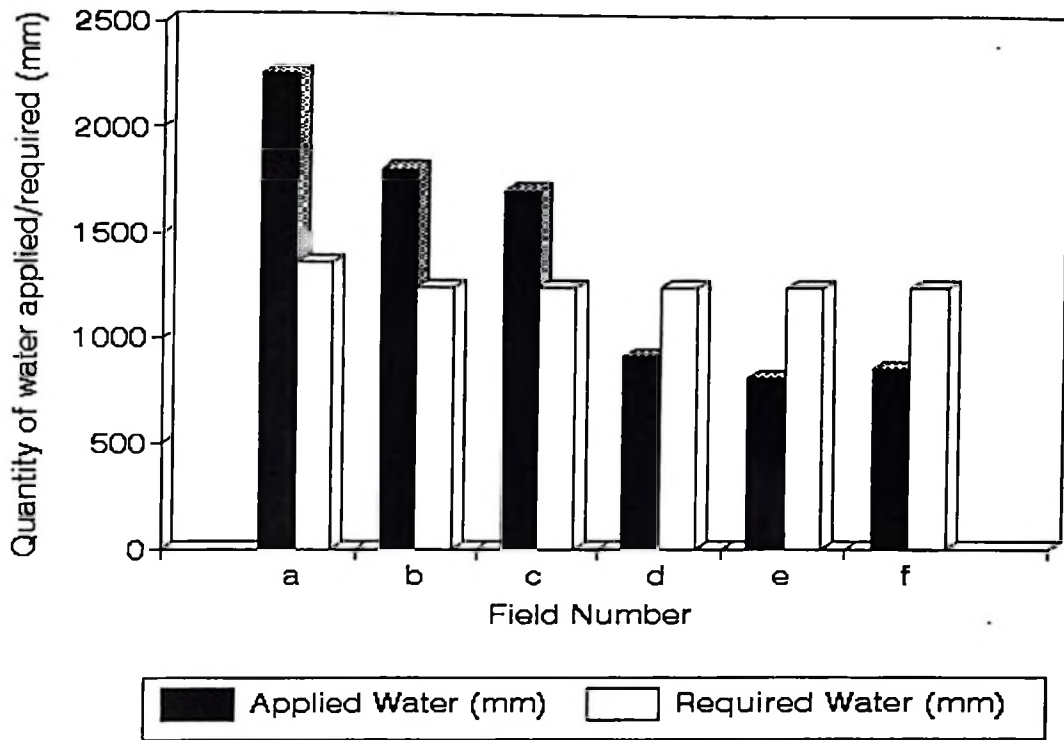


Fig. 4.8. Quantity of water applied/required (mm)/ha

Key: GMIS Fields: a = D8-D19; b = D47-D58; c = H28-H33  
 FMIS Fields: d = 78,77,76; e = 62,61,60; f = 45,44,43.

Table 4.4 Water delivery performance

Type of error	% Error in farmer farmer-managed	% Error in government -managed scheme
Adequacy error (Aer)	98%	86%
Equity error (Eer)	2%	11%
canal physical / management error (Cer)	0%	3%

On the other hand, the government-managed scheme had water men who were assigned to distribute irrigation water.

The management error (Table 4.4) between the actual and required amounts of water result is zero for both schemes. This means that the supply of irrigation water is highly reliable, being supplied according to schedule and that the secondary canals' physical condition is well. The high distribution efficiencies of secondary canals support this result.

#### 4.2.7 Water depth management

Analysis of the measured water depths against the required water depth (Table 4.5) generated a T-test statistic of 3.13 and 1.3 (Table 4.6) for the farmer and the government-managed schemes, respectively, against a critical T value of 3.169 and 2.228 at 1% and 5% levels of significance, respectively. This shows that there was no significant difference between the actual and the required water depths in the paddy fields from decades 1 to 9 after transplanting, for both the farmer and the government-managed schemes at 1% level of significance. There was a significant difference between the required water depth and the actual water depth in the FMIS at 5% level of significance, while, in the GMIS, there was no significant difference between the required and the actual water depth. Water depth in the GMIS was maintained at the recommended values more than in the FMIS because the GMIS had water men who were controlling water at the field inlets and fields outlets. These water men were opening the fields inlets at the time of irrigating, closing the inlets gates after irrigation and draining out water from the fields when field drainage was required.

Table 4.5 Water depth management

Decade after transpla- nting	Block	Required depth (cm)	Actual depth (cm)	
			FMIS	GMIS
1 to 6	Upper block (D8-D19)	5.0	5.6	3.0
	Middle block (D47-D58)	5.0	3.4	2.1
	Tail block (H25-H33)	5.0	3.8	2.9
7 to 9	Upper block (D8-D19)	10.0	4.6	9.2
	Middle block (D47-D58)	10.0	3.5	8.8
	Tail block (H25-H33)	10.0	3.5	10.8

Table 4.6 T-test results (Water depth management)

Degree of freedom $v = 10$		GMIS Against Required	FMIS Against Required
Decades 1 to 9	Test statistic T	1.300	3.130
	Critical T at 5% level of significance	2.228	2.228
	Critical T at 1% level of significance	3.169	3.169

### 4.3 Productivity and Economic Performance

Productivity of the government-managed scheme fell from 4.34 ton/ha in 1991 to 2.2 ton/ha in 1995 with the minimum of 1.85 ton/ha in 1993; while there was an increase in productivity for the farmer-managed scheme from 2.5 ton/ha in 1992 to 3.2 ton/ha in 1995 (Fig. 4.10). This continuous fall of productivity for the government-managed scheme impedes its sustainability.

Results of production from sample blocks of both the government and the farmer-managed schemes is presented in Table 4.7. The average yield from sample plots suggests that the mean production of the farmer-managed scheme (3.2 ton/ha; 0.35 kg/m<sup>3</sup> of water) is greater than that of the government-managed scheme (2.2 ton/ha; 0.1 kg/m<sup>3</sup> of water). The result of the T-test applied to compare the mean production rates of the two schemes had a T-test statistic of 7.19 against a critical T-value of 4.604 for yield/unit area and corresponding values of 38.5 against 4.604 for yield/unit of water which confirmed that the above mentioned mean yields are significantly different; with the farmer-managed schemes having better average yield than the government-managed scheme. However, this rate of production is still low compared to the 1991 mean yield of 4.34 ton/ha for the government-managed irrigation scheme, as well as the expected rate of paddy yield of 5

ton/ha. It was observed that farmers in plots 76-3, 17-1, 45-1, who correctly applied, fertilizer (100 kg urea 46% N/ha), water, and had timely planting and weeding, obtained a good yield of 4 ton/ha. Transplanting of seedlings is also a factor which contributed to increasing the rate of paddy yield in the FMIS than in the GMIS where direct seeding method is applied. Water stress at nursery stage and untimely application of herbicides, are the reasons for low yield in the government-managed scheme. This is partly due to problems of decision making by top management and partly due to low morale at the bottom management, arising from low pay. The government-managed scheme had an average low water use efficiency of 0.1 kg/m<sup>3</sup> which is far less than the standard value of between 0.7 - 1.1 kg/m<sup>3</sup> for paddy crop (Doorenbos et al., (1986); while, despite the deficit irrigation, the farmer-managed scheme had a better average water use efficiency of 0.35 kg/m<sup>3</sup>. Effective rainfall (Pe = 270 mm) which was received during the 1994/95 cropping season had contributed in meeting the required ET<sub>crop</sub> and basic flooding.

Table 4.7 Average yield from sample blocks in 1995.

Government-managed scheme		
Block/fields yield	Average yield (ton/ha)	Average (kg/m <sup>3</sup> )
Upper (D8-D19)	2.1	0.083
Middle (D47-D58)	2.5	0.117
Tail (H25-H33)	2.0	0.101
Average	2.2	0.100
Farmer-managed scheme		
Upper (76-78)	3.4	0.35
Middle (60-62)	3.0	0.36
Tail (43-45)	3.2	0.35
Average	3.2	0.35

Table 4.8 T-test (Average yield/unit area or unit of water)

Degre of freedom $v = 4$		GMIS against FMIS
	Test statistic T	7.190
	Critical T at 5% level of significance	2.776
Rate of yield (ton/ha)	Critical T at 1% level of significance	4.604
	Test T statistic	11.75
Rate of yield (Kg/m <sup>3</sup> )	Critical T at 5% level of significance	2.776
	Critical T at 1% level of significance	4.604

Compared to the national opportunity cost of capital of 23%, economic performance (Table 4.9) shows that both the government-managed and the farmer-managed irrigation scheme have low economic and financial internal rate of return. Both schemes have benefit cost/ratio less than one.

The main reason to such low performance is low average production per unit area, high operating costs and huge capital of the project development for the government-managed scheme. The farmer-managed scheme, however, performed better than the government-managed scheme economically as it has a relative higher benefit/cost ratio of 0.6 which approaches one against 0.13 which approaches zero for the GMIS. Even the economic benefit cost/ratio is slightly less than one (0.6) for the FMIS against 0.14 for the GMIS. The net income (cash flow) and the net present value (NPV) on Appendix 4.4 and 4.5 show that in about three years of further production the farmer-managed scheme can recover or pay back the capital and operating costs. At this rate of production and cash flow, the government-managed scheme cannot pay back the development and operation costs as the annual net income (cash flow) is negative (Appendix 4.6 and 4.7).

Irrigated area (Fig. 4.9) increased rapidly from 60% (1800 ha) in 1991 to 100% (3015 ha) from 1992-1995 in the government-managed scheme, while irrigated area in the farmer-managed scheme increased from 0% in 1991 to 76% (600 ha) in 1995. There is good performance in terms of percentage of irrigated area in the government-managed scheme than in the farmer-managed scheme. The reason is the availability of modern machinery in the government-managed

scheme. On the other hand, the long distance (26 km) from residence to farm area and, tillage machinery which were either not easily available to farmers or some farmers were not able to meet the machinery hiring costs were the limiting factors to the low percentage of irrigated area. It was assumed that during the project operation, farmers would have migrated and settled within the project premises. But, in practice, this was not the case. This had contributed to poor performance of the farmer-managed scheme due to long walking distances from farmer's residence to their paddy fields.

**Table 4.9 Economic and Financial Analysis**

Measure of profitability	Government -managed scheme	Farmer managed scheme
<b>Economic analysis</b>		
Internal rate of return	5.0%	3.2%
Benefit/Cost ratio	0.14	0.60
<b>Financial analysis</b>		
Internal rate of return	5.1%	3.9%
Benefit/cost ratio	0.13	0.6

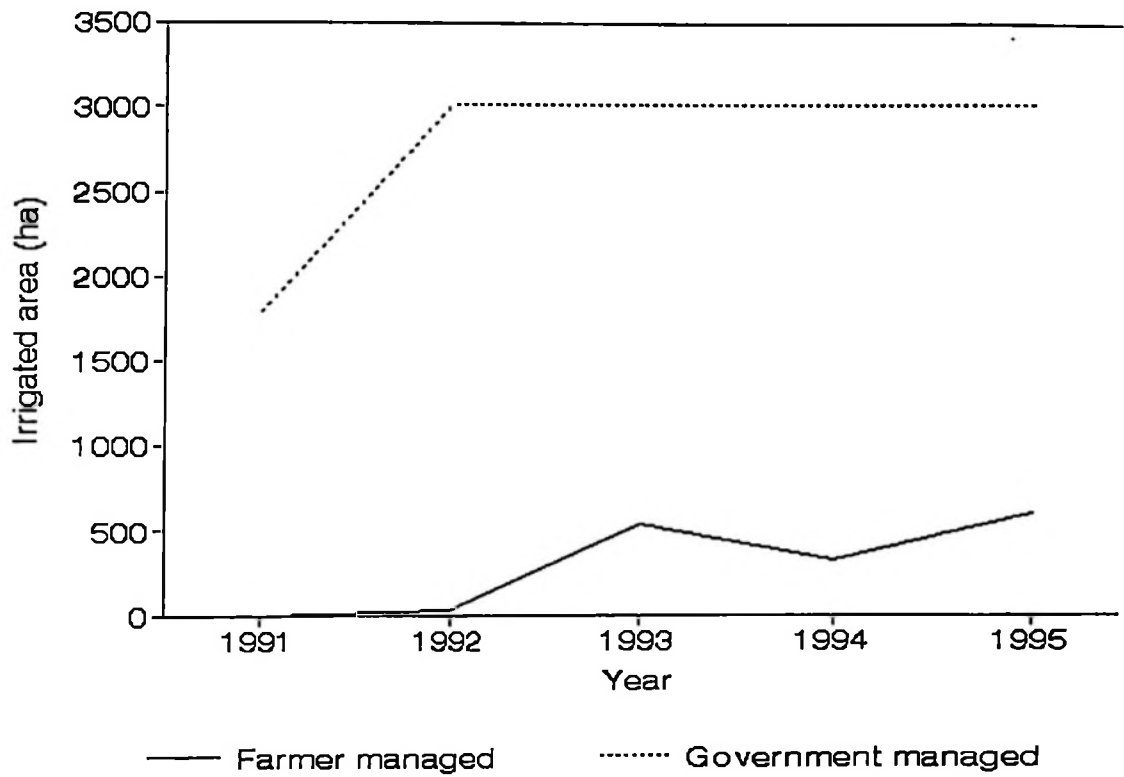


Fig. 4.9. Annual irrigated area (ha)

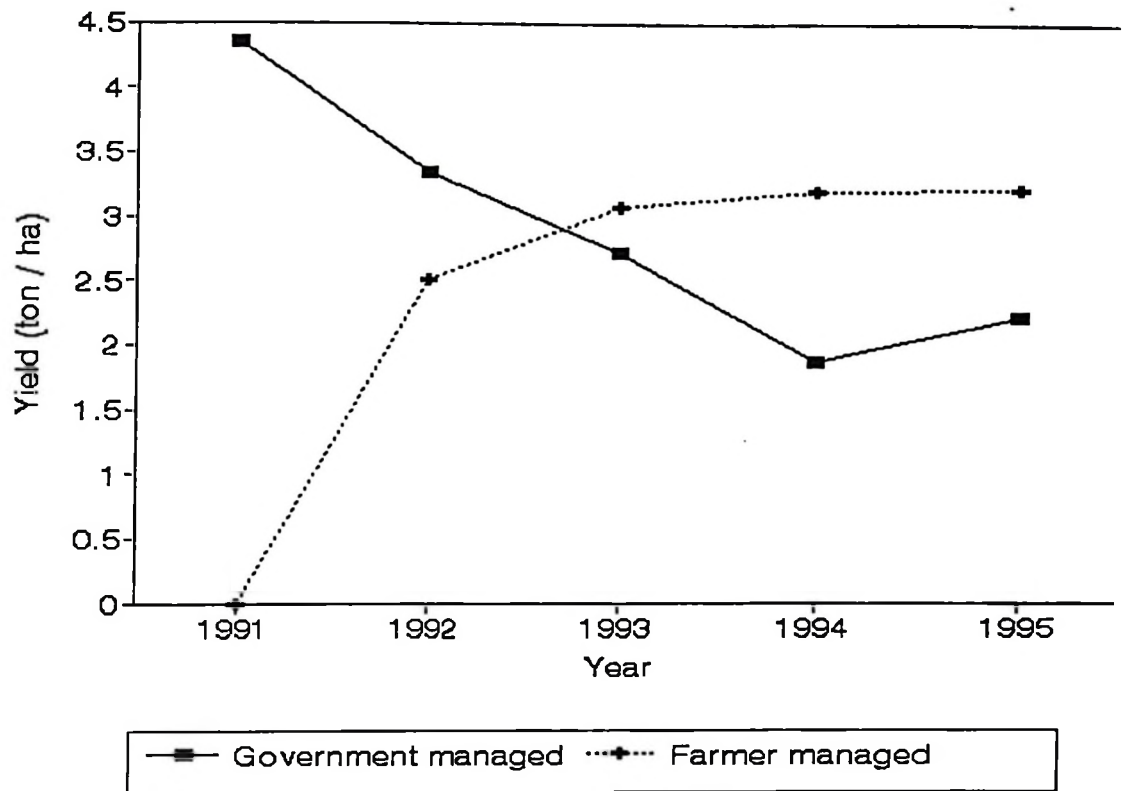


Fig. 4.10. Annual productivity (ton/ha).

Table 4.10 General results of farmers interview

Variables	FMIS <sup>1</sup>	GMIS <sup>2</sup>
1. Cooperation in allocating water	NO	YES
2. Cooperation in channel maintenance	YES	YES
3. Contribution to running costs	NO	YES
4. Determination of irrigation period	NO	YES
5. Use of sanction against excess use of water	NO	NO
6. Presence of a right for every farmer to irrigate	YES	YES
7. Priority of farmers leaders to receive water	NO	-
8. Maintaining of order of irrigation	NO	YES
9. Practice of complete irrigation	NO	YES
10. Presence of water theft among farmers	YES	NO
11. Presence of night irrigation	YES	YES
12. Resolving of conflicts by user committee	NO	YES
13. Adherence to irrigation charges	NO	YES
14. Maintaining the cropping calendar	NO	NO
15. Correct fertilizer application	NO	YES
16. Land preparation :-mechanization	YES	YES
- animal	YES	NO
- human power	YES	NO
17. Availability of credit, loan	NO	NO
18. Damage of irrigation structures	YES	NO

<sup>1</sup> Farmer-managed irrigation scheme

<sup>2</sup> Government-managed irrigation scheme

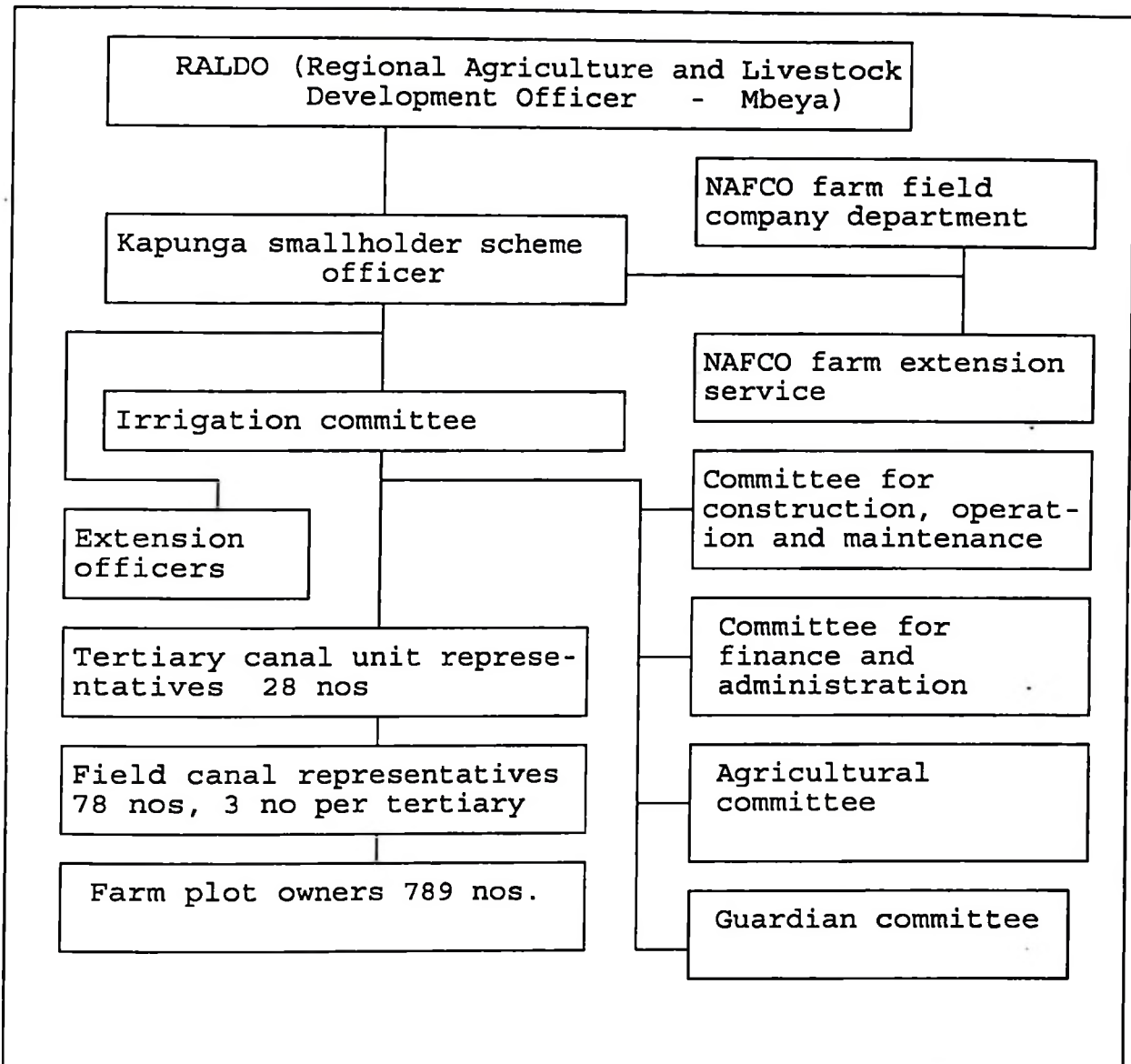


Fig. 4.11. Kapunga farmer managed scheme organisation.  
 source: Kapunga irrigation project

---- = Line of communication, — = Line of authority

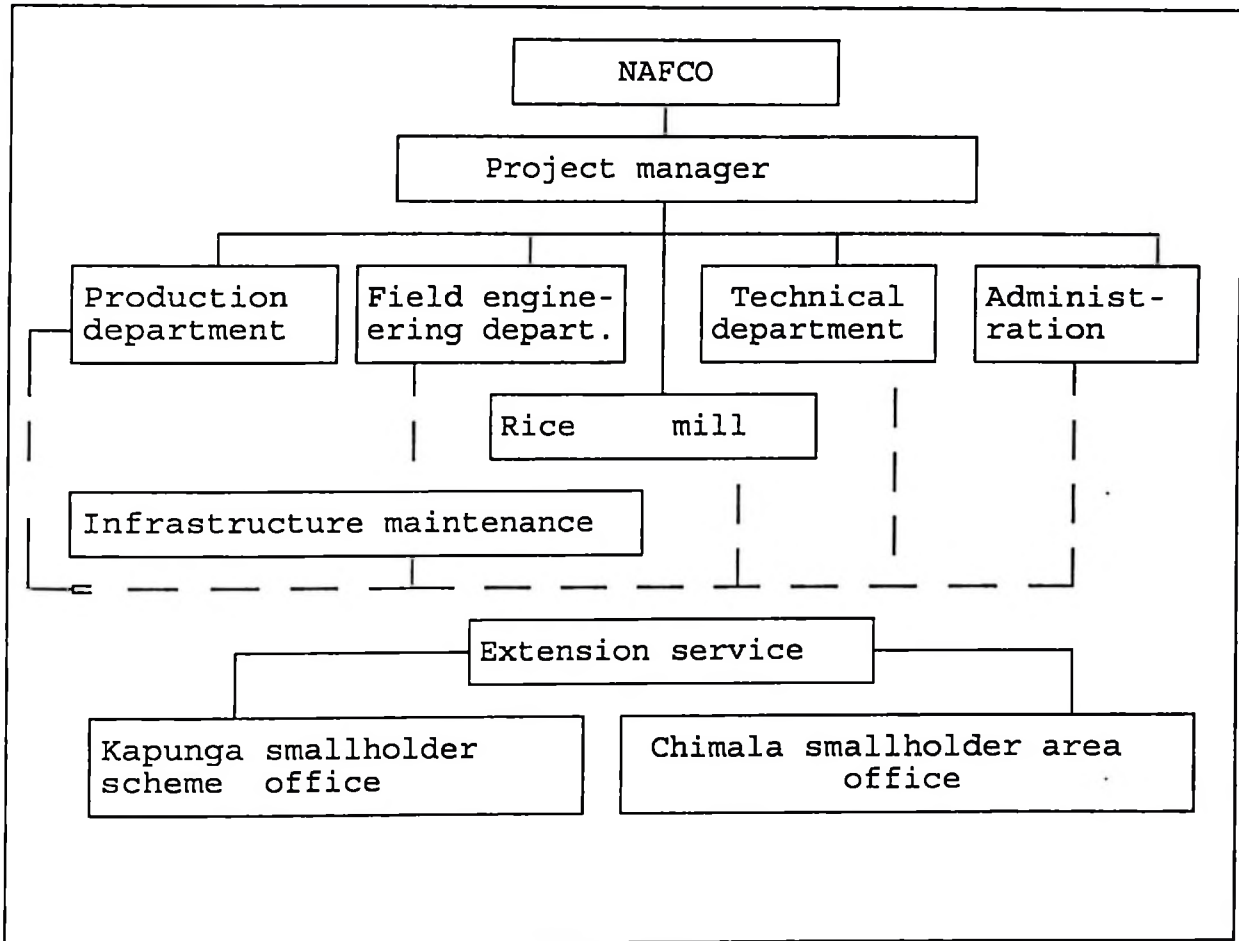


Fig.4.12 Kapunga government managed scheme organization  
source: Kapunga irrigation project.

#### 4.4 Organisation

The organisational structure (Fig. 4.11 and 4.12) of both the farmer and the government-managed schemes were found to be appropriate. A close examination on these structures revealed that all important activities for operation and maintenance of the schemes were taken care of during the project design. Job description for various functionaries had been provided. However, results of physical observation and interview (Table 4.10) conducted among sample farmers in the farmer-managed scheme and functional managers in the government-managed schemes, showed that both the government and the farmer-managed scheme had irrigation management problems.

##### 4.4.1 Farmer-managed irrigation scheme

There was no proper water control within the farmer-managed irrigation scheme. Water was being controlled at the main canal offtake by the Kapunga government-managed scheme worker, and after that operation it was the farmers duty to distribute water among themselves equally. However, this function was not properly performed by farmers. Interview results (Table 4.10) along with physical observation show that: Irrigation turns among farmers were not being followed. According to the system design, water would be

discharged at the farm level based on 24 hours irrigation time whereby three field canals would operate at the same time. But farmers were irrigating for only 8 hours daily. Under this condition, it was planned to irrigate under rotation of one field canal per day. This regulation was not complied with. Due to bad water management, much water was wasted. In an attempt to recover the lost water, farmers would block the drains, cut across field canals and try to use drain water to irrigate. But this practice caused a lot of damage to farmers' fields. For example a germinating plot no. 7 on field no 66 was completely destroyed after it was submerged by water from a blocked drain of field no. 66.

Several water control structures on canal inlets and outlets were damaged without replacement. Extension services to the farmer-managed scheme were inadequate. One extension staff from the Kapunga government-managed scheme was serving all smallholder farmers in 789 ha.

Only a small percentage of drainage and irrigation canals were adequately maintained. Drainage canals were 100% not maintained. This canal maintenance problem usually causes excessive vegetation in canals, obstruction of irrigation water and water losses through evaporation, seepage and percolation. There was no credit or loan facilities to meet

operational costs. This poor performance was not due to poor organisation but due to problems of management. According to Bottrall (1981), poor performance at a low hierarch level is a result of poor performance of top level hierarch. The root cause of poor performance in management in the farmer-managed scheme is the irrigation committee which is the central managing organ in the farmer-managed irrigation scheme. The poor performance of the farmer-managed irrigation scheme is associated with the fact that its organisation was started by the government. This result is similar to that reported by Abernethy (1991). According to the scheme organisation, the irrigation committee and the field canal representatives ought to have advanced training in irrigation management and farming practice, while beneficiaries (farmers) ought to have basic training in each aspect. However, physical observation for the 1994/1995 cropping season and interview to farmers revealed that formal training in water management and farming was not a common practice. It was observed that no motivation is made available to those who manage the scheme at different levels for example, the tertiary canal representatives and the irrigation committee members.

#### 4.4.2 Government-managed irrigation scheme.

In the government-managed scheme, there was no evidence of inappropriate organisation which was observed. The organisation is arranged according to specialisation. The Production Department was provided to deal with crop production activities and the Field Engineering Department was provided to deal with operation and maintenance of the irrigation scheme, while, the Technical and the Administration Departments were provided to deal with agricultural machinery and the administrative matters, respectively. The organisational structure is the traditional type which permits the top-bottom and the bottom-up communication as well as horizontal communication among functional managers. However, even though the organisational structure is well arranged, the following problems were observed;

- (1) Even though irrigation turns among different blocks were followed properly, monitoring of irrigation schedule was found to be inadequate; some irrigation events took place after a long interval of up to two weeks or more instead of the recommended interval of about 10 days.
- (2) The cropping calendar was not adequately followed.
- (3) Excessive weeds were observed. The reason behind was late application of weed killers (herbicides).

- (4) Drainage and irrigation canals were only 10% cleaned in the government-managed scheme. The GMIS operational costs including the canal maintenance costs are met by the scheme. The government does not meet these costs. Therefore, due to inadequate funds arising from low productivity and excessive operational costs, the GMIS cannot maintain irrigation canals effectively.

## CHAPTER V

## CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusions

From the study, the following conclusions are made;

1. In terms of productivity (yield per unit area; yield per unit of water), economic and financial measures, the Kapunga farmer-managed scheme performs better than the Kapunga government-managed scheme.
2. The organisational structure of both the government and the farmer-managed irrigation schemes are adequate. However, both schemes face a water management problem.
3. The conveyance, distribution efficiencies of the main and secondary canals for the farmer and government - managed schemes amounting to 85%, 81% and 80%, respectively, are quite high. This means that there are no substantial water losses through the main and secondary canals of the Kapunga irrigation project.
4. The average application efficiency in the FMIS which amounted to 91% are higher than those in the GMIS which amounted to 42%. Compared to the planned value of 63%, the application efficiency in the FMIS

are high while those of the GMIS are low. These variations in irrigation efficiencies were caused by poor water control at the tertiary block.

5. Farmers in the upper, middle and tail ends of both the farmer and government-managed schemes receive water in equal proportions. This is shown by a relatively low error of equity of 2% and 11%, respectively. However, water was more equally distributed in the FMIS than in the GMIS.
6. Paddy nurseries in the government-managed scheme undergo undesirable water stresses due to very long irrigation intervals.
7. Desirable water depths from transplanting to grain formation are maintained in both the farmer and the government-managed schemes.
8. From this study, it is concluded that the FMIS in Tanzania performs better than the GMIS as they are more profitable than the GMIS and therefore they should be promoted.

## **5.2 Recommendations.**

### **5.2.1 Farmer-managed irrigation scheme**

1. The Mbeya regional agriculture office and/or Kapunga irrigation project should intervene to make sure that

a responsible farmers organisation is formed within the farmer-managed scheme so that the scheme is put under proper irrigation management. A well functioning irrigation association would help in providing education, other services such as water distribution, canal maintenance, credits for agricultural inputs, extension and identification of markets for farmers produce. Allocation of a professional scheme officer is highly recommended in this regard.

2. Currently, those who manage the scheme (leaders) at various levels have no motivation. Availability of motivation to leaders, transport facility for the farmer-managed scheme officer who stays 26 km away from the scheme could increase the schemes performance.

#### **5.2.2 Government-managed irrigation scheme**

In the government-managed scheme the following should be done:-

1. Water losses should be reduced through improved water application efficiency. This can be achieved by adopting correct time of irrigation, size of irrigated basins and canal maintenance.
2. When there is no supplementary effective rain within

the first and second decade after planting, the irrigation interval for the nurseries should not exceed 10 days. Irrigation interval can be increased to 14 days from the 3rd decade onward.

3. The average production rate and therefore average income is low for the government-managed scheme. An effort should be made to increase the rate of production through the correct use of water and other agricultural inputs taking into account reducing unnecessary expenditure.
4. Enough budget should be set aside to cover maintenance and operational costs especially for machinery and canals.

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## APPENDICES

Appendix 3.1: Kapunga irrigation project: Sample of canal structures water flow rating table.

Gate opening or gauge reading (m)	SC/CH <sup>1</sup>	SC/CH	PRIMARY CANAL OFFTAKE			PRIMARY CANAL FLUME
	SC NO.1	SC NO.A and B	OT/SC1 <sup>2</sup> 1	OT/SC2	OT/SC3	
	Flow m <sup>3</sup> /sec	Flow m <sup>3</sup> /sec	m <sup>3</sup> /sec	m <sup>3</sup> /se	m <sup>3</sup> /sec	m <sup>3</sup> /sec
0.25	0.71	0.48	0.08	0.14	0.14	0.326
0.30	0.69	0.45	0.09	0.16	0.16	0.529
0.35	0.67	0.42	0.11	0.19	0.19	0.650
0.40	0.65	0.39	0.12	0.22	0.22	0.822
0.45	0.63	0.36	0.14	0.24	0.24	0.999
0.50	0.61	0.33	0.15	0.27	0.27	1.190
0.55	0.59	0.30	0.12	0.30	0.30	1.394
0.60	0.57	0.27	0.18	0.32	0.32	1.611
0.65	0.55	0.25	0.20	0.35	0.35	1.840
0.70	0.53	0.22	0.21	0.38	0.38	2.081
0.75	0.51	0.20	0.23	0.41	0.41	2.335
0.80	0.50	0.17	0.24	0.43	0.43	2.598

SECONDARY CANAL NO. 1&amp; 2

SECONDARY CANAL NO. 3.

Hole No.	Flow rate l/sec		Check structure gauge reading	Flow rate l/sec	
	Type 1 width 25cm	Type 2 width 30cm		width 30 cm	width 25cm
0	0	0	0.63	23	19
1	22	24	0.64	26	21
2	32	35	0.65	28	23
3	39	43	0.66	31	25
4	45	51	0.67	34	27
5	51	58	0.68	36	29
6	65	64	0.69	39	32
7	60	70	0.70	42	34

1 Secondary canal check structure

2 Primary canal offtake (Secondary canal intake)  
(Source: Kapunga irrigation project)

Appendix 3.2 Required depth (D mm ) of irrigation:  
2.1 Fields D8-D19

MONTH	DECADE	KC	ETO (mm)	ETcrop (mm)	BR (mm)	Pe (mm)	D (mm) = ETcrop-Pe+BR
NOVEMBER	1	1.10	73	80.3	50	5	125.30
	2	1.10	73	80.3	-	5	75.35
DECEMBER	3	1.10	55	60.5	5	20	45.50
	4	1.10	53	58.3	5	20	43.30
JANUARY	5	1.10	56	61.6	100	20	141.60
	6	1.10	52	57.2	-	17	40.20
	7	1.05	55	57.8	50	17	90.80
FEBRUARY	8	1.05	55	57.8	-	17	40.80
	9	1.05	48	50.4	50	17	83.40
	10	1.05	46	48.3	-	17	31.30
MARCH	11	1.00	47	47.0	-	17	30.00
	12	0.95	48	45.6	-	16	29.60
	13	0.95	49	46.6	50	16	80.60
APRIL	14	0.00	49	0.0	0	0	00.00
	15	0.00	45	0.0	0	0	00.00
	16	0.00	0	0.0	0	0	00.00
<b>TOTAL</b>							<b>857.75</b>

2.2 Fields D47-58, H25-H33 and Fields  
78,77,76; 62,61,60, 45,44,43).

MONTH	DECADE	KC	ETO (mm)	ETcrop (mm)	BR (mm)	PE (mm)	D (mm) = ETcrop+BR-Pe
DECEMBER	1	1.1	55	60.5	50	20.0	90.50
	2	1.1	53	58.3	-	20.0	38.30
	3	1.1	56	61.6	5	20.0	46.60
JANUARY	4	1.1	52	57.2	5	17.0	45.20
	5	1.1	55	60.5	100	17.0	143.50
FEBRUARY	6	1.1	55	60.5	-	17.0	48.50
	7	1.05	48	50.4	50	17.0	83.40
	8	1.05	46	48.3	-	17.0	31.30
MARCH	9	1.05	47	49.4	-	17.0	32.40
	10	1.05	48	50.4	50	16.0	84.40
	11	1.00	49	49.0	-	16.0	33.00
APRIL	12	0.95	49	46.6	-	16.0	30.60
	13	0.95	45	42.8	50	15.0	77.80
	14	0.00	44	0.0	-	15.0	0.00
MAY	15	0.00	45	0.0	-	15.0	0.00
	16	0.0	55	0.0	-	0.0	0.00
<b>TOTAL</b>							<b>780.50</b>

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**Appendix 4.1. Soil moisture characteristic/Bulk density  
(g/cm<sup>3</sup>)**


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PF	Field/Plot no.:					
	D15	D52	H28	77-6	61-4	44-5
Saturation	74	77	76	73	72	65
1	63	67	69	60	58	53
2	47	51	55	48	45	36
2.3	41	44	46	42	40	31
2.4	39	43	44	40	38	30
2.7	36	35	41	37	35	25
3.0	31	34	36	32	30	24
3.6	26	27	29	28	26	20
4.2	20	21	22	21	19	18
Hc (mm)	270	300	330	275	265	180
Bulk density (gm/cm <sup>3</sup> )	1.4	1.2	1.4	1.6	1.7	1.5

---

## Appendix 4.2. Nursery soil moisture balance

SEASON: 1994/1995 (GMIS)

FIELD NO. D15			FIELD NO. D52			FIELD NO. H28		
DATE/ MONTH	Soil Moisture (Se-Sb) mm	Ad mm	DATE/ MONTH	Soil Moisture (Se-Sb) mm	Ad mm	DATE/ MONTH	Soil Moisture (Se-Sb) mm	Ad mm
10/11	I214 <sup>1</sup>		01/12	I170			I318	
11	I214		02	I170			I318	
12	D100% <sup>2</sup>		03	D100%			D100%	
13	D100%		04	D100%			D100%	
14	000		05	000			000	
15	000		06	000			000	
16	-10		07	-08			-8	
17	-25		08	-14			-14	
18	-40		09	-22			-22	
19	-56		10	-30			-30	
20	-71		11	-38			-38	
21	-87		12	-28			-28	
22	-97	-34	13	-40			-40	-23
23	I235		14	-51	-30		I100	
24	I235		15	-60			I100	
25	D100%		16	-69			D100%	
26	000		17	-76			000	
27	000		18	-81	-53		000	
28	-06		19	-80			-10	
29	-10		20	-88			-18	
30	-20		21	-97			-27	
			22	-107			-37	
01/12	-30		23	-116			-46	
02	-42		24	-124	-75		-54	
03	-55		25	-133			-64	
04	-62	-70	26	-142			-73	
05	-70		27	-152			-83	
06	-78		28	-160			-91	
07	-85		29	-117	-107		-102	-70
08	-91		30	-180			I160	
09	-99		31	-175			I160	
10	-109		01/01	-180			D100%	
11	-117		02	-183			000	
			03	-195			-12	
12	-107		04	-203			-20	
13	-119		05	-209			-26	
14	-130	-91	06	-211			-28	
15	I196		07	-204			-32	
16	I196		08	-207	-150		-30	
17	D100%		09	-212			-36	
18	D100%		10	-218			-42	
19	000		11	-220			-43	-110
20	000		12	-207			-32	
			13	-213			-38	

<sup>1</sup> 214 mm of water was irrigated.<sup>2</sup> D100%. The field was 100% drained (irrigation was stopped).

## Appendix 4.3. Nursery plot soil moisture balance

SEASON 1994/1995		Farmer-managed scheme					
DATE/ MONTH	PLOT NO 77- 6		PLOT NO 61-4		PLOT NO 44-5		
	(Se-Sb) mm	Ad mm	(Se-Sb) mm	Ad mm	(Se-Sb) mm	Ad mm	
01/12	I47		I70		I38		
02	D100%		D100%		D100%		
03	000		000		000		
04	-07		-07		-07		
05	-15		-15		-15		
06	-24		-24		-24		
07	-31	-18	-31	-18	-31	-13	
08	I38		I50		I37		
09	000		000		000		
10	-10		-10		-10		
11	-18		-18		-18		
12	-16		-16		-16		
13	-29		-29		-29		
14	-40	-46	-40	-46	-40	-32	
15	I38		I43		I34		
16	000		000		000		
17	-07		-07		-07		
18	-11		-11		-11		
19	-16		-16		-16		
20	-18		-18		-18		
21	-27	-64	-28	-70	-28	-35	
22	I42		I35		-46		
23	000		000		I55		
24	-08		-08		-08		
25	-18		-18		-18		
26	-26		-26		-26		
27	-37		-37		-37	-53	
28	-45		-45		-45		
29	I75		I54		I48		
30	000		000		000		
31	-08		-08		-08		
01	-13		-13		-13		
02	-16		-16		-16		
03	-38		-38		-38		
04	-46	-102	-46	-103	-46	-75	
05	I40		I25		I37		
06	000		000		000		
07	003		003		003		
08	000		000		000		
09	-05		-05		-05		
10	-11		-11		-11		
11	-21		-21		-21		

Appendix 4.4. Financial analysis (FMIS).  
4.4.1 Internal rate of return

	1990/91	1991/92	1992/93	1993/94	1994/95
Capital costs (Tshs/ha)	1 492 469	0	0	0	0
Operational costs (Tshs/ha)	0	60 000	67 500	75 937	92 500
Tax at 1% of income	0	2 000	3 210	4 240	4 240
Total cost (Tshs/ha)	1 492 469	62 000	70 710	80 177	96 740
Income (Tsh /ha)	0	200 000	321 067	424 000	424 000
Subsidies	0	0	0	0	
Net Income	-1 492 469	138 000	250 357	343 823	327 260
Discounting factor at 10 %	1.000	0.909	0.826	0.7510	.683
NPV at 10% (Tsh)	-1 492 469	125 442	206 795	258 211	223 519
Discounting factor at 0%	1.000	1.000	1.000	1.0001	1.000
NPV at 0% (Tsh)	-1 492 469	138 000	250 357	343 823	27 260
Total NPV at 10%	= -678 502				
Total NPV at 0%	= -433 029				
IRR	=	0 + ( 10 - 0 ) *	$\frac{433\ 029}{678502 + 433\ 029}$		
	=	$\frac{4330290}{1111531}$			
	=	3.9			

## 4.4.2 Benefit/cost ratio

Year	Cost (Tshs)	Benefit (Tshs)	Disco- unting factor at 10%	Disco- unted costs	Disco- unted benefits
1990/91	1 492 469	0	1.000	14924690	0
1991/92	62 000	200 000	0.909	56 358	181 800
1992/93	70 710	321 067	0.826	58 406	265 201
1993/94	80 117	424 000	0.751	60 168	318 424
1994/95	96 740	424 000	0.683	66 073	289 59
				1 733 474	1 055 017
Benefit/cost ratio at 10 % discounting rate = 1 055 017 / 1 733 474 = 0.60					

## Appendix 4.5. Economic analysis (FMIS)

## 4.5.1 Internal rate of return

	1990/91	1991/92	1992/93	1993/94	1994/95
Capital costs (Tsh /ha)	1 492 489	0	0	0	0
operations	0	60 000	67 500	75 937	92 500
Total (shs /ha)	1 492 489	60 000	67 500	75 937	92 500
Income <sup>1</sup> (Tshs)	0	200 000	321 067	424 000	424 000
Net Income (Tshs) -	1 492 489	140 000	253 567	348 063	331 500
Discounting factor at 10%	1	0.909	0.826	0.751	0.683
NPV at 10%	-1 492 442	127 260	209 446	261 395	22 641
Discounting factor at 0%	1	1	1	1	1
NPV at 0% (Tshs)	-1 492 442	140 000	25 3567	348 063	331 500
Total NPV at 0% discount factor	= - 419 359				
Total NPV at 10% discount factor	= - 871 747				
IRR =	$0 + \frac{(10 - 0) * -419\,359}{871\,747 - 419\,359} = \frac{419\,359}{1291\,106} = 3.2\%$				

## 4.5.2 Benefit/cost ratio

Year	Cost (Tsh)	Benefit (Tsh)	Discount factor 10%	Discounted costs	Discounted benefit
1990/91	1 492 489	0	1	1 492 489	0
1991/92	60 000	200 000	0.909	54 540	181 800
1992/93	67 500	321 067	0.826	55 755	265 201
1993/94	75 937	424 000	0.751	57 029	318 424
1994/95	92 500	420 000	0.683	63 178	286 860
Total discounted cost, benefit				1 722 991	1 052 285
Benefit/cost ratio at 10% discount factor					
$1\,052\,285\,722 / 1\,722\,991 = 0.6$					

<sup>1</sup> = Rice is not exported, therefore, local (farm gate) price is adopted for farm produce instead of export price.

Appendix 4.6. Financial analysis (GMIS)  
4.6.1 Internal rate of return

	1989/90	1990/91	1991/92	1992/93	1993/94
Capital costs (Tshs 000)	6 898 078	0	0	0	0
Operations (Tshs 000)		252 550	757 891	1 114 472	1 447 673
Tax at 1% o Income (Tshs 000)		109	4 689	7 788	4 140
Total cost	6 898 078	252 659	762 580	1 122 260	1 451 813
Income (Tshs)	0	10 852	468 905	778 830	413 979
Net income	-6 898 078	-241 807	-293 675	-343 430	-1037 834
Discount factor (0%)	1	1	1	1	1
NPV at 0%	-6 898 078	-241 807	-293 675	-343 430	-1037 834
Discount factor (10%)	1	0.909	0.826	0.751	0.683
NPV at 10%	-6 898 078	-219 803	-242 575	-257 916	-708 841
Total NPV at 10%	= -8 327 213				
Total NPV AT 0%	= -8 814 824				
IRR	= $0 + (10 - 0) * \frac{(-8 327 213)}{8 814 824 - 8 327 213}$				
	= $\frac{88148240}{17142037}$				
	= 5.1%				

## 4.6.2 Benefit cost / ratio

Year	Cost Tsh 000	Benefit Tsh 000	Discounting factor 10%	Discounted costs	Discounted benefits
1989/90	6 898 078	0	1.000	6 898 078	0
1990/91	252 659	10 852	0.909	229 667	9 864
1991/92	762 580	468 905	0.826	629 891	387 316
1992/93	1 122 260	778 830	0.751	842 817	584 901
1993/94	1 451 813	413 979	0.683	991 588	282 748
			TOTAL	9 592 041	1 264 829
Benefit/cost ratio at 10% discount = $\frac{1 264 829}{9 592 041}$					
= 0.13					

Appendix 4.7. Economic analysis (GMIS)  
4.7.1 Internal rate of return.

	1989/90	1990/91	1991/92	1992/93	1993/94
Capital costs (Tshs/ha)	6 898 078	0	0	0	0
	1 408 720	0	0	0	0
Operations	0	252 550	757 891	1 114 472	1 447 673
Total cost	6 898 078	252 550	757 891	1 114 472	1 447 673
Income	0	108 532	468 905	778 830	413 979
Net Bene-fit	-6 898 078	-241 698	-288 986	-335 642	-1 033 694
Discount factor at 0%	1	1	1	1	1
NPV at 0%	-6 898 078	-241 698	-288 986	-335 642	-1 033 69
Discount factor at 10%	1	0.909	0.826	0.751	0.68
NPV at 10%	-6 898 078	-219 703	-238 702	-252 067	-706 013
Total NPV at 0%	= -8798098				
Total NPV at 10%	= -8314563				
IRR	= 0 +	$\frac{-8798098 * (10-0)}{8798098 - 8314563}$			
	=	$\frac{87980980}{17112661} = 5\%$			

## 4.7.2 Benefit/cost ratio

Year	Cost Tsh 000	Benefit Tsh 000	Discount factor at 10%	Discou- nted Benefit at 10%	Discou- nted costs at 10%
1989/90	6 898 078	0	1.000	6 898 078	0
1990/91	252 550	108 532	0.909	229 568	98 655
1991/92	757 891	468 905	0.826	626 018	387 316
1992/93	1 114 472	778 830	0.751	836 969	584 901
1993/94	1 447 673	413 979	0.683	988 761	282 748
Discounted		Totals		9 579 3941	353 620

Benefit/cost ratio at  
10 % discount =  $\frac{1\ 353\ 620}{9\ 579\ 394}$   
= 0.14