# ANALYSIS OF CROP PRODUCTION IN IMPROVED IRRIGATION SCHEMES: A CASE OF MWEGA MALOLO SCHEME IN KILOSA DISTRICT, MOROGORO.

BY

JULIUS DAUD KITOELOH



A DISSERTATION SUBMMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.



2011

## ABSTRACT

About 80% of arable land in developing countries is susceptible to drought. This is mainly due to inadequate and erratic rainfall. Consequently irrigated agriculture is the only viable option to ensure food security and reduction of poverty in developing countries. Tanzania has 4.8 million ha of land with high potential for irrigation. Despite the large area with high potential for irrigation only 227 486 ha (about only 4.7%) are currently under irrigation. The low proportion of land which is currently under irrigation makes it crucial to use the irrigated land efficiently. Thus the present study is amongst others, an attempt to establish the best way to utilize the irrigated land in Mwega Malolo irrigation scheme in Kilosa District. Data for the present study were collected from 120 farmers who were randomly selected from Mgogozi, Malolo A and B villages. A structured questionnaire was used to collect data. Data were analyzed by using Microsoft Excel, LP Wye Computer programmes and Regression. The results show lower yields caused by improper resource allocation, low use of inputs, lack of credit services, storage facilities, and poor extension services. Optimal plan for Mwega Malolo irrigation scheme resulted with the maximum net revenue of Tshs 336 501 384 which is an increase of about 22% compared to total revenue of Tshs 261 210 609 of the current plan. The results of the present study make it plausible to recommend improvement in the allocation of the land in order to maximize the returns for the scheme. In addition to proper allocation of land and other resources, improving extension services using farmer to farmer extension approach (FFS) and demonstrations is also important. The use of inputs, improved equipments and tools, storage structures, and strengthening CHAUMWE for management of the scheme are also necessary for improving revenue and the living standard of the farmers in the study area and similar schemes in other parts of the country.

## DECLARATION

I **JULIUS DAUD KITOELOH,** do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

15/06/2011

Julius Daud Kitoeloh

(MSc Candidate)

Date

The declaration is confirmed by

21/06/2011

Dr. Damas Philip

(Supervisor)

Date

## COPYRIGHT

## AKNOWLEDGEMENTS

The accomplishment of this study is an assortment of views, ideas, criticisms and help from various sources.

First and foremost, I thank my sponsor, the Government of Tanzania through the Ministry of Agriculture and Food Security through DADPS program for supporting me financially, so that i could pursue my studies at Sokoine University of Agriculture.

Special thanks are extended to my Supervisor Dr. Damas Philip for the intellectual and moral support he gave me throughout this study. His consistent and contributions shaped the study a great deal.

Also to all of the academic staff members in the department of Agricultural Economic and Agribusiness of SUA for their suggestions and constructive comments during development of this work.

I wish to express my appreciations for the assistance received from my colleagues at Zone Irrigation Office, DED and DADO'S Office- Kilosa during preparation and data collection of this work. I am also deeply in debited to the Mololo A, B and Mgogozi village leaders for their help and co-operation that contributed to successful accomplishment of this study.

Last but not least important, my heartfelt thanks are due to my wife Esther Pearsohn Kathenge for her prayers, and the commitments on my lovely children Kenneth, Keddy, Kessiah and Kerrisohn. Also to my relatives for their moral support while pursuing studies.

## DEDICATION

This study is dedicated to my Father and Mother Daud Kitoeloh Mpazi, and Juliana Kitundu respectively. Also to my senior brothers Nahson D. Kitoeloh, Paul Daud Kitoeloh and their wives who laid the foundation of my education. Finally to my wife Esther Pearsohn Kathenge for her encouragement and patience during the time of my studies.

## TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

# LIST OF APPENDICES

## LIST OF ACRONYMS

| | | |
|---|---|---|
| ASDP | - | Agricultural Sector Development Programme |
| ASDS | - | Agricultural Sector Development Support |
| CHAUMWE | - | *Chama Cha Umwagiliaji Mwega Malolo* |
| DALDO | - | District Agriculture and Livestock Development Officer |
| DED | - | District Executive Director |
| DPLO | - | District Planning Officer |
| EPTD | - | Environmental and Production Technology Division |
| EZCORE | - | Eastern Zone Client Oriented Research and Extension |
| FAO | - | Food and Agriculture Organization of the United Nations |
| FFS | - | Farmers Field Schools |
| FGD | - | Focus Group Discussion |
| GDP | - | Gross Domestic Product |
| HA | - | Hectare |
| I.E | - | That is |
| IWMI | - | International Water Management Institute |
| JICA | - | Japan International Co-operation Agency |
| KATC | - | Kilimanjaro Agricultural Training Centre |
| KDC | - | Kilosa Development Council |
| LP | - | Linear Programming |
| MAFS | - | Ministry of Agriculture and Food Security |
| MDB | - | Marketing Development Bureau |
| NIDP | - | National Irrigation Development Plan |
| NIMP | - | National Irrigation Management Programme |
| O & M | - | Operation and Maintenance |

| | | |
|---|---|---|
| PIM | - | Participatory Irrigation Management |
| PRA | - | Participatory Rapid Appraisal |
| RNFE | - | Rural Non Farm Economy |
| RWH | - | Rain Water Harvesting |
| SADC | - | Southern African Development Co operation |
| SMS | - | Subject Matter Specialist |
| SNAL | - | Sokoine National Agricultural Library |
| SUA | - | Sokoine University of Agriculture |
| TARP | - | Tanzania Agricultural Research Programme |
| TOSCA | - | Tanzania Official Seed Certification Agency |
| UN | - | United Nation |
| URT | - | United Republic of Tanzania |
| WAEO | - | Ward Agricultural Extension Officer |
| WB | - | World Bank |
| WUA | - | Water users Association |
| ZIE | - | Zonal Irrigation Engineer |

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background Information

Agriculture all over the world play a major role in provision of cash by exporting crops like cotton, tobacco, tea, maize and rice for the whole world's population. The world population is expected to grow from around 6 billion people to more than 8 billion by 2030, thus the additional 2 billion people need to be fed within the next 20 years and almost the entire population increase will be in developing countries whereby world food production needs to increase by 60% to feed growing world population (FAO, 2002). The increase in food requirement by 60% means developing countries should expand, and improve both rain fed and irrigated agriculture for household food security and income. Also industries producing food (Meat, fish, flores) are also significant on supplementing or narrowing the deficit.

In case of Tanzania, based on the 2002 population census, the population of Tanzania was 34.5 million people, and it has been projected by URT (2002) to reach 59.8 million by the year 2025. Thus the country needs to increase significantly its production of food crops in order to be able to feed its ever increasing population.

Tanzania has about 43 million hectares of land suitable for agricultural production of which about 6.3 million hectares or 15% are under cultivation. But rainfed agriculture remains susceptible to drought and inadequate and erratic nature of rainfall which makes irrigated agriculture a viable option to ensure food security (TARP II SUA Project, 2004). The requirement in increased food production certainly will increase the competition on water demand for agricultural production by other sectors (URT, 1997). As reported by FAO (2002) water has an active role in food security, contributing to the elimination of hunger and reduction of poverty in rural areas. Globally, growing water scarcity threatens food supply of nearly 3 billion people, as well as the health and productivity of majority wetlands and other ecosystems around the world.

According to FAO (2002) agriculture accounted for 69% of the world fresh water use in 2000, industry 21% and domestics 10%. The irrigated arable land in 2000 was 42% in Asia, 31% in the Near East and North Africa, 14% in Latin America and the Caribbean and only 4% in Sub- Saharan Africa. The low proportion of land under irrigation in Africa is likely to be one of the main reasons for recurring food crises. Therefore, according to FAO (2002) one of the viable strategies is to expand irrigation, whereby, the developing countries are expected to increasing their irrigated area from 205 million ha to 242 million ha by 2030.

Tanzania like other sub Saharan African countries is trying to expand the area under irrigation. One of the district in which irrigation is practiced is Kilosa in Morogoro region. It has a potential arable land of about 536 590 ha where 30 000 ha are suitable for irrigation, but only about 9410 ha are under irrigation including the two improved schemes of Mwega Malolo scheme (KDC, 2005).

In order to ensure maximum benefit from the government efforts in improving and developing irrigated agriculture by rehabilitation and construction of infrastructures, the irrigated land should be used efficiently. This can only be achieved if, amongst others studies on various scheme are conducted. Thus the present study which tries to determine the optimal land allocation plan for Mwega Malolo irrigation scheme is likely to have a significant contribution to the effort to enhance the efficiency with which the irrigated land in the country is used.

## 1.2 Problem Statement and Justification

Despite the efforts to increase the irrigated area in developing countries by improving the existing schemes and developing new ones of about 37million ha, yet the expected positive changes are not being obtained in the already improved small scale irrigation schemes (FAO, 2002).

The actual irrigated area in developing countries is 205 million ha (FAO, 2002). While in Tanzania as reported by Nzoboriahba (2007) the irrigated area is 227 486 ha with an effort to improve more than 1 000 000 ha of irrigation by 2010 as the Millennium Goal through the Agriculture Sector Development Programme (ASDP).

However, most schemes in the country were found and managed by small scale farmers many years ago and even after some of them being improved most of them are not performing as well as expected. This is depicted by the low yields. Therefore, there is a need to increase efficiency by ensuring optimal allocation of resources in irrigation schemes in the country. Increasing yield would enhance the contribution of irrigation schemes to household food security and poverty reduction.

Increasing yield will need amongst others studies on optimal need amongst others, studies on optimal resource allocation in the already improved irrigation scheme like Malolo. The present study which aims at determining the optimal resource allocation for Mwega Malolo irrigation scheme would contribute significantly towards the efforts to ensure food security and alleviate poverty among small scale farmers in the country.

## 1.3 Research Objectives

### 1.3.1 General objective

To determine the performance with regard to resource allocation of small scale farmers in Mwega Malolo irrigation scheme so as to suggest measures for enhancing their performance.

### 1.3.2 Specific objectives

1. To determine the optimal allocation of land and labour resources for maize, paddy, beans and onion in Mwega Malolo irrigation scheme.
2. To determine returns for major crops in Mwega Malolo irrigation scheme.
3. To identify factors that influence crop production in Mwega Malolo irrigation scheme.

### 1.3.3 Hypothesis

The present study is guided by the following hypothesis:-

1. Socio- economic factors have no significant influence on then output of maize, paddy, beans and onion in Mwega Malolo irrigation scheme.
2. The current resource allocation in Mwega Malolo irrigation scheme is not optimal.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Agriculture in the World

Agriculture all over the world plays a major role in provision of crops like cotton, tobacco, tea, maize and rice for the whole world population. Rain is the source of water for crop production in the more humid regions where some 60% of the world's foods are grown (FAO, 2002). But food production fluctuates from year to year, largely due to erratic and unreliable rainfall (Kasambala, 2004).

In order to accelerate the growth of agricultural output, a shift from traditional resources - based agriculture to science-based agriculture will be required, involving the utilization of more productive technologies and increasing quantities of agricultural inputs like fertilizers, draft animals and other many potential inputs. This can be done once there is proper resource allocation at farmer's level especially in irrigated agriculture.

Tanzania has about 43 million hectares of land suitable for agricultural production of which about 6.3 million hectares or 15% are under cultivation. Rainfed agriculture remains susceptible to drought and the inadequate and erratic nature of rainfall make irrigated agriculture a viable option to ensure food security (TARP II SUA Project, 2004).

#### 2.1.1 The role of agriculture in the World

##### 2.1.1.1 Food security

According, to United Nation (UN) the population on the earth will be 7.8 billion by 2025, a 38% increase of the present levels. These changes may have strong impact on food requirement and food production. However, it is estimated that 40% of more food grains would be required to feed the world's growing population (IWMI, 2000). While according to FAO (2002) states agriculture as being the only main source to increase food production in many developing countries.

Tanzania is one of the countries in Africa South of Sahara where food insecurity is a threatening problem that needs to be addressed urgently. According to URT (2001a) current estimates are that around 42% of Tanzanian's households have adequate food regularly, while 27% of the Tanzania's population lives in households with expenditure that are insufficient to obtain enough food to meet nutritional requirements.

At the house level food security is defined as having physical and economic access to sufficient, safe and nutritious food to meet dietary needs and food preferences for an active and healthy life according to FAO (1997) cited by URT (1999) and WB (2001). National level, food security is defined as satistifactory balance between food demand and food supply at reasonable prices (WB, 2001). According to URT (2003) food security at house level as the ability of the household to acquire food either through production, purchase transfer or exchange that is adequate in quantity and quality to fulfill the nutritional needs of the all members of the household. The household level of food security is probably the most important for the analysis in so far as the household is the basic unity, which determines the level of consumption by the individual (WB, 2001). Food security at household level is influenced by a variety of factors including food production, cash crop income, non- farm income, household size and consumption, access to market and food prices (WB, 2001).

Moreover, food security is influenced by the increase in number of persons living in the households, either by a natural increase (birth) or by in migration. Food production and income are in turn influenced by farm size and land quality, availability of labor, equipments, access to credit and management skills (WB, 2001). But according to Bureau of statistics (1996) cited by Ishengoma (1998) Tanzania has potential to expand food production, and any increase in the use of inputs, such as fertilizer, could subsntationally improve production.

There are several crops grown in Tanzania for food purpose in different climatic conditions. It has been reported by Maliyamkono and Bagachwa (1990) and Msambichaka (1983) that maize crop is both a major staple and the most important though due to its biological nature it is susceptible to weather changes. Table 1 show that apart from maize production paddy, wheat, millet, sorghum are among cereal crops grown in Tanzania. In volume (tonnage) cassava is the second after maize but paddy ranks the third while sorghum is the fourth.

**Table 1: Food production in Tanzania in metric tones (1994-2002)**

| Crop | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|
| Maize | 1458 | 2875 | 2822 | 2386 | 2073 | 2848 | 2870 | 3348 | 3495 |
| Paddy | 192 | 517 | 495 | 413 | 847 | 439 | 443 | 1010 | 1054 |
| Wheat | 44 | 47 | 49 | 51 | 53 | 68 | 61 | 65 | 68 |
| Millet | 295 | 222 | 269 | 195 | 50 | 76 | 72 | 74 | 77 |
| Sorghum | 258 | 443 | 360 | 449 | 249 | 363 | 365 | 364 | 380 |
| Cassava | 1697 | 1812 | 1873 | 1936 | 2048 | 2187 | 2118 | 2007 | 2095 |

Source: MAFS (2002)

### 2.1.1.2 Situation of smallholder farmers in Tanzania

Agriculture in Tanzania is dominated by small farmers cultivating an average farm size of between 0.9 hectares and 3.0 hectares on which they plant basically food crops. Most of food insecure households have a weak resource base, with lack of credit facilities, low use of technology and use of hand hoe (FAO, 2002).

Their harvests are normally enough to satisfy their food needs for only a short period therefore they depend on market supplies to meet their food needs while faced by poor road networks and marketing systems. Household's whose livelihood was based on livestock keeping also become food insecure due to water shortage and loss of vegetation. Also off farm income generating opportunities are limited in most location.

### 2.1.1.3 Factors contributing to food insecurity in Tanzania

Food security at house level is influenced by a variety of factors including food production, cash crop income, non- farm income, household size and consumption, access to market and food prices (WB, 2001).

However there are several constraints to sustainable agriculture production in Tanzania as reported by FAO (2002) the following are the majors:-

a) Drought in upland areas and drought and a flash floods in rain fed lowlands,

b) Poor maintenance of irrigation facilities,

c) Poor road networks and marketing systems,

d) Low use of technology (extension services),

e) In adequate and unreliable rainfall ( both vuli and main season),

f) Lack of effective farmer's organization and co operatives.

#### 2.1.1.4 Poverty reduction

Poverty arising from lack of access to sufficient land and capital, unemployment and political instability has resulted into chronic food insecurity in some Southern African Development Co operation (SADC).

In Tanzania food security is mainly a problem of poverty (URT. 1997). However, according to WB (1990) poverty as measured by income tends to be at its worst in rural areas. Existence of chronic food insecurity in a society is a reflection of poverty. Chronically food-insecure households constitutes the most important risk group that, for policy purposes, should be considered as the primary target group for interventions geared to alleviate food insecurity.

The Government of Tanzania has set a high priority effort to raise its people's incomes and alleviate poverty to tolerable levels by year 2025 (Development Vision 1). These efforts by the Tanzania governments to improve food security includes increasing output, quality, and availability of food commodities, to increase food crops production through productivity and area expansion, to introduce and develop new technologies which increase the productivity of labor and land, and to improve crop processing technologies (URT, 1997).

### 2.1.2 Agriculture performance in Tanzania

Agriculture Gross Domestic Product (GDP) has grown at 3.3% per years since 1985 the main food crops at 3.5% and Export crops at 5.4 per year. Considering the overall GDP growth target for halving object poverty by 2010 is in the range of 6.7% this performance falls short of the needed growth (FAO, 2002).

**2.1.3 The economy of agriculture in Tanzania**

Tanzania is basically an agricultural economy, poverty in region is attributed to low agricultural production productivity. The economy of Tanzania is characterized by low industrialization and high degree of external dependency on developed countries for capital, market, export and imported goods. The contribution of the manufacturing industry to GDP was reported to be only 3.6% in 1999 (URT, 2000). However, it as reported by Rhoda (2001) that its agricultural production potential is not given weight it deserves and much of it remains unexploited. Also as reported by FAO (1996) that our food systems in developing countries touch every one and are important engines of economic and social development.

Despite the fact that Tanzanian Economy is based on agriculture, there is a growing concern about the general food situation, where the declining production of food and cash crops per person has resulted into food insecurity to major portion of the population. This was supported by FAO (2002) that agricultural production is stagnating while population is growing fast and the availability of natural resource is also diminishing rapidly.

Economics provides the underlying principles of optimal resource allocation and thus enables individuals and firms to make economically rational decision. Therefore economics enables individual and organization to appreciate the constraints imposed by the economic environment within which any entity operates and is an analytical subject and its study helps to develop logical reasoning, which are never super flows.

The macro economic reforms in Tanzania have and continue to have significant impact on agriculture sector. The economic reforms have lead to the opening up of the sector to private investment in production and processing, input importation and distribution and agriculture marketing. Most of the production, processing and marketing function has been assigned to private sector. The theory of production in economics is concerned with the principles that facilitate the optimal combination of factors of production and is concerned with the reasons why societies develop and means of accelerating development.

### 2.1.4 Economic viability of Rain Water Harvesting (RWH) for adapting to risks in agriculture

In dry lands of Sub- Saharan Africa, the pressing development challenge is that rainfed agriculture should be upgraded to improve food and income security amidst agricultural water constraints. It has been suggested that to feed almost 2 billion more people in the next 25 years, most of the food increases will have to come from irrigated agriculture involving withdraw of blue water from rivers and lakes (FAO, 2002). Other, however see irrigation expansion as a more limited option since some quantity of water must remain in rivers to protect aquatic ecosystems.

However it is known that agriculture in Africa already accounts for 90% of all fresh water withdrawals from rivers (Falkenmark and Rockstron, 2004; Rosegrant *et al*, 2002) therefore this leaves us with the fundamental question on how rainfed agriculture especially in the lowland tropics could be upgraded to meet the ever increasing food needs of the huge population in the dryland areas of Africa. The promising break through for upgrading rainfed agriculture in the dryland remains on how efficiently the forgotten green agricultural water is utilized through practices such as Rain water harvest.

RWH for agriculture can be viable in areas with annual of as low as 300 mm (Ngigi, 2003). This means given the status of rainfall amount, which can be as high as 500-800 mm in most parts of dryland tropics RWH is confidently a viable option. While these presents the economies of water harvesting for agriculture, empirical analysis of the economic viability of RWH as a strategy for adapting to the risks caused by rainfall variability is not clearly explained. Exclusively, the past work concentrated more on analyzing the magnitude of farm outputs (yield and nutrients) given input factors such as land, labour and capital and water rather than how robust different RWH systems stabilize these outputs under different seasonality contexts. Production instability caused by rainfall variability is the major risk facing farmers in the dry areas.

## 2.2 Irrigated Agriculture

The irrigated arable land in 2000 was 42% in Asia, 31% in the Near East and North Africa, 14% in Latin America and the Caribbean and only 4% in Sub- Saharan Africa (FAO, 2002). However, agriculture is the biggest consumer of water, and irrigation is crucial to the world's food supplies though irrigation makes up only 20% of the total arable land in developing countries but produces around 40% of all crops (FAO, 2002).

The developing countries are expected to increase their irrigated area from currently 205 million ha to 242 million hactares by 2030 for food production as one of the aims for food security in Sub Saharan Countries (WB, 2002). Often irrigation systems in developing countries need to be modernized such that water institutions and infrastructures have to become service- oriented and cost effective (FAO, 2002). This improvement, facilitate efficiency use of water by proper design of the structures based on standard water requirements, which recommends at least 1.2 cubic meter of water to produce 1kg of rice while wheat needs 1 cubic meter of water (FAO, 2002). Therefore, for optimal production in irrigated areas, the use of an improved technologies, access to credit facilities, market information's and economic resource allocation is very important.

Tanzania has a very potential agricultural arable land of about 43 million hectares out of 96.4 million hectares of the total area of the country, while about 6.3 million hectares or 15% are under cultivation. The total high potential area for irrigation is about 4.8 million hectares, while the irrigated developed area at current is 227 486 hectares (Nzoboriahba, 2007). Rainfed agriculture remains susceptible to drought and the inadequate and erratic nature of rainfall make irrigated agriculture a viable option to ensure food security (TARP II SUA Project, 2004).

Water in rural societies in Tanzania is highly acknowledged as a strategic resource, and is often placed at higher level than land and livestock (Kagubila, 1996). But rainfall in many parts of the country is erratic and unreliable, yet water resources in great rivers valleys, lakes and grounds water reserves are unexploited. Studies conducted in the country show that, about 80% of the country receives less than 1000 mm of seasonal and unreliable rainfall and this pose a big threat to food production and unattainment of food sufficiency.

The need for irrigated agriculture has been of paramount importance and alternative way for the Government and Aid agencies promoting to improving small scale managed irrigation projects, so as to address the issue of food self sufficiency (Rhoda, 2001). This is due to the fact that rainfall in many parts of the country is erratic and unreliable.

In practice, water for irrigation goes together with land. Access to water is closely linked to land right, though a right to land does not necessarily confer access to water. Much as women are the main users of water and key players in irrigated agriculture, when it comes to access or ownership to resources, women hold a marginal position. Most often it is men who plan and make decisions on use and management of resources (Rhoda, 2001).

### 2.2.1 Improvement of irrigation in Tanzania

Rainfed agriculture takes place on some 80% of the arable land. but still traditional rain fed crop production has proved failure in food security, therefore many Sub Saharan Countries have feeble economy meaning they are unable to import food and high technology.

According to FAO (2002) one of the scopes is to expand irrigation as strategy to meet future needs. Irrigation is not yet wide spread in Tanzania, but where it is used, regulation of water consumption is a problem and smallholder farmers account for 80% of the water abstraction for irrigation and traditional furrows. However, most traditional furrows are prone to excessive water use and water logging (URT, 2000). In line with the Tanzania Government's Millennium Goal, the Ministry of agriculture and food security aims to improve about 1 000 000 hectares of irrigation by 2010 through the Agriculture Sector Development Programme (ASDP). This improvement is undertaken by the responsible sector which has developed a strategy which is a planning and coordinating frame work called the National Irrigation Development Plan (NIDP) and essentially is responsible to the pressing needs for:-

a) Food security,
b) Economic growth,
c) Counter measure against the drought cycle which dominates agriculture production in Tanzania.

Tough the government is trying hard to promote and improve small scale farmers to manage irrigation through the improvement of existing irrigation projects, the performance depends to a great extent on the performer where women being the majority (Rhoda, 2001).

### 2.2.2 Improvement of irrigated agriculture under irrigation zones in Tanzania

For efficient management of irrigation activities in Tanzania the irrigation development is divided under seven zone irrigation office namely; Mwanza, Tabora, Manyara, Kilimanjaro, Mbeya, Mtwara and Morogoro zone which comprises three regions of Dare-s-Salaam, Coast and Morogoro. The study area of Mwega Malolo scheme fall under Morogoro zone in Kilosa district. The potential area for irrigated agriculture in the zone is estimated to be at 2.83 millions hectares according to the National Irrigation Management Programme (NIMP): (2000) study.

The irrigation development at the zonal level is guided by the Agricultural Sector Development Support (ASDS) focusing on NIMP with the target year 2017 which covers three categories as shown in Table 2 where, the improvements of irrigation into three categories and targeted areas in the zone are presented. While Zonal Irrigation Engineer's office (ZIE) provides technical backstopping in survey design and construction, supervision, farmers organization and agronomic packages.

**Table 2: Irrigation development at regional level in Morogoro zone**

| Region | Rehabilitation or traditional irrigation | Rehabilitation / New construction of water harvesting | New construction of small holder irrigation schemes (ha) | Total |
|---|---|---|---|---|
| Coast | 900 | 400 | 6900 | 8200 |
| Morogoro | 25 800 | 3800 | 24 500 | 54 100 |
| **Total** | **26 700** | **4200** | **31 400** | **62 300** |

Source: JICA Study team on NIMP (2000)

### 2.2.3 Challenges in irrigation development by Morogoro irrigation zone

The following are some challenges in irrigation development by Morogoro zone:-

i) Inadequate financial resource hinders satisfactory implementation of irrigation development,

ii) Inadequate of main power such as irrigation civil engineers. sociologist, economists and technicians are urgently needed for survey, design, and close supervision in construction, and implementation,

iii) Lack of competency contractors in construction of irrigation schemes,

iv) Poor district capacity to handle scheme implementation.

## 2.3 Crops Grown in Irrigated Agriculture

The major crops grown by farmers under irrigation scheme are mainly maize, paddy , onions, beans, and vegetable while both maize and paddy can be grown twice a year in Malolo irrigated areas as cereal crops. However doubling of the crop depends on many combined factors influencing production like time available, water availability, agricultural equipments, labour cost of production, marketing aspects and price offered and transpotation. Hence one of the objective of improving irrigation is for food security. According to the national agricultural policy as reported by URT (1995) rice is placed in the category of prefered staples which also include maize and wheat. These crops form the most important cereals crops and dietary mainstay of the majority of Tanzanians.

Cereal consumption in Tanzania is estimated at 2897 thousand tonnes per annuam, while maize consitutes 78% of this amount, rice and wheat contribute 16.6% and 3.2% respectively. In Tanzania paddy is mainly grown by smallholder farmers and the leading producers being Shinyanga, Mwanza, Morogoro, Mbeya, and Tabora regions which together account together for about 70-80% of the national rice production per annum (Lemweli, 1992).

However according to evaluation report by Kavana (2006) Eastern Zone Client Oriented Research and Extension (EZCORE) crop production of maize and paddy increased tremendously in three districts in the eastern zone after intervention as the results are shown in Table 3. The reasons for yield increase tremendously in three districts in the eastern zone were due to adoption of technologies, on tillage, planting at recommended spacing, use of improved seed and proper fertilizer application after intervention (Kavana, (2006). However, Kilosa district in considering yield after intervention 26 bag/acre and their percentage (272%) it reflects below average but efficient. While for paddy yield after intervention 52 bag/acre (108%) shows it is above average buts looks inefficient all based on averages as show in Table 3 bellow.

**Table 3: Maize and paddy yield before and after intervention in Eastern Zone (Morogoro zone)**

| District | Crop | Yield before intervention (bags /acre) | Yield after intervention (bags /acre) | Increase % |
|---|---|---|---|---|
| Kilosa | Maize | 7 | 26 | 272 |
| Muheza | Maize | 10 | 33 | 230 |
| Ulanga | Maize | 12 | 28 | 132 |
| **Mean** | **Maize** | **10** | **29.** | **190** |
| Kilombero | Paddy | 16 | 50 | 213 |
| Kilosa | Paddy | 25 | 52 | 108 |
| Muheza | Paddy | 12 | 38 | 217 |
| Ulanga | Paddy | 17 | 47 | 177 |
| **Mean** | **Paddy** | **18** | **47** | **162** |

Source: Kavana (2006)

## 2.4 Farm Labour

Availability of the family labour on the smallholder farmers assumes a great signaficance in the concept of Tanzanias' agriculture reliance on family labour for farm work. Family labour is used in production like land preparation, planting, weeding, fertilizer and pestcide application harvesting, post harvesting and marketing activities. The use of hired labour in and out of the family especially during peak demand operations depends on the individual wealth and daily activities of an individual (Anyelwisye, 2007).

## 2.5 Agricultural Inputs, Equipments and Tools Used in Irrigated Agriculture

### 2.5.1 Agricultural inputs

Generally, the use of agricultural inputs in developing countries has registered a substantial increase in consumption level over the last few decades (FAO, 2002). The total consumption level has been increasing annually though at a smaller pace to bring about the sustained growth of agricultural sector. Green revolution has been major driving force, through creation of massive demand for enhancing higher yield. It placed emphasis on initiative cultivation by structural utilization of modern farming inputs such as pesticides, herbicides, and improved seeds.

Access to agricultural inputs is an important as the provision of proper knowledge or skills to farmers. Also many inputs are not affective unless they are used in combination with other inputs and are applied in a skilled fashion. In other hand not all farmers can afford to purchase inputs directly unless there is already a well organized system of farm credit either through their water user's organization/ associations or co-operatives.

Studies in other places of Tanzania on fertilizer use have shown that nitrogen and phosphouruos are major limiting farmers of increased crop production. This is due to farmers inability to suppliment nutrients taken by the previous season crops. It is estimated that about 100 -150 kg/ha of Nitrogen and 40-60 kg/ha of P2O5 are lost at yield of 5-6 t/ha (FAO, 2002). Other causes of nutrients loss essentialy includes leaching, erosion and continues cereal crops cultivaton like maize,sorghum, millet and paddy. Inorganic fertilizer are said to be impotartant and fast reacting source of soil enriching nutrients. They are good in sense that they act fast and provide quick crop improvement results. They increase yield and the sametime crop remains when decompose tend to improve the water holding capacity of the soil. However the technology has been poorly adopted by small holder farmers due to high fertilizer cost related to farm gate prices. Irrigation increases yield not only by doubling cropping but also through complementary benefits of combined use of irrigation with high yielding varieties, fertilizer and pesticide (Green technology).

### 2.5.2 Agricultural equipment and tools in irrigated agriculture

Agriculture in Tanzania is dominated by small farmers (peasant) cultivating an average farm size of between 0.9 hectares and 3.0 hectares each. About 70 pecent of Tanzanian's croped area is cultivated by hand hoe, 20 percent by ox plough and 10 percent by tractors (FAO, 2002).

However, new technology like the use of hand tractors are introduced to save time and simply work. Methods of land preparation which have a greater influence on the soil fertility and moisture conservation varies with the type of crop to grown , availabe farm implements, land topograph and availability of individual household to afford to hire or buy the particular farm implements. According to KATC (2005). *''Power tiller''* has proved beyond doubt that it is real simple in both cost and operation but can perfom several operations.

The type of farm implement available to farmer is critical in determining the manner of the farm implements for ploughing, and weeding. Farmers without the tools and implements are like to plough and plant late as those who have to take first priority over their use. Those without are therefore exposed to the risk of missing the first rains which are critical for crop growth thereby already jeopardize the harvest prospects for the particular seasons in question (Ifejika and Wiesmanna, (2006).

### 2.6 Irrigation Contribution

Most of the available water in the world is used to grow food crops. In most cases rainfall is sufficient but when it is not enough, irrigation can make well this shortfall and can increase yield of most crops by 100-400% DIFD and OASIS (2003) cited by ( FAO, 1996). However, irrigation makes up only 20% of the total arable land in developing countries but produces around 40% of all crops (FAO, 2002).

In the low income countries, irrigated agriculture can reduce the risk to farming allowing families to increase their food security and nutrition, enhance rural income and create jobs. Irrigated agriculture also offers a chance for double cropping which provides high income for household members and can in turn avoid the drift to the cities DIFD and OASIS, (2003). It should be visualized that irrigation in Tanzania is still very important as it helps in achieving the following primary objectives:-

i) Satisfying substance requirements in many parts of the country, equal increase food security at household level due to erratic and unreliable rainfall,

ii) Creating local surplus of main staples, particularly rice in order to achieve food security in the country,

iii) Ensuring the production of much need dietary supplements such as vegetables, fruits and pulses.

According to some studies on assessing changes in gross returns per hectare as a result of irrigation scheme intervention, it is found that there was positive contribution of the scheme on changing levels of the household's farm income is positive. According to study done by Zablon (2002) as the results shown in Table 4 presents changes in gross returns per hectare as a result of irrigation scheme intervention, he found that there were positive contributions of the irrigation scheme on changing levels of the household's farm income as shown between scheme participants and non participants (rain fed).

**Table 4: Farm income in irrigated and none irrigated land**

| Category of household | Income/unit prior 1985 single harvest /year (Tshs/ha) | Income/Unit 2001 single harvest/year (Tshs/ha) | Income/Unit 2001 double harvest /year (Tshs/ha) |
|---|---|---|---|
| Scheme participants (irrigated) | 240 000 | 625 000 | 1 250 000 |
| Non-participants (rainfed) | 240 000 | 210 000 | No double cropping |

**Source: Zablon (2002)**

The Kilimanjaro Agricultural training Centre (KTC) is working very close with the Model schemes in Tanzania for disseminating the improved technology on high rice production where Key farmers with Extension officer are involved (Zablon, 2002). Results in Table 5 shows the statistical data indicating the change in farming indicators for two irrigation model sites involved in KATC II project training before and after KATC intervention.

**Table 5: Comparison of changes in farming indicators in Mombo and Nakahunga Model sites**

| Indicators | Mombo | | Nakahungu | |
|---|---|---|---|---|
| | 2003 | 2004 | 2003 | 2004 |
| Yield (kg/ha) | 3799 | 4532 | 3095 | 4443 |
| Cultivated area (ha) | 0.60 | 0.51 | 0.37 | 0.19 |
| Production (ha) | 2209 | 2285 | 903 | 847 |
| Price (Tshs/bag) | 11 798 | 14 874 | 11 725 | 19 465 |
| Gross return (Tshs) | 375 470 | 487 798 | 146 763 | 238 683 |
| Unit Gross return (Tshs/ha) | 638 429 | 967 040 | 499 701 | 1 248 339 |
| Operation cost (Tshs) | 102 007 | 168 944 | 46 426 | 27 108 |
| Net return (Tshs) | 273 463 | 318 854 | 100 337 | 211 575 |
| Unit Net return (Tshs/ha) | 460 094 | 632 772 | 301 300 | 1 108 193 |
| Net return rate (%) | 69.9% | 61.5% | 34.6% | 87.4% |
| Unit operation cost (Tshs/ha) | 178 335 | 334 268 | 198 401 | 140 146 |
| No. of households interviewed | 76 | 45 | 64 | 119 |

Source: KATC (2004)

### 2.7 The Role of Water Users in Irrigation Schemes

Water resource management is now more than ever, an important agenda in Tanzania plans and policies. The recent trend on Participatory Irrigation Management (PIM) the government is making serious attempts of ensuring maximum farmer participation by decentralizing the management of irrigation projects. Often irrigation systems in developing countries need to be modernized such that water institutions and infrastructures have to become service- oriented and cost effective (FAO, 2002).

However women contribute large part of the farm labour participating in many different irrigation activities though they represent low number in most water users organization. According to Rhoda (2001) transferring the projects to the hands of farmers has finally enabled women to participate in the management of water irrigation. This can solve the problem of poor maintenance of irrigation facilities and lack of effective farmer's organization and co-operative. The scheme of Mwega Malolo had formed water user's co-operative association known as *Chama Cha Umwagiliaji Mwega Malolo* (CHAUMWE) for maintenance of irrigation facilities and credit services of inputs.

## 2.8 Agricultural Research and Extension

### 2.8.1 Agricultural research

Agricultural development in most countries comes out as a result of a serious research work aimed at solving problems facing farmers in their fields (KATC, 1996). The efforts by the Tanzanian's government to improve food security includes increasing output, quality, and availability of food commodities, to increase food crops production through productivity and area expansion, to introduce and develop new technologies which increase the productivity of labor and land, and to improve crop processing technologies (URT, 1997).

### 2.8.2 Extension services

Also for agriculture to develop, research findings must be clearly communicated to extensionists who will interpret them in a language farmers can understand, but first and foremost the information must be in the mind of extension. If the government intension is to improve the irrigation scheme, the realization of importance of researchers and extensionists to come together to collect and convey information useful for small scale farmers area is ideal. More effort on research especially on crop husbandry, operation and maintenance of irrigation infrastructures, mechanization, marketing, agricultural inputs like improved seed, fertilizer and chemical application aiming to improve the production of crops are important.

Demonstration is one of the extension methods used by extension worker to convey message by doing and observing the outcomes or results. Hence demonstration plot is a transfer of skills as a field method and setting of the demonstration plot especially in one of the farmers' fields can accelerate the transfer of cultivation techniques to other farmers, both nearby and passer-by farmers, because *''seing is believing.'* 'Demonstration becomes more effective when the extension workers involves farmers to participate in doing all skills applied because learning by doing becomes more fruitful and unforgettable (KATC, 1997).

If extension methods are well used and accepted by farmers, production of locally Declared Seed can be done hence reduce the cost of buying seeds as input from retail shops with high price. As reported by KATC (1997) the new approach of community based seed production introduced to selected farmers, who get specific training and provided with Foundation seeds for multiplication under the supervision of extension workers reduces the cost of buying and also accessibility of improved seeds to farmers. Tanzania Official Seed Certification Agency (TOSCA) is responsible for inspection the fields and the final product. Farmers sell the seeds produced locally as ''quality Declared Seed'' with simple packaging and labeling, at reduced prices.

Farmer to farmer extension approach is the most fruitful methods used by the KATC phase II Project model site, approach which was also introduce and used by farmers at Mwega Malolo irrigation scheme in the year 2003 to 2005. This approach is used by irrigation schemes in Tanzania and other neighbouring countries aim at increasing land and labour productivity in irrigated agriculture especially rice and other crops grown under irrigation conditions. The assertion is that irrigation scheme has to be highly productive for them to be justifiable.

This approach of farmer to farmer extension using two categories of farmers in each scheme namely:-

(a) Key farmer at least 20 per scheme.

(b) Intermediate farmers (100) per scheme carefully selected using set criteria.

The number can be adjusted according to circumstances (KATC, 2003). However it is believed that the 120 strong contingents of well trained farmers can be able to spread improved farming technique to the rest of scheme beneficiaries through demonstrations in their small groups.

## 2.9 Agricultural Marketing and Co-operatives

### 2.9.1 Agricultural marketing

Kohls and Uhls (1990) defined marketing as the series of services involved in moving a product or commodity from the point of production to the point of consumption and have classified the function involved in agricultural and food marketing processes as sets of functions of a marketing system. Among the classes are physical function and facilitating function. Each of these functions adds value to the product and they require inputs, thus they incur costs.

Along as the value added to the product is positive most firms or entrepreneurs will find it profitable to compete in supplying the services Also as reported by Shepherded (1997) the important role of trade and marketing information is that of reducing trading risks of losing money during marketing transaction. However, concerning agricultural products Farmers are free to sell their crops to cooperatives o private traders. Due to this to competition normal producers prices for food and export have increased as such farmers can now sell their produce much faster and this make farmers no longer confined to single source for essential inputs for crops and livestock. The price of food stable at present is determined by the market forces (Putterman, 1995). The study carried by Santorum and Tibaijuka (1992), Limbu (1993), and MDB (1994) cited by Ashimogo (1996) on maize and rice marketing system reveal that the grain marketing system is occupied by numerous small traders operating with no stable government policy to support them.

**2.9.2 Agricultural products processing**

Processing of agricultural products may be considered as a wider context as an activity for adding value to agricultural products before marketing the products to consumers (Ekman and Anderson, 1998). According to Slee (1991) processing is an activity creating utility by altering the product in some ways from raw state. Ekman define on farm processing as activities of adding value to agricultural produce by growers before selling the produce to consumers.

Processing the agricultural products in many developing countries has been identified to offer an alternative to diversification, income generation and rural development in the event of increasingly deregulated agricultural markets (Ekman and Anderson, 1998). The process has economic implication at both household and national level, as it may be argued that an increasing degree of on farm processing at various stages of food markerting chain may facilitate a transition from traditional agricultural policy, mainly characterized by price supports and direct income payments to an integrated rural development policy (Hayami *et al.,* 1998).

Despite the considerable efforts from agricultural research to increase productivity, through improved farm based technologies; rural household income have largely remained low, thereby perpetuating poverty levels and low productivity and low incomes. It is becoming increasingly clear that ıeal benefits to rural communities are going to come from forward linkages of rural producers to more stable and higher value induced products. The main challenge is lack of ability to actively engage in market linkage. The either need to identify new marketing channels/outlets or works within the old marketing channels (IITA, 2004).

Tanzania like many other developing countries is now attempting to diversify its export base to agro -processing with a view of gaining new resource of income to small farmers and foreign exchange. According to MAFS (2002) processing of agricultural crops has the following basic advantages:-

a) Preparing the crop so that they can be used more readily and by so doing, expands markets in which they can be sold,
b) Processing increases the shelf life of some crops for example, by processing fruits to produce juices, jams etc. then be used throughout the year while unprocessed fruits can only last for several days after ripening,
c) Crops processing provides reduces the volume and weight of crops by extracting the parts required only and leaving out what is not needed and by so doing reducing costs of transportation,
d) Processing provides employment to the people and thus contribution to increase incomes and reducing poverty,
e) Processing adds value to the crops due to the factors already alluded to. In some cases value addition can be very high,
f) Processing may provide markets for other materials thus encouraging the growth of facilities for the production of those materials.

### 2.9.3 Storage facilities

Many farmers have small traditional structures, *vihenge* and near or in residential houses. One of the problems cited by farmers is the presence of rodents for cereal crops. While in other side no traders have proper storage facilities, normally use their homes for temporary storage of paddy pending haulage to selling centre. It was reported by Gabagambi (1998) that only 38% of all traders in Ulanga district store paddy to take advantages of increased prices later in the season. According to TARP II SUA Project (2004) declared that as time progresses and production of crops picks up, farmers may soon realize the need for other requirements such as storage structures for inputs and for the produce to facilitate marketing.

### 2.9.4 Infrastructures

The transportation is chiefly one of making product or crop available where it is needed without adding unreasonably to the overall cost of the produce. It is an economic catalysis and a primal mover of development in the processing of growth. Mlambiti and Mlay (1997) and Rutabinga (1992) emphases that good road systems enhance agricultural productivity by reducing marketing margins expanding the right time and place. An efficient roads system helps to improve smallholders' access to markets with a reduced price of consumer goods and services. Adequate performance of this requires consideration of alternative routes and types of transportation of alternative routes and types of transportation, with a view to achieve timeless, maintaining produce quality and minimizing shipping costs. "*A cheap and extensive network of communication is the greatest blessing that a country can have from the economic part of view.*"

### 2.9.5 Co-operatives

Access to agricultural inputs is an important as the provision of proper knowledge or skills to farmers. However, many inputs are not effective unless they are used in combination with other inputs in a skilled fashion. At the same time not all farmers can afford to purchase inputs directly unless there is already a well organized system of farm credit either through their water users' organization associations or co-operative. According to Mirau (2007) co-operative as one of the marketing channels are of paramount importance to small farmers in articulating farmers demand and facilitating collective actions in overcoming problems in agricultural and capital markets. These may influence process or performance of small scale farmers in relation to their production objectives.

Worldwide co-operatives play an increasingly important role in job creation, economic growth, and social development. It has been reported by Repello and Cavalcant (1995) that co-operatives mainly operate in agricultural marketing and supply, finance, whole sale and retailing, health care, housing and insurance. Definition by Tewin (2004) the term co-operative is a business owned and controlled by members and formed to provide them with work or goods at reasonable prices. The other definition by Kharallah and Kirstem (2001) co-operatives and farmers organization are institutional arrangements, the importance of which has re-emerged recently to organize small farmers in developing countries in making of agricultural marketing liberalization. Any type of business can be organized as a co-operative which can provide services of a wide range of social needs (McLeod 2006) such as agricultural inputs, equipments, computer co-operative, producer, workers and co-operative organization.

However services like credit in term of inputs (agrochemicals, sprayers etc) are not frequently provided. The study by Banturaki (2000) highlighted that primary co-operative had a negligible co-operative capital base; a fact which made the rural co-operatives unable to have sufficient to perform their activities efficiently and effectively after the government has withdrawal in funding the co-operatives. It has been reported by Seetharanman (1992) that potentials for the cooperatives are that, they can help small farmers to formulate their income in three ways namely:-

- Increase land/ water productivity or yield per acre.
- Reduce the cost of production,
- Ensure remunerative prices of output.

Area of co-operative was chiefly in agricultural production but also in rural supply and marketing, and agricultural credit (Khou, 2004). Co-operatives is a useful tool to analyze how to overcome the force- render problem and come up with co-operative solution or the management of common resources or the provision of public good as reported by (Kharallah and Kirstem, 2001).

**2.10 Income Diversification**

Opportunity to diversify income is important particularly for rural poor. who are dependent on agriculture and vulnerable to weather fluctuations and crop cycles. Income can be diversified into additional farm activities such as new crops and new crops or expanded non farm activities. Also off farm income generating opportunities in rural areas are limited in most location.

The diversification of assets can reduce the risk of castrophic loss, for example, when a households relies on the mono cropping system, it could easily be bankrupted by the a single crop loss county to a household that relies on a diversified base of crops and livestock and other non farm activities such as handicraft, income could easily survive until next harvest (Zaman, 2000).

This set of circumstances puts the spotlight on the Rural Non Farm Economy (RNFE) as a potential vehicle for poverty reduction in rural areas. Also saving can be achieved through forced savings or diversification from increased income (Davis. 2003). However allow them to smooth consumption, invest in earning activities and prepared for emergencies to draw from savings during critical times of need (WB, 2000). Also credit provides the opportunities to begun or expand new non farm activities, such as agro- processing, food distribution, small scale manufacturing, equipment repair and rented, tourism mining and services sector activities (Davis, 2003). It also can change production methods in farming with yield enhancing inputs. These changes in production lead to new and different employment opportunity for the borrowers as well as others in the community.

### 2.11 Main Crop Production Constraints in Irrigated Agriculture in Tanzania

There are several constraints to sustainable crop production in Tanzania, a few to mention are; weak research and extension support, inadequate and irregular input suppliers. Poor maintenance of irrigation facilities, use of insufficient traditional methods of production and agricultural products are subjected to frequent price fluctuations (FAO. 2002).

### 2.12 Optimization of Profit in Irrigated Agriculture

The main problem facing Tanzania as well as other countries within the region is that of keeping food supply in balance with the ever- increasing demand. this entail rapid growth in agriculture productivity, which has to be in a sustainable way so that to conserve a fragile ecosystem and genet heritage. One option of meeting this challenge while agriculture under rain fed is unreliable making this option rather risky. This means that the much of the increase in agricultural production has to come from expansion of the irrigated area or through increased productivity of irrigated land as reported in (TARP II SUA Project, 2004). Thus it can be done by using linear programming which has been applied in various fields of study proving useful in modeling diverse types of problems in planning, production, transportation, technology routing, scheduling, assignment and design.

### 2.12.1 Linear programming model

Linear programming (LP) is a technique for optimization of a linear objective function, subject to linear equality and inequality constraints. Informally, linear programming determines the way to achieve the best outcomes (such as maximum profit or lowest cost) in a given mathematical model and given some list of requirements represented as linear equations. Linear programming is a technique for optimization of a linear objective function, subject to constraints (Chinneck, 2001).

Informally, linear programming determines the way to achieve the best outcome such as maximum profit or lowest in a given mathematical model and given some list of requirements that represents in a linear equations. Therefore linear program as an optimization technique in economics provides the underlying principles of optimal resource allocation and thus enables individuals and firms to make economically rational decision (Chinneck, 2001). An economics enables individual and organization to appreciate the constraints imposed by the economic environment within which any entity operates and is an analytical subject and its study helps to develop logical reasoning, which are never super flows.

### 2.12.2 History of linear programming models

Linear programming can be applied to various fields of study, and this as a problem solving system of inequalities dates at least far as Fourier, after whom the method of Fourier-Motzkin elimination is named. Linear programming arose as a mathematical model developed during the Second World War to plan expenditures and results in order to reduce costs to the army and increased losses to the army. It was kept secret until 1947 and postwar, many industries found its use in the daily planning (Paris. 1981).

The founders of the subject are Leonid Kantorovich, a Russian mathematician who developed linear programming problems in 1939, Dantzing, who published the simplex method in 1947, John Von Neumann, who developed the theory of the duality in the same year. The linear programming problem was first shown to be solved in polynomial time by Leonid Khachiyan in 1979, but a large theoretical and practical breakthrough in the field came in 1984 when Narendra Karmarkar introduced a new interior point method for solving linear programming problems (Paris, 1981).

### 2.12.3 Description of important Terms

The objective function includes a number of variables of each should be build to maximize revenue. The LP model to be used is as follows:

$$\begin{array}{ll} \text{Maximize} & z = c_1 x_1 + \ldots + c_m x_m \\ \text{s.t.} & a_{1,j} x_1 + a_{2,j} x_2 + \ldots + a_{m,j} x_m \le b_j, \quad j = 1 \ldots n \\ & x_i \ge 0, \quad i = 1 \ldots m \end{array}$$

**a) Terminologies**

The following are linear programming terminologies as defined by (Chinneck, (2001).

**Decision Variable:** Physical quantity controlled by the decision maker. Decision variables describe the quantities that the decision makers would like to determine. They are unknown of the mathematical programming model.

**Objective function:** Mathematical function of the decision variable that converts a solution into a numerical evaluation of that solution or evaluates some quantitative criterion of immediate importance such as cost, profit, utility, or yield.

**Constraints:** May be physical, economic, technological, legal, and ethical or other limits on what numerical values can be assigned to the decision variables. A constraint is an inequality or equality defining limitations on the decisions; they rise from variety of sources such as limited resources, contractual obligations, or physical laws.

**Parameter or Coefficients of the Model:** Constants given in the problems assumptions used to determine the objective function and constraints. These are the collection of coefficient for all values of the indices *I and j*. For the model to be completely determined all parameters values must be known.

**Sensitivity analysis:** Allows the decision maker to perform "What if" analysis, we recognize that the prices, demands, and products availabilities assumed in constructing the model are simply estimates and may differ in the practice. That is, we want to know how sensitive the optimal solution is to the assumption of the model (Mc Carl, 1982).

### 2.12.4 Application of linear programming model

Linear programming can be applied to various fields of study, mostly extensive it is used in business and microeconomics situations but can also be utilized for some engineering problems. Some of industries use linear programming models including transportation, technology, energy, planning, production, telecommunication, company management and manufacturing. Also linear programming is considered as field of optimization for several reasons many practical problems in operations research can be expressed as linear programming problems (Chinneck, 2001). Historically, idea from linear programming has inspired many of the central concepts of optimization theory, such as duality, decomposition, and importance of convexity and its generations are important. Although the modern management issues are ever-changing, most companies would like to maximize profits or minimize costs with resources. Therefore, many issues can boil down to linear programming problems.

### 2.12.5 Assumption of linear programming models

Linear programs are constrained optimization models that satisfy three requirements:-

1) The decision variables must be continuous; they can be on any value within some range,
2) The object function must be a linear function,
3) The left - hand sides of the constraints must be linear functions.

**a) Implicit assumptions**

1) *Proportionality* means that the contribution of individual variables in the objective function is proportional to their values,
2) *Additivity* means the total value of the objective function and each constraint is the sum of the individual contributions from each variable. (Variable must have the same units of measure),
3) *Divisibility* means the decision variables that can take on any real number values within a specified range,
4) *Certainty* means the parameter are known.

### 2.12.6 Steps in problem formulation

There are three steps in problem formulation namely:-

1) Identify and define the decision variables for the problems,
2) Define the objective function,
3) Identify and express mathematically all of the relevant constraints.

### 2.12.7 Different solutions to linear programming models

*Multiple optimal solutions*: if the optimum exists for the problem, there is an extreme point that is optimal, but it may not be unique. Two or more adjacent extreme points share a common edge that may tie for the best solution. In this case not only are extreme points optimal, but all points on edge connecting them are optimal.

*Infeasible problem:* In this situation there is no combination of variables that satisfy the original constraints simultaneously. Identifying this useful because we can then identify which constraints might be relaxed or modified in order to attain a feasible solution, and what the consequences of relaxing the constraints will be.

*Unbounded Problem:* In this situation the objective function can be achieved a value of positive infinity for a maximization problem or negative infinity for a minimization problem (Mc Carl, 1982).

*Shadow Price or Dual Price:* The marginal change of the optimal objective function value that occurs if the right- hand side of a constant is changed for example if it is increased by one unity, or the change in the objective value of the optimal solution of an optimization problem obtained by relaxing the constraint by one unity. In a business application, a shadow price is the maximum price that management is willing to pay for an extra unity of a given limited resource. More formal, the shadow price is the value of the Lagrange multiplier at the optimal solution, which means that it is the infinitesimal change in the objective function arising from an infinitesimal change in the constraint (Chinneck, 2001).

### 2.12.8 Methods of solving linear programming problems

There are three methods for solving linear programming problems namely:-

1) Graphical solution,
2) Simplex method formulated by (Dantzing, 1949),
3) Computer Solution.

### 2.12.9 Limitation of linear programming models

Each linear programming problem (the optimal problem) has associated dual problem. For example a maximization of profit function, subject to resource constraints has an associated dual problem. The dual is a minimization of the total costs of the resource subject to constraints that the value of the resource used in producing one unit of each output is at least as great as profit received from the sale of the output. Also all parameters/Coefficients should be well defined/ or estimated and known before are used in linear programming (Mc Carl, 1982).

## 2.13 Validation of Linear Programming Models

Systematic approaches to validation of linear programming models are discussed in two categories which are prescriptive and predictive applications to economic problems as reported by (Mc Carl, 1982). In prescriptive applications, a model is used to prescribe actions in a particular decision environment. Predictive model is built either to improve the quality of decisions or to automate routine decisions (for example, feed blending) and its usage refers to applications in which the model is used to predict or describe.

According to Rodriquez and Kurkel (1980) predictive models may also be used by decision makers who are interested predicting the consequences of possible decisions (for example, investments) or policymakers who are interested in predicting consequences of policy alternatives and/ environmental factors. Model validation is an important part of any empirical economic analysis and can be utilized in many ways but cannot be utilized with confidence unless it is considered a valid portrayal of the system modeled.

Validation is necessary for both and all categories of LP model use, though validation procedures may be tedious and time consuming; they will often lead to improvement in programming models. Perhaps equally important, such procedures can be valuable in providing the researcher with insight into the behavior of the model and the interpretation of model.

**2.13.1 Approach to validation of linear programming models**

Specific references are made to a general linear programming formulation; however, the approaches are applicable to mathematical programming application in general. Model validation is an important part of any empirical economic analysis. A model cannot be utilized with confidence unless it is considered a valid portrayal of the system modeled. LP models can be utilized in numerous ways. But can be classified into two categories: Approaches to validation vary widely, however validation testing involves measuring how well a model serves its intended purpose.

For predictive models, such a test could involve a comparison of model results to observe outcomes of the system modeled within all the different contexts in which the model would be used for prediction. Thus, models are frequently validated using historical events and outcomes. Although a particular LP model may have a potentially broad range of uses, it will likely be valid only for a proper subset of those uses. The validation process becomes one of determining the model's usefulness for the intended application(s) and/or the range of applications for which the model is valid.

A fundamental issue underlying the validation process is subjectivity. Model validation, Modelers subjectively choose the tests with which they will validate, choose criteria to measure the validity tests with which they will validate, choose criteria to measure the validity of model, choose what to validate within their model, choose which uses of the model will be validated, choose what data to use in validating, etc. Thus, the statement "the model was judged valid" can mean almost anything (Mc Carl, 1982).

### 2.13.2 Types of validation of linear programming models

Two types of validation may be applied to a LP model, but before validations by construct and by results are discussed, consider the components of the model which need to be validated. The output of a LP model consists of at least three items namely:-

a) Optimal values of the primal decision variables,

b) Dual variables, and

c) The objective function.

All of these items need to be systematically validated in order to judge a LP model valid. However, the least important item is the objective function value as it will be correct if the other items are correct.

For predictive models, such a test could involve a comparison of model results to observed outcomes of the system modeled within all the different contexts in which the model would be used for prediction. Also for prescriptive models, adoption of the model (or the model's prescriptions) by decision makers could represent the ultimate validation test.

In other cases, the efficacy of a prescriptive model could be determined through several exposit evaluations of the performance of the pre-scrimptions. Unfortunately, these procedures can rarely be used because they are expensive and time-consuming (this is often the reason for modeling in the first place). Thus, models are frequently validated using historical events and outcomes. Although a particular LP model may have a potentially broad range of uses, it will likely be valid only for a proper subset of those uses (Mc Carl, 1982).

The validation process becomes one of determining the model's usefulness for the intended application(s) and/or the range of applications for which the model is valid. A fundamental issue underlying the validation process is subjectivity. Model validation is subjective in many ways as follows:-

i) Modelers subjectively choose the tests with which they will validate.

ii) Choose criteria to measure the validity tests with which they will validate,

iii) Choose criteria to measure the validity of model,

iv) Choose what to validate within their model,

v) Choose which uses of the model will be validated and,

vi) Choose what data to use in validating.

**a) Validation by construct**

Validation by construct refers to a procedure wherein "sensible" techniques motivated by real world observations are employed in model construction and because these procedures are used, the model is judged valid. This Validation is the most common type of LP model validation and is the sole method of validation, and is justified by one of several approach which relies on the use of procedure believed to be appropriate by the model builder events occurring in :-

(i) Theory and/or knowledge of the problem strongly dictated it a priori,

(ii) Other scientific validation effort has failed.

A final validation by construct approach ensures by assumption, that a real world outcome will be replicated. This approach is manifest in the related field of input-output modeling where the model building approach ensures that the model will always give back the base solution (Mc Carl, 1982).

**i) Disadvantages**

This approach relies on the use of procedures believed to be appropriate by the model builders and involves the conceptualization of a problem based on experience, precedence (i.e. other models and/ or writing) and/or theory and the specification of the data for the problem using reasonable scientific estimation or accounting procedures (deducing the model data from the real world observations).

Use of special constraints to replicate an observed outcome is a validation by construct. This approach is typified by the application of so called "flexibility" constraints within a recursive programming frame work. Such constraints impose maximum and minimum bounds on the individual activities (or group of activities) within a model based on the values of lagged variables. Rather ambition claims have been made for such an approach: "*Recursive programming is capable of predicting the actual behavior where linear programming can only estimate an optimal behavior*" (Henderson. 1959). Also it was reported by Sahi and Craddock (1974) "The *recursive programming has not been overly successful in the empirical estimation of supply response in part due to some major weaknesses in the estimation procedures for the flexibility coefficients.*"

**b) Validation by results**

Validation by results refers to a procedure wherein the results of the model are systematically compared expost against corresponding real world observations with association tests conducted upon the degree of association. Validation by results consists of a comparison of model solutions with corresponding real of world outcomes and a model should be built relying on appropriate experience precedence, theory, and estimation and measurement procedures.

Thus, a type of validation by construct will naturally precede any validation by results. Determining whether the model of the real world system reproduces real world results is the next logical step. For such an exercise, five distinct steps can be identified:-

i) a set of observed outcomes is gathered,

ii) second, a validation experiment is selected,

iii) third, the experiment is applied to the model,

iv) fourth, the degree of association is tested,

v) and, finally, a decision is made regarding model validity. Each of these steps is discussed to reveal more details. The first two are presented in relation to this study.

**i) Parameter-Outcome Sets**

Numerical representations of real world observations consist of parameters which de-scribe the environment of the system and outcomes describing the corresponding behavior of the system. A model should not be validated using only the data from which validated using data from which the model parameters were estimated. Tests of the model beyond this data set will generally be more representative of model accuracy in applications. The observations must be consistent with the intended uses of the model. Also, the underlying structure of the system upon which observations are made must be consistent with the structure which the model is intended to capture. While complete parameter-outcome sets are most desirable for validation purposes, partial sets will generally be useful as will inform observations about the direction or relative changes in system outcomes associated with particular parameter changes (Mc Carl, 1982).

**ii) Validation experiments**

A number of validation experiments are possible. A proposed set of experiments is described below. These experiments are designed to yield information on a model's ability to replicate various portions of the outcome sets. These experiments are not mutually exclusive; rather they are a set of sequential experiments which should be performed (or at least considered) in a given order. Five general validation experiments will be presented:-

a) Feasibility experiment,

b) Quantity experiment,

c) Price experiment,

d) Prediction experiment,

e) And a change experiment.

*Feasibility Experiment*: A feasibility experiment actually has two forms, the primal feasibility experiment and the dual feasibility experiment. The basic form of the feasibility experiment involves setting up the LP model (primal or dual) equations, constraining the variables at their base period levels, then observing whether or not the solution is feasible The primal test involves solution of the original LP problem.

This particular experiment yields information about the internal consistency of the model in terms of production and resource terms of production and resource usage. Often, the feasibility experiment is neglected in favor of more advanced experiments.

For example, the replication of a real world outcome may be attempted when that outcome is in fact not a feasible solution to model. In such cases, the feasibility experiment may provide a more direct means for determining needed corrections in the data or model structure. An attendant possibility is that real world data may be inconsistent. Such an experiment also finds errors arising due to faulty calculations and coefficient placement. The dual feasibility experiment involves an examination of whether the observed shadow prices are feasible in the dual problem (Rodriquez and Kurkel, 1980).

**2.13.3 A procedure for employing a validation test**

There are several identifiable stages to the process of model validation. The purpose of this section is to briefly present steps for conducting one of the named experiments.

Step 1: Specify the model (s) relying on relevant theory, experience, and/or precedence.

Step 2: Enter the constraints and/or activities which hold the shadow prices and/or variable values at observed levels for the specific validation experiment at hand.

Step 3: Solve the model (s).

Step 4: Evaluate the solution(s). Is it in-feasible, unbounded, or optimal?

(a) If the model solution is infeasible, examine the results to find the cause of infeasibility. If this in not easily found, consider adding artificial variables to those rows which are suspected of creating the infeasibilities and solving the model again, Once the cause is found, go to Step 6.

(b) If the model is unbounded, examine it to find the source. If this is difficult, consider first adding large upper bounds to the individual variables, then solving the augmented model and identifying which variables equal the large upper bounds. These will be the variables that are un-bounded. Complete a hand budget for the unbounded variables, pricing each re-source at the shadow prices, and attempt to discover the cause of the unbounded solution. Once the cause is found, go to Step 6.

(c) If the solution is optimal, perform association tests to discover the degree of correspondence between the "real world" and the model solutions (except for the feasibility experiment). These tests should be conducted upon both the primal and dual variables.

Step 5: If the model variables exhibit a sufficient degree of association, then:-

(i) Do higher level validation experiments if and desired.

(ii) Determine whether the model is valid and proceed to use the model.

Step 6: If the model does not pass the validation tests, consider whether:

(i) Data are consistent and correctly calculated,

(ii) Model structure provides an adequate representation of the real world system,

(iii) Objective function is correctly specified.

Procedures for recalculating model parameters will be problem specific. If, for example, all the variables have been fixed at "real world" levels and infeasibilities occur, unit input and/or output levels of production activities may be incorrect. If the data are considered accurate and model structure problems are suspected, one should consider whether: errors have been made in constructing the matrix; additional constraints are needed which have been omitted; constraints have been entered which are not really constraints; some variables have been omitted which are, in fact, important; or whether such factors as risk and/or willingness to adjust (i.e., flexibility constraints) should be entered into the model. If the model has been respecified either structurally or through its data, proceed back to Step 3: and repeat the validation test. If not, go to Step 7.

Step 7: If the preceding steps do not lead to a valid model, one must decide whether to:-

(i) Do demonstrations with an invalid model-assuming as an approximately correct structure, .

(ii) Abandon the project, or

(ii) Limit the scope of validation to a lesser set of variables (aiming at a less strict level of validation), subsequently qualifying model use. This may happen in many cases due to some considerations discuss subsequently (House and Ball, 1980).

### 2.13.4 Causes of validation failure in linear programming models

From practical stand point models do not always validate. A particular model will probably not validate initially since the assumptions are made in the process of model building. Failure to validate likely indicates that a subset of these assumptions is violated. Consequently, if a model fails validation tests, the relevant question is, what assumptions need to be corrected?

There are two different types of assumptions are presented in linear programming models which are algorithmic and modeling.

#### a) Algorithmic

The algorithmic assumptions are additivity, divisibility, certainty, and proportionality. These assumptions, when severely violated, will cause validation tests to fail. The model designer then must consider whether these are the cause of failure. If so, the use of techniques such as separable, integer, nonlinear, or stochastic programming may be desirable to construct a new model (House and Ball, 1980).

#### b) Modelling

Modeling assumptions may also lead to an invalid linear programming solution. These assumptions embody the correctness of the objective function, variables, constraints, coefficients, and coefficient placements. Linear programming algorithms are quite useful in discovering violations of these assumptions. Linear programming solutions are also rather transparent. "*At an optimal solution, one may easily discover what resources were used, how they were used, and marginal resource values*".

**i) Reasons for invalid solutions**

Thus, when presented with an invalid solution, resource usage and resource valuation should be investigated. Models are most often invalid because of inconsistent data, bad coefficient calculation, bad coefficient placement, incomplete structure, or an incorrect objective function. Thus, common fixes for a model failing validation involve data respecification and/or structural corrections (House and Ball, 1980).

**c) The characterized term basic of an optimal solution in a linear programming model**

According to House (1980) when dealing with linear programming, there are several other aspects of the model which can lead to validation failures. An optimal solution to a linear program is characterized by the term basic, i.e. no more activities can be in the model than the number of constraints. For example, if a disaggregated regional model is constructed with a single constraint in each region, at most one activity will be produced in each region (if other constraints are not present in the model). This is ordinarily inconsistent with real world performance.

Models then may be judged invalid because they overspecialize in production due to the nature of basic solutions. Several approaches may be taken when faced with this sort of inadequacy in a model solution:-

i) First, one may be satisfied with validating only aggregate results and not worrying about individual production results,

ii) Second, one may constrain the model to the observed solution and investigate whether this solution is an alternative optimal solution may commonly occur,

iii) Third, one may recognize that a basic solution will not validate and enter constraints that limit the adjustment process of the activities within the model (flexibility constraints as above),

iv) Fourth, the model may be expanded by including risk considerations.

Fifth, one may feel the model is structurally inadequate in that many of the factors that constrain production may be inadequately portrayed sequenced after activities which must have in the mode. For example such a situation leads to either one of two fixes; more constraints can be added or the activities within the model may be respecified so they represent feasible solutions within the omitted constraints (House and Ball, 1980).

**d) Failure of validation because of the objective function**

Specification of the constraints identifies the set of possible solutions; while specification of the objective function must be carefully specified and reviewed (especially if a feasible real word solution can be investigated through the dual feasible test). Finally, a correct objective function may for all practical purposes posses' alterative optimal solutions, one of which is the desired solutions, one of which is the desired solution.

**e) Preformed activities in a fixed sequence through several time periods**

Another phenomena which may lead to difficulty with model validation, particularly within agricultural models is that the agricultural activities are quite often have to be performed in a fixed sequence through several time periods (crop calendar). For example a rotation that includes a legume crop for soil enrichments. An annual model with these activities of this type may well be invalid because the activities are not properly sequenced after activities which must have occurred before. Thus unless the model has initial conditions identical to those in real world it may be very difficult to validate (House and Ball, 1980).

### 2.13.5 Common fixes of validation failure in linear programming model

The following are ways in which a well validated model have to follow:-

i) First, validation is an important concern within any modeling exercise. A well validated model will have gone through both the validation by construct and validation by results phases with care exercise at all points is optimal. Although a model user may nominally be satisfied, true validation will never occur. However, the through satisfactory completion of the experiments outlined the level of satisfaction may be increased.

ii) Finally, one of the ultimate tests of validity deals with adoption of the model by the decision maker. Satisfactory validation via the procedure given is not sufficient for acceptance. A numerically valid model may solve the wrong problem and, thus will never be valid from the decision makers' viewpoint. "*Clearly, under these circumstances, validation in the broadest sense is only achievable by redefining the model which takes into account the true problems*" (Kutcher, 1983).

# CHAPTER THREE

## 3.0 RESEARCH METHODOLOGY

### 3.1 Overview

This chapter outlines the methodology under several sections that was used in the study. Section 3.2 is the conceptual frame work which presents the scope guiding the empirical inquiry and section 3.3 describes the study area, while the research design is presented in section 3.4. The following section 3.5 presents the sampling procedures and the outline on data collection process and instrumentation is in section 3.6 followed by pre- testing in section 3.7 which intends to gauge the response expected and validity of the data.

The data collection is presented in section 3.8 under which there are several sub -sections describing collection of primary data by first beginning with reconnaissance survey, different methods used in colleting e.g. Participatory Rapid Appraisal (PRA), Focused Group Discussion (FGD) of key farmers and intermediate, collect estimated parameters/technical coefficients on labour requirement in different agronomic practices, acreages for major crops, production costs, yield , revenue and crop calendar of Mwega Malolo scheme.

Lastly in section 3.9 presents data possessing and analysis where the description of general characteristics of the respondents and data on empirical inquiry of the study was analyzed by use of analytical tool of Linear Programme model for determination and presents results of the specific objectives of yields, revenues and optimal plan for crops production in Mwega Malolo scheme.

### 3.2 Conceptual Framework

Conceptual or analytical frame work presents scope guiding the empirical inquiry which helps to indicate the most useful research domains on which analysis and limited resources should focus in order to attain the specific objectives of the study. A conceptual frame work (Fig.1) was developed for the following purpose:-

i) Help in guiding and meet the information needed for the objective of the study,

ii) and to identify the variables for data collection according to the objectives.

iii) Determine factors that influence the crop production in Mwega Malolo scheme.

The dependent variable in the conceptual framework is land as a factor of production including labour (family/hired labour) as the two major resources considered in the study.

The socio-economic variables as described in the left hand side are age, gender, education level, family size, farm size and distance from home to farm and water availability for irrigation. These socio-economic factors in combination with the use of improved technology and use of agriculture's inputs and equipments, markets information and access to market and water management together influence the production of crops in Mwega Malolo scheme resulting for optimal net revenue. The net revenue obtained from these crops in the scheme has direct influence to the farmers' income, household food security and poverty alleviation of the smallholder farmers in Mwega Malolo irrigated scheme.

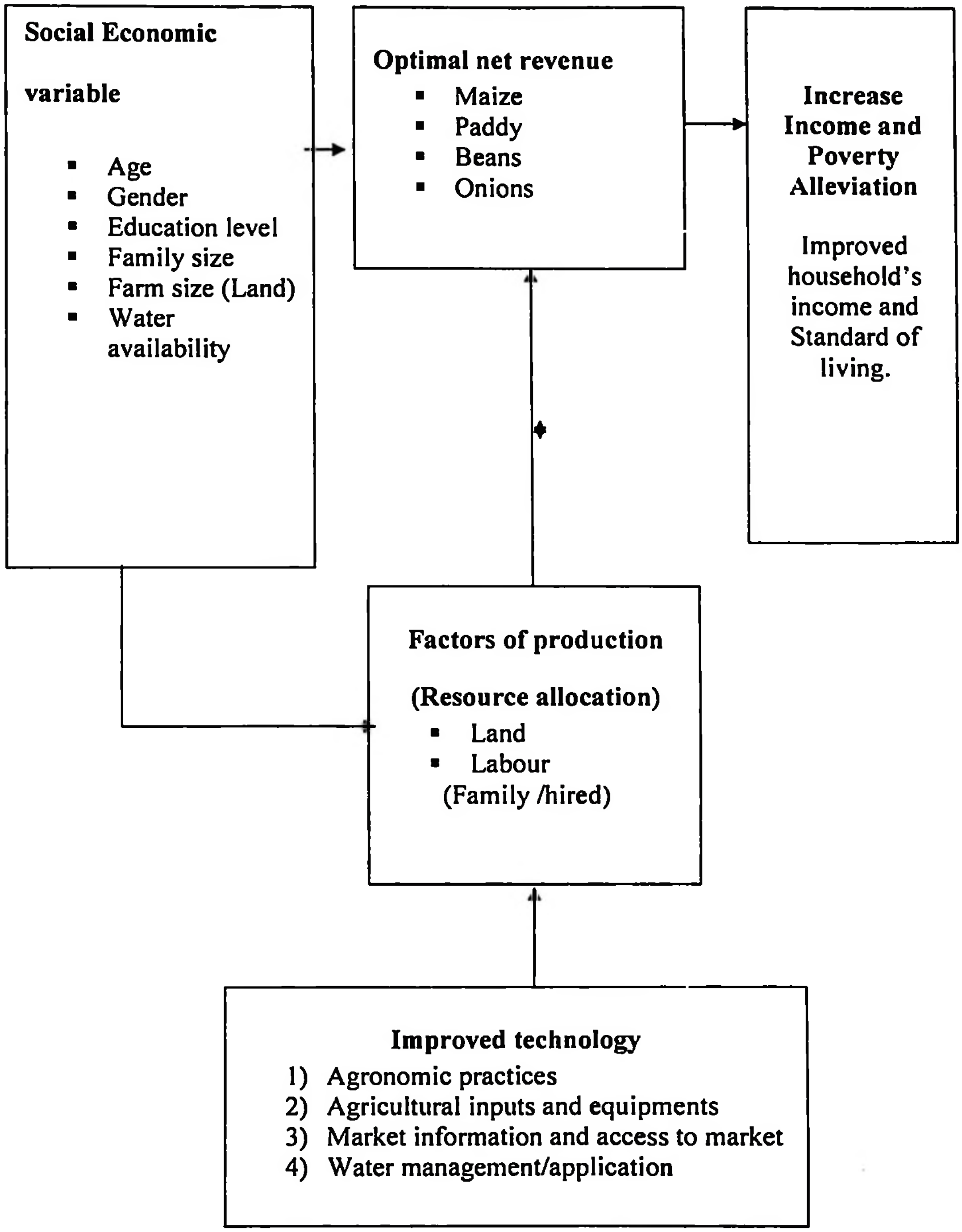


**Figure 1: Conceptual framework**

### 3.3 The Study Area

The study area was carried out in Mwega Malolo irrigation Scheme in Kilosa district allocated 21km north from Ruaha Mbuyuni village in Kilolo District Iringa Region along the main road to Iringa as indicated in the district map attached as Appendix 1. The scheme is accessible throughout the year both from Ruaha Mbuyuni -Iringa and Mpwapwa District via Msagani village and now the short cut road from Malolo through Kisanga ward, Madizini village to Ulaya in Kilosa District is passable in dry season.

The Malolo ward had open market *(Mnada)* conducted twice a month where villagers in the ward and local traders meet including others from Uleling'ombe ward and Mpwampwa district for selling their agricultural produce, livestock and its where they can buy other household's necessities. The selection of this scheme (1550 acres) is based on the high level of improved scheme and low annual rainfall of about 3000mm per year as reported by KDC (2005) hence farmers depends solely on irrigation for crop production.

The improvement of the Mwega Malolo scheme by Japan's Government through Japan's International Cooperation Argent (JICA) for the total costs of about 6.3 billion in 2002. The scheme comprises of two main canals located left and right from the Mwega intake. The total allocation of water from the permanent intake is 890 l/s which are diverted into two main canals where left main canal has 570 l/s while the right main canal conveys about 320 l/s.

The types of crops grown are paddy maize, beans, onions and vegetables like tomatoes, cabbage and pepper, while maize and paddy are grown as staple food and income generation. In case of livestock poultry, shoats and cow are managed under free range system and supplementary feed (maize, and rice bran).

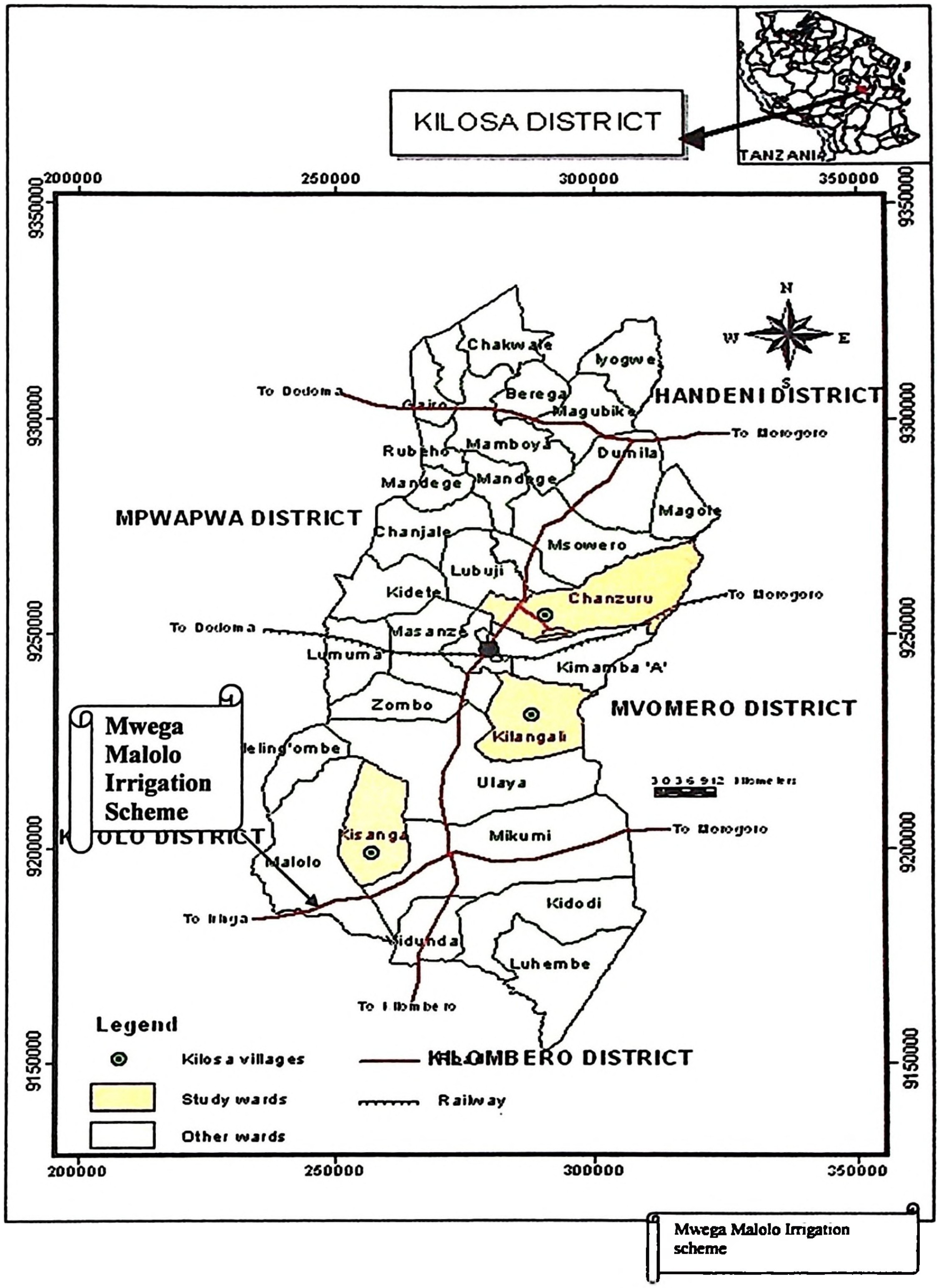


**Figure 2: Kilosa District Map showing Mwega Malolo irrigation scheme**

### 3.4 Research Design

A cross sectional research design was adopted during data collection. The design allows a collection of data from the population at one point in time. The data were collected during crop production period between January and March therefore it was possible for physical observation in the farmer's field.

### 3.5 Sampling Procedures

A purposive sampling approach was used to choose the study site of Mwega improved irrigation scheme because of the high level of the improvement. The sampling frame targeted to population of all small farmers in the scheme growing four major crops of paddy, maize, onion and beans in the irrigated area. A randomly sampling size of 120 respondents' household heads from Mwega Malolo irrigation scheme which includes three villages of Mgogozi, Malolo A and B was identified and used in collecting data. As a result of unbiased sampling method (randomly) the 120 respondents selected come from the three villages in the scheme comprised 50% respondents (household heads) from Malolo A and 26% Malolo B while 24% from Mgogozi. Gender ratio was male 66% and 34% female.

### 3.6 Instrumentation

Data for this study were collected by using structured questionnaire with both close and open ended questions including going through relevant secondary documents. Also estimated parameters/Technical coefficients were described and used in the analytical model of linear programming for determination of yield, revenue and optimal plan for crop production in the Mwega Malolo irrigation scheme. The questionnaire captured the intended data is attached as Appendix 1 and check list for key informant as Appendix 2.

### 3.7 Pre Testing of Research Instruments

Pre testing of the research instruments was applied to few respondents (60 in number) obtained by random sampling from the list of irrigated farmers at Kilangali scheme near Kilosa District under similar field conditions of improved structures and crops grown district town. The selection involved 41.6% female and the left 58.4% male of the total 60 respondents. The pre testing intended to gauge the response expected and validity of data collection according to specific objectives of the study.

### 3.8 Data Collection

Structured questionnaires were the main instrument for data collection which was both closed and open ended including check list administered to Scheme Irrigation technician and Agriculture extension officer in the area of study. Close ended questionnaire had advantages of collecting specific required data while open ended give chance the respondent to give more information as much as possible.

#### 3.8.1 Primary data

A reconnaissance survey was conducted in the study area in order to get the general view of the scheme, crops grown and the agronomic practices in place. The Participatory Rapid Appraisal method such as Focus Group Discussion with key and intermediate farmers were conducted whereby data collection concerning labour requirement for different crops, yield levels, crop varieties, type of equipments and tools used, price offered to crops, agricultural techniques and extension services provided and used in production, problems encounter in farming activities, getting agricultural inputs, marketing and transportation. This data were important and enriched the findings and provided estimates of different parameters of this study.

Semi structured interviews was conducted using the overall sample size of 120 households drawn randomly from the three villages in the study area. Data collected were sub divided into six sections of biographic, land issues, farming information, Source of income, marketing and their constraints in which involved visiting individual farmers at their farms and homes including physical observations on irrigation structures, conveyance methods, and application of water to the different crops in the field. No trouble were made to replace the missed households heads as the sizes of reached were still statistically plausible.

### 3.8.2 Secondary data

Source of information was sought insights on the global, regional, and national issues of relevance to aspects of interest to this research. A number of secondary sources of information (publications) were reviewed from Subject Matter Specialists (SMS) in the District Agriculture and livestock Office (DALDO) District Planning and Lassoing officer, (DPO) and Zonal Irrigation Office at Morogoro (ZIE) in order to get the clear view of the activity in question and study area and Other Documents were reviewed from National Agricultural library (SNAL) at Sokoine University of Agriculture (SUA) and internet.

### 3.8.3 Descriptions of estimated parameters/ Technical coefficients

Parameters or Coefficients of the Model are constants given in the problems assumptions used to determine the objective function and constraints. These are the collection of coefficient for all values of the indices *I and j*. These coefficients are called technical coefficient which represents the rate of use of the limited resources.

The principle of linear programming is that if the model is to be completely determined all parameters values must be known. Potential parameters collected as estimates for this study of crop analysis in Mwega Malolo scheme includes the major crops, labour required and related costs for different agronomic practices, crop calendar, price during harvesting period and post harvesting price and water distribution in the two main canals, yields and revenue of the four major crops.

The total area of the scheme is 620 hectares which is equivalent to 1550 acres (this including 100 acres after expansion as a result improvement. The result in Table 6 shows the estimation of acreage for the major four crops grown in Mwega Malolo irrigation scheme.

**Table 6: Acreage for various crops grown in Mwega Malolo scheme**

| Crops | Total estimated acres |
|---|---|
| Maize | 600 |
| Paddy | 220 |
| Beans | 180 |
| Onions | 550 |
| **Total** | 1550 |

The total allocation of water from the permanent intake is 890 l/s which are diverted into two main canals where left main canal has 570 l/s while the right main canal conveys about 320 l/s.

### 3.8.4 Labour requirements and wage for different agronomic practices for paddy

The agronomic practices of paddy and their related costs were summarized by use of survey questionnaires from farmers growing paddy including formal meeting with key and intermediates farmers in the scheme organized by the Ward Extension officer.

**a) Estimation of social costs and revenue**

The social costs of inputs have to be decomposed into their tradable and non tradable components. Small farm tools, land and labour were treated as totally non tradable land and labors which are domestic factors of production had their social prices estimated based on domestic opportunity cost and market wage rate respectively. Small farm are treated non tradable and their social prices were assumed to be equal to he observed prices.

**b) Social price of labour**

The social price of labour is output foregone in other parts of the economic activities as a result of employment in the activity in question. In a completive and underdistoted labour market, the social price would equal the wage rate. However, since the government does not have any registration on agricultural wage rate for daily agricultural labour in the district was assumed to reflect the social value of labour. The results in Table 7 shows the labour required for each agronomic practices and their wage for paddy crop.

**Table 7: Labour requirements and wage for different agronomic practices for paddy**

| Agronomic practices | Labour requirements (m/days) | Wage/acre per activity (Tshs) |
|---|---|---|
| Nursery preparation | Apiece of land (3mx10m) 1 | 5500.00 |
| Land preparation | 10 | 30 000.00 |
| Paddling | 7 | 15 000.00 |
| Transplanting | 12 | 30 000.00 |
| Weeding | 14 | 30 000.00 |
| Fertilizer application | 1 | 4000.00 |
| Bird scaring | 30 | 30 000.00 |
| Harvesting | 10 | 30 000.00 |
| Threshing | 3 | 18 000.00 |
| Transporting | 3 | 18 000.00 |
| Irrigation | 14 | 36 000.00 |
| **Total** | **105** | **246 500.00** |

### 3.8.5 Labour required and wage for different agronomic practices for Maize

According to erratic and unavailability of rainfall at Mwega Malolo scheme with the annual mean rainfall of 300 mm. The low amount of rain fall necessitate maize (600 acres) to be grown in the scheme as the main staple food for three villages. The agronomic practices of maize and their related labour costs were summarized by use of survey questionnaires, through PRA from Maize farmers and also as using secondary data experienced for four years by the Malolo Ward Extension officer in providing extension services. The agronomic practices and labour requirement and wage for the maize are as results shown in Table 8.

**Table 8: Labour required and wage for different agronomic practices for maize**

| Agronomic practices | Labour requirements per acre (m/days) | Labour wage /acre (Tshs). |
|---|---|---|
| Land preparation | 8 | 30 000.00 |
| Harrowing | 4 | 15 000.00 |
| Planting/Sowing | 3 | 30 000.00 |
| Weeding | 7 | 30 000.00 |
| Pesticide application | 1 | 4000.00 |
| Fertilizer appl. | 1 | 4000.00 |
| Harvesting | 5 | 8000.00 |
| Threshing | 4 | 10 800.00 |
| Transporting | 4 | 9000.00 |
| Irrigation | 14 | 36 000.00 |
| **Total** | **51** | **176 800.00** |

### 3.8.6 Labour required and wage for different agronomic practices for beans

The agronomic practices of bean and their related costs were summarized as were reported by Malolo ward Extension officer including information from survey questionnaires from bean farmers. Labour required (man days) for each agronomic practices in the Malolo irrigation scheme the results are summarized in Table 9.

**Table 9: Labour requirements and wage for different agronomic practices for beans**

| Agronomic practices | Labour requirements (m/days/acre) | Labour wage /acre (Tshs) |
|---|---|---|
| Land preparation | 8 | 30 000.00 |
| Harrowing | 3 | 15 000.00 |
| Planting | 4 | 10 000.00 |
| Weeding | 7 | 12 000.00 |
| Pesticide application | 1 | 4000.00 |
| Fertilizer appl. | 1 | 4000.00 |
| Harvesting | 5 | 10 000.00 |
| Threshing | 4 | 8000.00 |
| Transporting | 3 | 10 000.00 |
| Irrigation | 14 | 24 000.00 |
| **Total** | **50** | **127 000.00** |

### 3.8.7 Labour requirements and total wage for different agronomic practices for onion

Table 10 shows yield of onion, labour required and wage for different agronomic practices of onion for one acre grown in Mwega Malolo irrigation scheme. Summary was based on secondary data as were reported by Malolo ward Extension officer include information collected by use survey questionnaires from onion farmers.

**Table 10: Labour requirements and wage for different agronomic practices for onion**

| Agronomic practices | Labour requirements (m/days) | Labour wage /acre (Tshs) |
|---|---|---|
| Nursery preparation | Apiece of land (3mx12m) 1 | 6000.00 |
| Land preparation | 10 | 40 000.00 |
| Harrowing | 5 | 15 000.00 |
| Transplanting | 10 | 30 000.00 |
| Weeding | 7 | 25 000.00 |
| Fertilizer application | 2 | 8000.00 |
| Pesticide application | 1 | 6000.00 |
| Harvesting | 7 | 20 000.00 |
| Post H/ activities | 5 | 15 000.00 |
| Transporting | 3 | 28 000.00 |
| Storage | 3 | 24 000.00 |
| Irrigation | 14 | 36 000.00 |
| **Total** | **67** | **253 000.00** |

### 3.8.8 Total hired labour and wage for crops grown in Mwega Malolo irrigation Scheme

The results in Table 11 describes the total hired labour requirements, total labour wage per acre, obtained by summing up the individual man days requirement per activity for each crop in the irrigated scheme and total estimated hired labour per scheme (m/days) obtained by considering the total acreage for each crop.

**Table 11: Total hired labour and total estimated labour wage for crops in Mwega Malolo scheme**

| Crops | Labour requirements (m/days/acre) | Total estimated hired labour/per scheme (m/days) |
|---|---|---|
| Paddy | 105 | 23 100 |
| Maize | 51 | 30 600 |
| Beans | 50 | 9000 |
| Onion | 68 | 37 000 |
| **Total** | **274** | **99 700** |

### 3.8.9 Yield and prices offered during harvesting and post harvesting for crops grown in Mwega Malolo irrigation scheme

The results in Table 12 describes the total yield and prices offered for the four major crops grown in the scheme, Data were obtained by summing up information obtained in thee PRA conducted in the scheme with respect to the activity for each crop grown in the irrigated scheme and total acreage for each of the respondents. This data were used in linear programming to determine the revenue and optimal profit of the four crops of maize, paddy, beans and onion.

**Table 12: Yield and prices offered for four crops in Mwega Malolo irrigation scheme**

| Crops | Packages (bags) | Yield per acre (bags) | | | Harvesting Price | Post harvesting |
|---|---|---|---|---|---|---|
| | | Min | Mean | Max | Price (Low) (Tshs /bag) | Price ( high) (Tshs/bag) |
| Paddy | 8 tins/bag (75 kg) | 12 | 18.5 | 25 | 33 109.08 | 38 940.20 |
| Maize | 6 tins/bag (120 kg) | 8 | 11.5 | 15 | 39 578.96 | 45 546.72 |
| Beans | 6 tins/bag (120 kg) | 2.5 | 5 | 8 | 147 630.00 | 180 000.00 |
| Onion | 9 tins/bag (140 kg) | 30 | 44.5 | 55.4 | 15 005.00 | 74 600.00 |

Yields per acre for four crops is paddy 75 kg/bag, Maize 120 kg/bag, beans 120 kg/bag and onion 140 kg/bag

### 3.8.10 Yield level and the revenue per acre for crops grown in Malolo

The yield levels and revenue of the four major crops in irrigated scheme as results in shown in Table 13 was a result of collected data and some calculation the summary of them the yield level and their related revenue of the study area were as shown below. However the extension worker assisted in appraising and approved the calculation and estimates in relation to monthly agricultural Malolo ward reports prepared in each month and submitted to District agriculture and livestock office.

**Table 13: Yield level for crops per acre and for the whole Mwega Malolo scheme**

| Crops | Yield per acre (bags) and tones/acres | | | | Yield per scheme in bags and (*tones*) |
|---|---|---|---|---|---|
| | Min (bags) | Mean (bags) | Max (bags) | Tones/acres ( Mean ) | |
| Paddy (220 acres) | 12 | 18.5 | 25 | 1.39 | 4070 *(305.25)* |
| Maize (600 acres) | 8 | 11.5 | 15 | 1.40 | 6900 *(828)* |
| Beans (180 acres) | 2.5 | 5 | 8 | 0.6 | 900 *(108)* |
| Onion (550 acres) | 30 | 44.5 | 55.4 | 6.23 | 24 475 (3426.50) |

Yields per acre for four crops is paddy 75 kg/bag, Maize 120 kg/bag. beans 120 kgs/bag and onion 140 kg/bag

### 3.8.11 Crop calendar for major crops grown in Mwega Malolo irrigation scheme

Crop calendar for Mwega Malolo scheme as prepared by scheme extension officer in co-operation with scheme irrigation technician has been used by farmers for many years especially after improvement of the scheme by Japan's Government through Japan's International Cooperation Argent (JICA) for about 6.3 billion in 2002, (KDC, 2005). A cropping calendar as presented in Table 14 provides information on the sequence of crops grown on the timing of their cultivation i.e. transplanting/ planting or sowing dates and harvesting. The crop year can be divided into two or three crop seasons normally crop seasons are the rain season and the dry season each with its own crop intensity per year. However all interviewed farmers in Malolo agreed with the period as mentioned in the crop calendar.

**Table 14: Crop calendar for major crops grown in Mwega Malolo irrigation scheme**

| Crop | Paddy | Maize | Beans | Onions |
|---|---|---|---|---|
| *Agronomic practices* | *Months in which activities are implemented* | | | |
| Nursery preparation | December | - | - | April - May |
| Land preparation | Dec- Jan | Nov- Dec | April –July | April - May |
| Paddling/harrowing | Dec- Jan | Nov- Dec | April –July | April - May |
| Transplanting/Sowing | January | Nov- Dec | May - August | May - July |
| Weeding | Feb.- March | Jan - Feb | June -Sept | July -August |
| Fertilizer application | February | Jan - Feb | July -Sept | July -Sept |
| Pest application | Feb.- March | Jan - Feb | July -Sept | July -Sept |
| Bird scaring | March-April | - | - | - |
| Harvesting | May- July | Feb- March | Aug - Sept | August-Oct |
| Post harvesting | May- July | Feb- March | Aug - Sept | August-Oct |
| Transporting | May- July | Feb- March | Aug - Sept | August-Oct |
| Storage | May- July | Feb- March | Aug - Sept | August-Jan |
| Irrigation | Jan- April | Nov-Feb | April - Oct | - |

### 3.9 Data Analysis

Data analysis was done using available and appropriate statistical software of Micro-Computer Package for Linear Programming specifically (LP) version 4 (1985) or Microsoft Excel and Regression. Collected data from the primary sources were verified, coded and analyzed. Qualitative analysis was done by using descriptive statistics. Quantitative analysis was done using computer package for linear programming specifically or Excel for all three specific objectives and presented in different tables in chapter 4.

### 3.9.1 General characteristics of the respondents

A substantial part of the analysis was based on descriptive statistics to describe the Respondent's characteristics and trends of the data and information. This included age, education level, gender, family size, distance from home to farm and land acquisition.

### 3.9.2 Specification of the Linear Programming model

To determine the optimal allocation of land and labour resource for four crops production in irrigation schemes the LP model used was as follows:-

Maximize: $\Sigma C_i X_i$

**The objective Maximize** Z = CX1 + CX2 + CX3 +C X4 - CX5

Where the following are summary of decision variables/activities

X1 , X2 , X3, X4, are acreage for maize, paddy, beans and onion while X5 is hired labour and *CIF* is net revenue for an acre for all four crops while C5 is wage of hired labour/man-day.

Subject to;

**Constraints**

1. Land; L1 + L2 + L3 + L4 $\leq$ 1550 (Acres)

   L1 $\geq$ 0, L2, L3, $\geq$ 0, and L4 $\geq$ 0

**Where:** L1, L 2, L3, and L4 are land (acreage) allocated for crops maize, paddy, beans and onion productions.

2. Labour (i) $H_{mi} X_i \leq B_m$ (ii) $W_i X_i \leq B_{11}$

**Where:** $H_m$ = Average day's farm household/hired labour work in crop i in months M per acre. $B_m$ = Days available for work per month. $W_i$ = Average labour working capital required per acre for crop i. $B_{11}$ = Available working capital, $B_{12}$ = Total land allocated for each crops/households in a scheme.

Given the production activity in the LP matrix, the objective function to be maximized is total net returns subject to resources (Chinneck, 2001). This linear programming was applied as an analytical tool and the results are discussed and presented in chapter 4.

The validation of this model is presented before the LP results of yield, revenue and the optimal plan for crops grown in the scheme.

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSION

### 4.1 Overview

This chapter presents the empirical findings of the study. The findings are presented in a way that allows logical flow of the ideas as governed by study objectives and hypothesis. The chapter begins by describing the farmer's socio- economic characteristic followed by optimal allocation of land and other resources for crop production in the irrigation scheme. The objective function was to maximize net revenue for the purpose of attaining optimal profit of crops to be grown subject to the resources availability in Mwega Malolo irrigation Scheme. The output for the major four crops grown in Mwega Malolo irrigation scheme is presented and lastly factors influencing crop production in Mwega Malolo irrigation scheme.

### 4.2 Socio– Economic Characteristics of the Respondents in Mwega Malolo Irrigation Scheme

#### 4.2.1 Distribution of respondents from the three villages of residence

The present study of Mwega Malolo irrigation scheme included a randomly selected sample of 120 household heads residing in three villages of Mgogozi, Malolo A and B. The result provided in Table 15 show that 50% of the respondents (household heads) were from Malolo A and 25.8% Malolo B, while 24.2% came from Mgogozi village. Moreover the results show that 66% of the respondents were male and 34%were female. All farmers from the three villages grow four main crops, *i.e.* paddy, maize, beans and onions and information collected from them contributed much to this study. The results in Table 15 show the distribution of the respondents from the three villages in Mwega Malolo irrigation scheme.

**Table 15: Distribution of respondents from the three villages of residence**

| Village | Frequency | Percent |
|---|---|---|
| Malolo A | 60 | 50.00 |
| Malolo B | 31 | 25.8 |
| Mgogozi | 29 | 24.2 |
| **Total** | **120** | **100.0** |

### 4.2.2 Age distribution of respondents in the Mwega Malolo irrigation scheme

The results in Table 16 show that 2.5% of the respondents were aged between 18-25 years old, 25.8% of the respondents were aged between 26-35 years. The proportion of respondents in this age category is almost equal to those having age between 46-60 years. The leading group in irrigated agriculture is the one having mid age i.e. between 36-45 which account for 37.5% of the total number of farmers in Mwega Malolo irrigation scheme. Age groups of the respondent above 60 years old are only 9.2%.

It has been reported by FAO (2004) that age has a significant influence on the farmer's decision to adopt technologies and this was also observed true in some studies in the central zone of Tanzania which shown that older numbers of households had more knowledge related to agricultural practices. Age has a significant influence on the farmers' decision to be engaged in adoption of technologies in agriculture production. Also the relevance of the technology in relation to the prevailing constraints and target group in the given dominant farming system is another factor that often influences adoption. Farmers would make decisions to adopt a technology or its components if it is relevant to them. Thus the large proportion of respondents with advanced age is likely to have a positive influence on productivity in the study.

**Table 16: Age distribution of respondents in the Mwega Malolo irrigation scheme**

| Age Groups | Frequency | Percent |
|---|---|---|
| 18 - 25 | 3 | 2.5 |
| 26 - 35 | 31 | 25.8 |
| 36 - 45 | 45 | 37.5 |
| 46 - 60 | 30 | 25.0 |
| Above 60 | 11 | 9.2 |
| **Total** | **120** | **100.0** |

**4.2.3 Distribution of respondents by gender in Mwega Malolo irrigation scheme**

The results in Table 17 show that more male by (65.8%) were engaged in farming activities than female (34.2%). This might be because women had less chance to access land through inheritance, purchase and that being distributed by the village government. However women in Tanzania are the chief labour force in the Agricultural sector. They constitute about 75% of the total labour force which it was estimated to be 19 miliion in 2004 (CIA, 2005).

Also women's employment opportunities outside their home are limited due to inadequate resources. especially lack of access to capital and assets and land, although women are the primary producers of food for family consumption (Wright, 2000). Therefore. due to a family desire to increase income and be able to overcome various economic difficulties at family level including sending children to school, improving the quality of shelter women access to technology, credit and land should enhanced in order to increase their participation in economic activities such as crop and livestock production.

**Table 17: Distribution of respondents by gender in Mwega Malolo irrigation scheme**

| Gender | Frequency | Percent |
|---|---|---|
| Male | 79 | 65.8 |
| Female | 41 | 34.2 |
| **Total** | **120** | **100.0** |

### 4.2.4 The marital status of the respondent in Mwega Malolo irrigation scheme

Table 18 in the present study presents the distribution of marital among the respondents. Marriage was taken to include both formal and informal unions and was categorized as single, married, window or separated. It was important to examine the marital status of the respondents because it can influence the resource owned by a household and the capacity to work on farm. Generally, single people tend to have less own labour as compared to couples other factors remaining constant. The results in Table 18 show that 86.7% of farmers in Mwega Malolo irrigation scheme are married, 8.3% were single, divorced 1.7% and widow were 3.3%.

**Table 18: The marital status of the respondent s in Mwega Malolo irrigation scheme**

| Marital Status | Frequency | Percent |
|---|---|---|
| Married | 104 | 86.7 |
| Single | 10 | 8.3 |
| Divorced | 2 | 1.7 |
| Widow | 4 | 3.3 |
| **Total** | **120** | **100.0** |

### 4.2.5 Education levels of the respondents in Mwega Malolo irrigation scheme

In the study area the level of the education among sampled farmers is generally low, as the results in Table 19 show. With the exception of the three household heads (2.5%) that had secondary school education (12 years) the rest 93.3% had completed primary education

(7 years). Five farmers (4.2%) did not have formal education at all; instead they just attended adult education (Literacy) programs.

In some studies as reported by FAO (2004) that shown that formal education is a key factor in technology adoption. Hence low education of farmers in the irrigated area is likely to lead to low adoption to improved technology which is a key factor in crop production.

**Table 19: Education levels of respondents in Mwega Malolo irrigation scheme**

| Education level | Frequency | Percent |
|---|---|---|
| Primary school | 112 | 93.3 |
| Secondary school | 3 | 2.5 |
| Informal Education | 5 | 4.2 |
| **Total** | **120** | **100.0** |

### 4.2.6 Household size for the respondents in Mwega Malolo irrigation scheme

The distribution of household size and composition for the respondents is provided as Table 20 show that most of the families in the Mwega Malolo scheme have average household size between 4-6 people per family, which is 60% of the farmers engaged in Mwega Malolo irrigated scheme. This average is equal to the number of households in the Kilosa District of 105 635 with average households of 4.6 people (KDC, 2005). The number of respondents with family size between1-3 is only 16.7 % while households that have family size between7-10 is almost equal to the households with 1-3 people i.e. (18.3%). The households with a number of people above 10 is only 5%.

Food production and income are in turn influenced by farm size and land quality, availability of labour, equipments, access to credit and management skills (WB, 2001). Moreover is also influenced by the increase in number of persons living in the households, either by a natural increase (birth) or by in migration. Hence family is one of the sources of labour as an important factor for crops production which depends on many complex factors and involves several activities which require a good number of labour during production and post harvesting activities (DFID and OASIS, 2003).

According to URT (2001) around 42% of Tanzanian's households have adequate food regularly. Moreover, 27% of the Tanzania's population lives in households with expenditure that are insufficient to obtain enough food to meet nutritional requirements. But Tanzania has potential area to expand for food production, and any increase in the use of inputs, such as fertilizer, improved seed and use mechanized equipments could substantially improve production (Bureau of statistics, 1996 cited by Ishengoma (1998). It is important that each household produces sufficient food for its members so as to improve food security situation in their households. The large average of household size their farm sizes amongst others in order to produce enough food for their families and for the market.

**Table 20: Family size of respondents in Mwega Malolo irrigation scheme**

| Household size | Frequency | Percent |
|---|---|---|
| 1 - 3 | 20 | 16.7 |
| 4 - 6 | 72 | 60.0 |
| 7 - 10 | 22 | 18.3 |
| Above 10 | 6 | 5.0 |
| **Total** | **120** | **100.0** |

### 4.2.7 Mode of land acquisition for the respondents in Mwega Malolo irrigation scheme

In Tanzania the recent land reforms under the 1999 land Act have vested the power of issuing rights of occupancy to villagers on the respective village councils. The results summarized in the Table 21 show that most of the farmers in Mwega Malolo irrigation area obtained land through inheritance (64.2%) while those who purchased land were only 28.3% and the chances for those who had plots to get more land either by being allocated by the village government or purchase was very minimum of about 3.3% and 4.2% respectively. This indicates that getting land in improved irrigation scheme of Mwega Malolo is hardly difficult even if they had access to credit due to many farmers to depend on agriculture for their lives.

**Table 21: Mode of land acquisition for respondents in Mwega Malolo irrigation scheme**

| Mode of land ownership | Frequency | Percent |
|---|---|---|
| Inherited | 77 | 64.2 |
| Purchased | 34 | 28.3 |
| Given by village Government | 4 | 3.3 |
| Inherited & purchased | 5 | 4.2 |
| **Total** | **120** | **100.0** |

### 4.2.8 Distance from home to the farm and market for the respondents

The Mwega Malolo local scheme is believed to have existed even before the First World War and has two main canals, left and right of the dead river used as drainage. The results in Table 22 show that the overall minimum distance covered by farmers is 0.25 km with the mean of 2.04 km and maximum distance covered by farmers in the scheme being 10 km. The mean distance covered by farmer is 5 km and maximum was 20 km covering distance for going to farm and returning home. Therefore owning land by either of the sides of the scheme far distance from home reduces the time that should be spent to work.

The improvement of Mwega Malolo irrigation scheme was done by Japan's government through Japan's International Co-operation Argent (JICA) for the total costs of about 6.3 billion in 2002. The scheme comprised of two main canals located left and right from the

Mwega permanent intake. The total allocation of water allowed discharge from the intake is 890 l/s which is diverted into two main canals where the distribution is left main canal 570 l/s while the right main canal conveys about 320 l/s.

**Table 22: Distance from home to the farm for respondents in the Mwega Malolo irrigation Scheme**

| Village | Statistics | Distance from home to the farm (Km) | Time spent from home to the farm (minutes) | Years of cultivating in the same irrigated farm. |
|---|---|---|---|---|
| Malolo A | Minimum | 0.50 | 10.00 | 2.00 |
| | Maximum | 10.00 | 90.00 | 62.00 |
| | **Mean** | **2.33** | **30.00** | **13.60** |
| | Std. Deviation | 2.11 | 18.52 | 11.17 |
| Malolo B | Minimum | 0.25 | 5.00 | 3.00 |
| | Maximum | 5.00 | 20.00 | 50.00 |
| | **Mean** | **1.53** | **15.63** | **11.74** |
| | Std. Deviation | 1.14 | 4.96 | 10.09 |
| Mgogozi | Minimum | 0.25 | 10.00 | 4.00 |
| | Maximum | 8.00 | 60.00 | 20.00 |
| | **Mean** | **1.83** | **29.09** | **8.48** |
| | Std. Deviation | 1.63 | 13.38 | 4.99 |
| **Overall** | Minimum | 0.25 | 5.00 | 2.00 |
| | Maximum | 10.00 | 90.00 | 62.00 |
| | **Mean** | **2.04** | **26.95** | **11.92** |
| | Std. Deviation | 1.85 | 16.16 | 9.90 |

### 4.3 Output Level and Crop Yield for Respondents in Mwega Malolo Irrigation Scheme

Agricultural productivity is dependent on many factors. Some of these factors major ones are level of technology used; soil fertility, and moisture availability which determine the farmers yield level. On other hand profit is determined by the level of yield of the farmer, price offered in relation to production cost per unit area. Thus for irrigation to be beneficial, it must be with the combine use of high yielding varieties, fertilizers and pesticide.

In Mwega Malolo irrigation scheme the level of yield for the major crops are presented in Table 23. The results show that the minimum yield for maize is 1.38 t/acre and maximum 4.6 t/acre this level of yield was low level compared to yield of 7.8 t/acre obtained by some farmers in the same zone. This necessitate farmers in this scheme to adopted improved technology on maize production such as the use of improved seed, fertilizer use, proper spacing and timely weeding of the crop. Paddy yield (mean) is 1.40 t/acre while onion is 6.24 t/acre and beans 0.6t /acre and these yield results show variation of the farmers in adoption of the technology in irrigated agriculture.

The ability to analyze the market and to reflect changing marketing expectations in production schedules inputs purchasing and product selling strategies is an essential component of a profitable farm. Hence the farmer must be aware of the supply and demand relations for the particular product, the impact of consumer incomes and the availability of substitute's product prices as suggested by income and cross price elasticity of and the expected response of other producer to current prices.

To maximize income or even to survive, farmers must not only produce the crop efficiently, but they must also buy the inputs and sell the product at the prices that result in a profit. However, even in irrigated agriculture as reported by Carruthers (1984) that the expected yields in irrigation schemes are not being obtained, technical problems continue, poor planning, financing of operations and maintenance has been inadequate and health problems are created.

The other reasons as reported by World Bank (1981) included water control being poorly managed and not all developed areas are cultivated. However, according to Kohls and Uhl (1990) the need for price and cost data to make adequate farm management decisions underscore the necessity for expertise in the field of marketing. Also the level of technology used in production determines the yields and quality of produce.

**Table 23: Yields for various crops in Mwega Malolo irrigation scheme**

| Crop | Statistics | | | |
|---|---|---|---|---|
| | Minimum (tones /acre) | Maximum (tones /acre) | Mean (tones /acre) | Std. Deviation |
| Maize | 1.24 | 4.60 | 1.38 | 2.57 |
| Rice | 1.20 | 5.00 | 1.40 | 3.05 |
| Beans | 0.42 | 2.00 | 0.6 | 1.02 |
| Onions | 3.90 | 10.54 | 6.24 | 6.53 |

## 4.4 Revenue for Crops Grown by the Respondents in Mwega Malolo Irrigation Scheme

To maximize income or even to survive, farmers must not only produce the crop efficiently, but they must also buy the inputs and sell the product at the prices that result in a profit. The results in Table 24 show different net revenue of the four crops in Mwega Malolo irrigation scheme.

The net revenue for bean crop of Tshs 611 161 per acre as value for the low limit while upper limit value is indicated as *"Open"* means the net revenue can rise as high as possible depending on increased price offered and cultivated piece of land while other factors remaining constant. It has been supported by Mkunda (2006) that the producers are constrained by lack of storage facilities hence produce were often sold direct from the field by farmers. But storage facilities normally add value due to differences in time (temporal arbitrage). Onion net revenue starts at the present net revenue of Tshs 414 725 up to Tshs 3 069 577 as upper limit.

**Table 24: Revenue for crops grown by respondents in Mwega Malolo irrigation scheme**

| Crops | Level | Maize | Paddy | Beans | Onions |
|---|---|---|---|---|---|
| Land (acres) | | 1.00 | 1.00 | 1.00 | 1.00 |
| Net Revenue | Low limit | 215 611.56 | 293 791.28 | 82 572.81 | - |
| (Tshs) per acre | Present N.R | 279 158.00 | 366 018.00 | 611 161.00 | 414 725.00 |
| | Upper limit | 347 787.22 | 473 893.22 | Open | 3 069 577.80 |

### 4.5 Socio- Economic Factors Influencing Crop Production in Mwega Malolo Irrigation Scheme

The study also determined the main factors that influence crop production in Mwega Malolo irrigation scheme with two dependent variables of land size and then total revenue for all crops. The same explanatory variables were used in order to make both models comparison. The results in Table 25 show that the four major factors (explanatory variables) had influence in crop production in both models when dependent variable is land and total revenue. The four factors which had significant influence in crop production in Mwega Malolo irrigated agriculture are gender, education level, water availability for irrigation and household size.

Each of the factors is discussed separately on how it influences the crop production in the scheme while the dependent variable is land and the same reasons are for assumed to be applicable revenue. According to World bank (2001) some of the constraints to sustainable agriculture production in Tanzania are poor maintenance of irrigation facilities, poor road networks and marketing systems, low use of technology (Extension services), in adequate and unreliable rainfall (Both vuli and main season) and lack of effective farmer's organization and cooperatives. While, the report by FAO (2002) constraints facing agriculture production are weak research and extension support, inadequate and irregular input supplies, use of insufficient traditional methods of production and agricultural products are subjected to frequent price fluctuations.

**Table 25: Socio – economic factors influencing crop production in Mwega Malolo irrigation scheme**

| Variables | Unstandardized Coefficients | | Standardized Coefficients | | | |
|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | t | Sig. | |
| **(Constant)** | -0.80 | 0.69 | 0.21 | -4.16 | 0.03 | ** |
| Gender of respondents | -1.01 | 0.74 | 0.39 | -4.46 | 0.02 | ** |
| Education levels of respondents | -0.02 | 0.53 | 0.00 | -4.01 | 0.04 | ** |
| Water availability for irrigation | 0.36 | 0.44 | 0.18 | 4.09 | 0.04 | ** |
| Household size | 0.04 | 0.41 | 0.35 | 3.63 | 0.05 | ** |
| **Dependent Variable: Land size for irrigated agriculture** | | | | | | |
| (Constant) | -48 423.65 | 405 607.21 | 0.17 | 2.10 | 0.05 | ** |
| Gender of the respondents | 240 816.30 | 119 204.26 | 0.21 | 2.02 | 0.05 | ** |
| Education levels of the respondents | 66 767.96 | 277 813.82 | 0.03 | 4.22 | 0.02 | ** |
| Water availability for irrigation | -13 967.88 | 140 627.95 | 0.01 | 2.42 | 0.04 | ** |
| Household size | 32 514.11 | 24 655.87 | 0.14 | 4.78 | 0.01 | ** |

Dependent Variable: Total revenue for irrigated agriculture

**** means significant at 0.05 (P<0.05)**

### 4.5.1 Effect of gender of respondents on crop production in Mwega Malolo irrigation

Gender as results in Table 17 shows that more male by 65.8% were egged in farming activities while only 34.2% were female involved in irrigated agriculture. The low number of female engaged irrigated agriculture might be because women had less access to land through inheritance compare to men due customs.

Despite the women in Tanzania being the chief labour force in the agricultural sector. constituting about 75% of the total labour force and estimated to be 19 million in 2004, yet their involvement in agriculture is still low (CIA, 2005). Also women's employment opportunities outside the home are limited due to inadequate resources. especially lack of access to capital and assets, although women are the primary producers of food for family consumption (Wright, 2000). However participation of men. women, youth and children in improvement and production will be very helpfully in decision making. planning, implementation and development of water resources more sustain ably in irrigation scheme (Kasambala, 2004).

### 4.5.2 Education levels of the respondents in Mwega Malolo irrigation scheme

In the study area the level of the education among sampled farmers is generally low. Where most of farmers 93.3% had completed primary school (7 years). In some studies as reported by FAO (2004) that formal education is a key factor in technology adoption. Hence low education of farmers in the irrigated area indicated the low adoption in technology which is a key factor in crop production. The demonstration plots can be used as extension methods with reason that by natural farmers are an inquisitive lot for them, seeing is believe (TARP II SUA Project, 2004).

### 4.5.3 Effect of water availability for crop production

Water is an important natural resource required for crop production from initial stage of land preparation, general plant growth and good yield for ensuring food security of the society. The low available water resource has direct effect on the agricultural production, hence lowering food availability (Kasambala, 2004). A proper understanding of irrigation schedule by farmers is therefore important if efficient use of water, energy and other production inputs such like fertilizer are to be realized. However, much water to apply normally depends on the state of depletion in the soil requirements and the water holding characteristics of the particular soil (TARP II SUA Project, 2004).

### 4.5.4 Household size of the respondents in Mwega Malolo irrigation scheme

Family is one of the sources of labour as an important factor for crops production which depends on many complex factors and involves several activities which require a good number of lab ours during production and post harvesting activities (DFID and OASIS 2003). The house hold size and composition have influence on crop production as a major source of family labour in the Mwega Malolo irrigation scheme. As reported by WB (2001) that food production and income are influenced by farm size and land quality, availability of labor, equipments, access to credit and management skills.

Moreover, availability of labor is influenced by the increase in number of persons living in the households, either by a natural increase (birth) or by in migration. It is important that each household produce sufficient food for its members so as to improve food security situation in the households.

### 4.6 Validation of the Model

#### 4.6.1 Overview

According to Rodriquez and Ball (1980) model validation is an important part of any empirical economic analysis and can be utilized in many ways but cannot be utilized with confidence unless it is considered a valid portrayal of the system modeled. Systematic approaches to validation of linear programming models are discussed in two categories which are prescriptive and predictive applications to economic problems as reported by (Mc Carl, 1982). Validation is necessary for both and all categories of LP model use, though procedures may be tedious and time consuming, but they will often lead to improvement in programming models and can be valuable in providing the researcher with insight into the behavior of the model and the interpretation of model.

#### 4.6.2 Type of Linear Programme validation used in the study

There are two types of LP model validations that are validation by construct and by results. The approach of linear programming validation that has been selected for this model tool is validation by construct. As reported by Mc Carl (1982) the Validation by construct is the most common type of LP model validation and is the sole method of validation in most cases and is justified by the arguments that procedure believed to be appropriate by the model builder and events occurring in theory or knowledge of the problem strongly dictated it a prior validating the model consideration of all the important items has been taken in account as advised and these are:-

i) Careful to precisely articulation of what is to be optimized was observed as follows:-
   a) Deciding a product schedule (How many A's and B's and C's to produce) so as to minimize costs,
   b) Decide a product schedule so as to maximize revenue,

c) Finally, sufficient data are included that could decide a production schedule to maximize profit contribution equal to revenue minus cost.

The sufficient variables of costs and revenues for production mix of crops Mwega Malolo irrigation scheme made possible to determine that production (optimal Plan) that can maximize profit contribution so as to sub- optimize with a product schedule.

ii) All the components of the model which need to be validated were considered first as recommended to be considered before doing any type of validation. In LP linear problems solving all procedures were followed as suggested by the model in which the formulation of linear problem, the translation of world problem statement into mathematical equation was done and the output of a LP model consisted three important components namely:-

a) Optimal values of the primal decision variables,

b) Dual variables, and

c) The objective function.

The LP model results of optimum land plan and range of optimality for the crops grown in Mwega Malolo irrigation scheme are presented in section 4.7. where for optimal profit maize crop production require only 168.82 (acres), paddy 249.60 (acres), onion 290.66 (acres) and beans 126.76 (acres) out of the total 1550 acres in the Mwega Malolo irrigation scheme.

iii) Production schedule to maximize profit tailed with the crop calendar prepared by the Ward extension officer in collaboration with key farmers and accepted by all farmers in the scheme as well in LP model the four major crops of maize, paddy, beans and onion were accepted by the Linear Programme in the analysis though a limit size of the area (835.84 acres) is proposed for the purpose of optimal profit. The other area (714.16 acres) can be utilized in the next season with respect to crop calendar in the same year under the recommended agricultural techniques presented in chapter 4 in order to attain the optimal revenue.

According to guide in agricultural optimization in this case may mean to decide a production schedule that is decide a product schedule (How many A's and B's and C's to produce) so as to minimize or get production schedule so as to maximize revenue provided sufficient data are collected and used to reach decision on production schedule. The production schedule is well presented by crop calendar as cropping intensity and cropping pattern governed by climatic condition such as a rainfall or Dry season as well as market forces. Crop calendar provides information on sequence of the crop and on timing of their cultivation *i.e.* transplanting, sowing dates, harvesting agreed by the farmers in the scheme. Hence based on the three reasons mention above "*the model is judged valid.*" for this study and the LP results are presented in section.4.7

## 4.7 Optimal Allocation of Land and other Resources for Crop Grown in Mwega Malolo Irrigation Scheme

### 4.7.1 Model Parameters

The results in Table 26 show linear programming parameters used in determining optimum land allocation plan in acres for four crops namely maize, paddy, beans and onions. The results show that two resources namely monthly labour and land were used in determining the plan. In view about labour, on using estimated ratios for monthly labour requirements for each crop, parameters for labour requirement and available were calculated. While labour requirements for maize and paddy happen from January to July, for beans and paddy take place from August to December. However due to unavailability of the mechanization equipments in the irrigation scheme high labour requirements for all agronomic practices of all crop especially initial activities of land preparation and others relative to their monthly labour requirements for example maize in December land preparation and ridge formation need (29.14 Mandays) while paddy has high (59.51 Mandays) per acres due land preparation, paddling and transplanting activities, in June beans require (24.18 Mandays) and Onion (37.49 Mandays) as the results in Table 26 shows the different labour requirements in a year.

**Table 26: Parameters used in the linear programming model**

| Crops grown | Maize | Paddy | Beans | Onions | |
|---|---|---|---|---|---|
| 1.Monthly Required labour (Mandays) | | | | | Monthly available labour (Mandays) |
| December | 29.14 | 59.51 | - | - | 25 284.00 |
| January | 27.20 | 9.15 | - | - | 16 052.10 |
| February | 7.44 | 12.63 | - | - | 4 408.50 |
| March | 14.88 | 0.96 | - | - | 4 074.60 |
| April | 5.46 | 26.63 | - | 37.49 | 4 445.60 |
| May | 13.86 | 15.16 | - | 28.23 | 14 431.00 |
| June | 7.44 | 7.58 | 24.18 | 20.98 | 12 776.10 |
| July | - | - | 21.98 | 4.20 | 4 314.25 |
| August | - | - | 14.18 | 11.54 | 5 153.25 |
| September | - | - | 3.55 | 17.83 | 5 632.45 |
| October | - | - | 14.18 | 13.64 | 5 763.05 |
| November | - | - | 2.84 | - | 360.00 |
| 2. Land resource Land ( acres) | 1.00 | 1.00 | 1.00 | 1.00 | - |
| Net profit (Tshs) per acre | 279 158.00 | 366 018.00 | 611 161.00 | 414 725.00 | - |

### 4.7.2 Optimum land allocation plan and range of optimality

Linear Programming software developed at Wye College of the University of London was used to generate the optimum plan. Results in Table 27 show that all crops, maize, paddy, onion and beans are included in the plan. The plan further shows that in order to maximize profit, 168.82 acres (20%) should be allocated for maize, 249.60 acres (30%) for paddy, 290.66 acres (34.8% ) for onion and 126.76 (15.2%) for beans. On perfecting the plan, the harvest will generate total net profit amounting to Tshs 336 501 384 which is an equivalent of net profit per acre of Tshs 279 158 for maize, Tshs 366 018 for paddy, Tshs 414 725 for onion, and Tshs 611 16! for beans.

**Table 27: Optimum land allocation plan, lower net revenue and upper revenue in Malolo**

| Crop | Land allocated in acres | Land distribution (%) | Lower limit for revenue (Tshs) | Present net revenue (Tshs) | Upper limit for revenue (Tshs) |
|---|---|---|---|---|---|
| Maize | 168.824 | (a) 20<br>(b) 11 | 215 611.56 | 279 158.00 | 347 787.22 |
| Paddy | 249.600 | (a) 30<br>(b) 16 | 293 791.28 | 366 018.00 | 473 893.22 |
| Onion | 290.659 | (a) 34.8<br>(b) 18.7 | 0.00 | 414 725.00 | 3 069 577.80 |
| Beans | 126.761 | (a) 15.2<br>(b) 8.2 | 82 572.81 | 611 161.00 | Open |
| **a)Total land allocation in** (optimal plan) | **835.844** | **53.9** | **1.00** | **1.00** | **1.00** |
| **b)Total land** ***(Scheme)*** | **1550** | **100** | - | - | - |

### 4.8 The Revenue of the Optimal Plan

According to the Optimal Plan for Mwega Malolo irrigation scheme (1550 acres) the maximum net revenue that can be obtained is Tshs 336 501 384 which is an increase of about 22% compared to total revenue of Tshs 261 210 609 for all crops from the study area without the plan. Revenues of the crops grown in Mwega Malolo irrigation scheme are subject to price fluctuation, and this was supported by Mkunda, (2006) that producers were constrained by lack of storage facilities and these produce some were often sold direct from the field. Hence the construction of storage facilities is important to farmers for adding value of produce due to the advantage of increased price due to differences in time (temporal arbitrage) and hence attaining high prices at post harvesting time.

#### 4.8.1 Growing of Paddy

The results of optimal plan are that all four major crops can be grown in Mwega Malolo irrigation scheme. Paddy as a staple food requires in an acre had lower limit net revenue of Tshs 366 018 with high demanding labour 59 Mandays during land preparation in November and December. However its net revenue at harvesting time is Tshs 293 791 per acre and upper limit is Tshs 473 893 considering the net revenue at lower limit and upper limit the difference is small due to costs of production of land preparation, transplanting, water management and post harvest activities cost of the crop. Also low net revenue is contributed by low and high fluctuation of prices of many agricultural produce year after year. Though paddy needs more labour than the other three crops, still is more preferred and highly recommended to be grown in irrigated schemes due to fact that it can be grown twice to generate the net revenue in regard to fixed land available many in irrigated schemes and its potential use as staple food and source of income.

#### 4.8.2 Onion

Table 28 shows that it requires an acre of land to earn net revenue of Tshs 414 725 (Lower limit) while the upper limit increases up to Tshs 3 069 577 at the post harvesting time. Also the crop has high demanding labour of 37.49 Mandays during land preparation and between 17 to 13 Mandays. However in a good season /year after storing the produce farmer can earn more net revenue of Tshs 3 069 577 per acre at the post harvesting time.

#### 4.8.3 Beans

The third crop in the plan is bean which has a net revenue of Tshs 611 161 (lower limit) while upper limit can be attained at high net revenue (open) depending on the flexibility of the decision variable of capital, labour and allocated land for production as Slack variable. Beans have other advantages of fixing nitrogen in the soil thus improving the soil structure and water retention capacity in spite of being intercropped by other crops like maize.

#### 4.8.4 Maize crop

In the study area maize crop is grown as a staple food and has low net revenue of Tshs 215 611 per acre while at upper limit the net revenue is Tshs 347 787 per acre. Also during harvesting time farmers obtain maize from Malolo local market scheduled twice a month. However, maize crop can be intercropped by beans with an advantage of bean being short and can fix nitrogen in the soil at the same time bean remains can add nutrients and improve soil composition in the same piece of land in irrigated area. The other advantages of intercropping maize and beans in irrigated area are:-

a) To increase yield per unit area,

b) To improve moisture retention capacity,

c) To improve soil fertility,

d) To obtain two or more crops from one area.

Intercropping technology is observed as the traditional farmer practice which has been widely adopted, reflecting the relevance and the appropriateness of the technology in the area due to land constrains with the outgoing variable.

General observations of the optimal plan of growing all crops in Mwega Malolo irrigation scheme there are two basic things:-

i) Price fluctuation and middle men contribute at large for the low net revenue earned by smallholder of Malolo farmers. Middlemen took advantage of purchasing crop at low price during harvesting time. Farmer had no power to bargain for price of their crop, this problem is exacerbated by lack of storage facilities and financial buffering scheme where farmers can keep their produce and obtain some money while waiting for better price for their crop in a letter period,

ii) Land as constraint is a limiting factor for expansion and more production of the irrigated crop to households in Mwega Malolo irrigation scheme. As it was reported by Ifejika and Wiesmanna (2006) land is a basic factor for crop production. In the study the overall size land owned for different crops in Mwega Malolo scheme is 2.31acre available land for irrigation and only an average size of 1.01 acre can be hired in the scheme.

# CHAPTER FIVE

## 5.0 CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusions

The results of the present study make it possible to conclude that the plan can be adopted by Smallholder farmers of Mwega Malolo irrigation scheme in order to maximize net revenue. Also there is significance influence of socio economic factors to output of maize, paddy, beans and onion in Mwega Malolo irrigation scheme. However, recommendations provided are based on the results of the study area and highlight priority in provision of technical issues for high crop yields and revenues which improve standard of living as well for poverty reduction of small scale farmers in Mwega Malolo irrigation schemes.

Also optimal net revenue in Mwega Malolo irrigation scheme can be reached if the improved techniques are adopted through extension services, and use of both agricultural inputs and equipments in the presence of strong water users association (CHAUMWE).

### 5.2 Recommendations

In order to attain maximum net revenue of Tshs 336 501 384 (Optimal plan) in Mwega Malolo irrigation scheme the following technical recommendations should be adhered:-

#### 5.2.1 Agricultural extension services

Due to limited number of extension staff an approach of farmer to farmers should be employed in provision of extension services. Under this approach a key farmer demonstrates good farming practices by emphasizing an outstanding local example which creates conducive tearing environment in the irrigation scheme.

Activation of the agricultural extension services by provision of working materials (Extension kit) to assist extension services provider to effectively conduct method and results demonstrations of irrigated farming technology for different economic crop production in Mwega Malolo irrigation scheme. Transport and training packages for extension staff are also ideal.

**i) Agricultural inputs**

Access to agricultural inputs is important as the provision of proper knowledge or skills to farmers as well many inputs are not effective unless they are used in combination with other inputs in a skilled fashion. Therefore placing mind emphasis on initiative cultivation by structural utilization of modern farming inputs such as fertilizer, pesticides, herbicides, improved seeds and improved techno lodge for attaining higher yield (Green revolution).

**ii) Agricultural equipments**

The type of farm implements available to farmer determine how fast different farm activities/operations can be caried out such as ploughing, and weeding (adhering to crop calendar). Farmers without the improved tools and implements are like to plough and plant late. Creation of enabling environment and provide proactive support to CHAUMWE (appending for subsidy system) this can enable them to afford buy equipments such as power tiller, different tools and access to agricultural inputs in time. Also these will reduce high labor requirements and costs of production in Mwega Malolo irrigation scheme hence high revenue.

### 5.2.2 Storage facilities

The importance of storage facilities normally adds value due to difference in time (temporal arbitrage) by attaining high prices at post harvesting rather than selling produce direct from the field. Therefore, consolidating construction of the go-downs and storage facilities for crop produce and farm inputs by CHAUMWE which will reinforce the supply system of agricultural inputs such as certified seeds, fertilizer and agro- chemicals. Credit can be raised through water users' organization efforts (CHAUMWE) by contribution capital from their own crop if they set objective. Farmers can store produce in their go-downs and these produce later can fetch high prices and avoid selling direct from the field by low prices.

### 5.2.3 Agricultural products processing

Processing of agricultural products by farmers in Mwega Malolo irrigation scheme is important hence adds value to agricultural products before marketing the products to consumers. It has the advantage of creating utility by altering the product in some ways from raw state and adding value to agricultural produce by growers before selling to consumers. Therefore, farmers of Mwega Malolo irrigation scheme should start processing of agricultural crops like rice by using rice huller and maize flour in order to add value.

### 5.2.4 Agricultural research

Agricultural development in most developed countries comes out as a result of a serious research work aimed at solving problems facing farmers in their fields. A research on irrigated agriculture in our irrigation scheme is important in order to develop new technologies on improved tools, and equipments, improved seeds which influence crop production to the small scale irrigation farmers.

### 5.2.5 Farm road and access to market

The provision of good road systems by local and central Government in Mwega Malolo irrigation scheme enhance agricultural productivity by reducing marketing margins and commodity reach at the right time and place. However, good roads act as an economic catalysis and a primal mover of development in the processing of growth. Therefore consolidation of truck roads as well as access roads to the scheme areas is important hence facilitates both marketing of crop produce, easy transportation, and access to farm inputs which reinforces supply system of agricultural inputs such as certified seeds, fertilizer and agro- chemicals to the farmers of Mwega Malolo irrigation scheme.

### 5.2.6 Income diversification

Though off farm income generating opportunities in rural areas are limited in most location as well as dependency on irrigated agriculture, vulnerable to weather fluctuations and crop cycles. Therefore we recommend diversification to other activities are that increase income by introducing new crops, agro- processing, food distribution, small scale manufacturing, and equipment repair and rented, tourism mining and services sector activities. The other advantages is that diversification assets can reduce the risk of atrophic loss, for example, when a households relies on the mono cropping system, it could easily be bankrupted by a single crop loss countray to a household that relies on a diversified base of crops and livestock and other non farm activities such as handicraft, income could easily survive until next harvest.

### 5.2.7 Water users association

Improvement of the water management especially in Tanzania rests on the beneficiaries (farmers) who are now entrusted with the operation and maintenance of the irrigation schemes. Based on the constitutional scheme members (CHAUMWE) should have plans stipulated in their constitutional for strengthening their organization and improving operation and maintenance of their irrigation scheme as a means of saving water for irrigating more land sustain ably. Also for easy management and implementation of the scheme, by laws and other operation aspects including having a schedule for holding meeting. Recommended meeting specifically to irrigators group, scheme committee and general assembly are ideal to address such things like collection of water fees and introduction of the special account to cater for depreciation of the irrigation system.

As such to make this endeavor to reality, more seminars and training efforts by KATC institute, Kilosa district and Zonal irrigation Office should be directed to Mwega Malolo irrigation farmers actively in improvement of water management techniques in the scheme in collaboration with the irrigation personnel.

### 5.2.8 Financial services

*Chama Cha Umwagiliaji Mwega Malolo* (CHAUMWE), as a co-operative is supposed to cater for maintenance of irrigation facilities and provision of credit services of inputs. Hence, not all farmers can afford to purchase inputs directly unless there is already a well organized system for farm credit services provision either through their water users' organization association (CHAUMWE). Therefore, ways of raising fund and management and maintenance of the infrastructures is ideal for sustainability of the scheme.

### 5.2.9 Conservation of environment and water management

Priority should be targeted for provision of technical training courses especially those related to technology for conservational and irrigation- based agricultural production to small scale farmers of Mwega Malolo in irrigation scheme. The overall objective on Participatory conservation of environment and water management within the scheme, catchment and sub catchments should be well understood and shared by all irrigators. RWH as a viable option for agriculture which can upgrade water for irrigation in areas with annual of as low as 300mm as at Mwega Malolo scheme. If RWH is stored or directed to the main canal at the tail can increase availability of water, increased water efficient and even expansion of irrigated area hence contribute in ever increasing food production for overcoming need of huge population in the dry rural areas.

## REFERENCES

Anyelwisye, B. (2007). Impact of microfinance institutions on poverty reduction among smallholder farmers: Case of selected saccos in Dodoma urban and Kongwa Districts. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 89pp.

Ashimogo, G.C. (1996). *Agricultural Marketing Liberalization in Tanzania. History and Prospects.* Discussion Paper Presented at Workshops on Country Policy Review, SUA Morogoro, Tanzania,1-9 April 1996. 37pp.

Banturaki, J. A. O. (2000). *Cooperative and Poverty Alleviation.* TEMA Publishing Company Ltd., Dare s Salaam, Tanzania. 148pp.

Bureau of Statistics, (1996). *Women Affairs and Children Analysis of African Women and Men: The Tanzania case.* Government Printer, Dare s Salaam. 35pp.

Carruthers, I. (1984). Irrigation Investment. A problem, Palliative or Panacea for Agricultural Development. In: *Aid for the Development of Irrigation*: OECD Ltd. Paris. 45pp.

CIA, (2005). The World Fact Book. *[Http//:www.cia.gov/cia/publications/fact book/geos/tz.html]* site visited on 11/05/2009.

Chinneck, J.W. (2001). Practical Optimization: A Gentle Introduction. *[Http//: www.sce.carleton. ca/faculty/chinneck/po.html]* site visited on 19/06/2009.

Davis, J.R. (2003). *The Rural Non Farm Economy, Livelihoods and their Diversification: Issue and Options.* NRSP (DFID) World Bank, NRI University of Greenwich, UK. 87pp.

Ekman, E., and Anderson, N. (1998). The Economic of on farm processing: Model development and an empirical analysis. *Journal of Economics* 52 (2): 117-120.

Falkenmark, M. and Rockstron, J. (2004). *Balancing Water for Humans and Nature:* The New Approach in Ecohydrology. Earthsoan, London. 247pp.

Food and Agriculture Organization (1996). Water and Food Security: World Food Summit in Rome. *[http://:www.World -Food Summit]* sited visited on 12/06/2009.

Food and Agriculture Organization (1997). *The State of Food and Agriculture: Food and Agriculture Organization of the United National*, FAO, Rome. Italy. 24pp.

Food and Agriculture Organization (2002). Crops and Drops: Making the Best Use of Water for Agriculture, World Food Day. FAO, Rome, Italy: *[*http://www.fao.org*]* site visited on 13/05/2009.

Food and Agriculture Organization (2004). Nutritional Problems in Sub- Saharan Countries. FAO, Rome. Italy. *[http://www.fao.org]* site visited on 07/07/2009.

Gabagambi, D.M. (1998). Evaluation of agricultural marketing efficiency in Tanzania: A case study of paddy and cotton in Ulanga District. Dissertation for Award of MSc Degree at Sokoinea University of Agriculture, Morogoro, Tanzania. 137pp.

Hayami, Y., Kavagoe, T., Moroka, Y. and Siregar, M. (1988). Increase and employment generation from agricultural processing and markerting: The Case of soyaabeen in Indonesia. *Agriculture Economics Journal* 1 (19): 327-339.

Henderson, J. (1959). The Utilization of agricultural land a theoretical and empirical inquiry. *Revised Economics and Statistics Journal* 41: 242-259.

House, P and Ball, R, (1980). Validation: A Modern day Spine Hunt: Conceptual Difficulties of Validation Models. In: *Validation and Assessment of Issues in Energy Models: Proceedings of Workshops, National Bureau of Standards (Edited by Gass S.I)*. Spec Publishing Company Ltd. Washington, D.C. pp.164.

Ifejika, S. C. Wiesmanna, U. (2006). Post Harvest Management Strategies: Draught Vulnerability and Food Security. *[Http://:www.cde.unibe.ch./CDE/Publist-staff-cd.asp]* sited visited on 21/05/2009.

Ishengoma, C. G. (1998). The role of Women in household food security in Morogoro Rural and Kilosa District. Unpublished Theisis for Award of PhD Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 371pp.

IITA, (2004). Cassava *[Http://:www:iita.org/ crop/cassava html]* sited visited on 18/05/2009.

IWMI, (2000). *World Water Supply and Demand: 1995 to 2025.* International Water Management Institute, Colombo, Srilanka. 23pp.

JICA, (2000). The Role of in Irrigation, Food Security and Poverty. [*Http://:wwwerb. go.tz/3rd –AED proceedings/chiza.pdf]* site visited on 23/5/2009.

Kasambala, S. P. (2004). Assessment of water resources for food security in Tanzania. An application policy dialogue model (Podium). Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 119pp.

Kagubila, M. M. (1996). *Performance Measurement in Farming Projects: The Case of Kimani Irrigation Project Tanzania.* Paper Presented at International Workshop on FM Performance, Mendoza, 12-15 November, 1996. 15pp.

KATC PHASE I (1996). Rice and People in Tanzania: Linkage between Research and Extension. KATC Newsletter of January, Volume 1 Issue No 3. P. 1.

KATC PHASE I (1997). Rice and People in Tanzania: Water Management in Irrigation Scheme. KATC Newsletter of January, Volume 2 Issue No. 3. P. 2

KATC PHASE II (2004). Realizing the Importance of Irrigated Rice Cultivation. KATC Newsletter of January, Volume 1 Issue No. 2. P. 2.

KATC PHASE II (2005). World Food Day: Focus on Mechanized Agriculture. KATC Newsletter of July December Volume 1 Issue No. 4. P. 4.

Kavana, P. and Mkangwa, C. Z. (2006) *Monitoring and Evaluation Annual Report: Eastern Zone client orientation research and Extension project.* Mzumbe Publishing, Morogoro , Tanzania. 89pp.

KDC, (2005). District Development Vision 2015 MKUKUTA Document, (Unpublished) Kilosa District Council. 58pp.

Kharallal, M and Kirstern, J. (2001).The Institution Economics: Application for agriculture policy research in development cooperation. *Institutional and Theoretical Economic Journal* 154 (2): 1-15.

Khou, K. L Y. (2004). Chinas Experience with Agricultural Cooperative in the Era of Economic Reform. In: *Cooperative: Issues and Trends in Development Countries. (Edited by Trewin, R)*, 24-25 March 2003 Perth Australia. 9-21pp.

Kohls, R. I and Uhl, J. N. (1990). *Marketing of Agricultural Products.* Macmillan Publishing Company, New York. 385pp.

Kutcher, G.(1983). A Regional Agriculture Planning Model for Mexico Pacific Northwest. In: *Programming Studies for Mexican Agricultural Policy (Edited by Norton, R and Solis, L)*, Johns Hopkins Press, New York. Chapter 11

Lemweli, I.O. N. (1992). Economic analysis of the effects of Government intervention on production, marketing and consumption of rice in Tanzania. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 143pp.

Limbu, F. (1993). Efficieny of rice marketing systems in Tanzania. Theisis for Award of PhD at Berling University, German. 112pp.

Maliyamkono, T. L and Bagachwa, M. S. D. (1990). *The Second Economy in Tanzania.* ESAURP and Heiremem, Nairobi, Kenya. 197pp.

MAFS (2002). Agriculture Development Programme Strategy. [*Http://:www.drd.mafs.go.tz/asds.pdf]* site visited on 25/06/2009.

Mc Carl, B. (1982). Cropping activities in agricultural sector models: A methodological proposal. *Agricultural Economics Journal* 64 (4): 768-772

Mc leod, A. (2006). Types of Co-operatives. *[Http//:www.co-operative.Info]* site visited on 16/06/2009.

(MDB), (1994). *Marketing Development Bureau 1993/94*: *Industry Review of Cotton.* MALD, Government Printer, Dares Salaam, Tanzania. 80pp.

Mkunda, J. J. (2006). Commodity (Rice) chain analysis in Tanzania: A case of Morogoro region. Dissertation of Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 82pp.

Mirau, M. (2007). Analysis of coffee marketing system in Arumeru District. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 100pp.

Mlambiti, M. E and Mlay, G. I. (1997). Agricultural development opportunity and constraints. In: *The Petal of Ulanga District Potential Constraints Current Resource Utilization and Food Security of District. (Edited by Mlambiti M. E and Mlay G. I)*. Sokoine University of Agriculture, Tanzania.pp.134- 162.

Msambichaka, L. A, Ndulu, B. J. and Amani, H. R. K. (1983). *Agriculture Development in anzania. Policy Evaluqtion, Performance and Evaluation. The First two – Decade of Independence.* Gottiger Tageblatt Gmbtt & Co. Coloque. Bonn Germany. 283pp.

Ngingi, S. N. (2003). What is the Limiting of Up- Scaling Rain Water Harvesting in a River Basin? *Physics and Chemistry of the Earth Journal* 28: 943-956.

Nzobonarihba, I. J. (2007). *Challenges on Irrigation Development in Tanzania.* Paper Presented in Asian Agricultural Seminar held in Tsukuba, Japan on 15 September. 2pp.

OASIS and DFID, (2003). Water for Food Security. *[Http://:www.lboro.ac.uk/ well/resources/waterdome-fact-sheets/food]* site visited on 16/04/2009.

Paris, Q. (1981). Multiple optimal solutions in linear programming models. *Agricultural Economics Journal* 63 (4): 724-727.

Putterman, L. (1995). Economic reform and smallholder agriculture in Tanzania. *Discussion of Recent Marketing and Technology Dissemination Effort World Road Libelization and Development Journal* 23: 311-326.

Reppello, R. S and Cavalcanti, M. (1995). Original of Co operative. *[Http: //:www.fao.org/DOCCP. Html]* sited visited on 22/05/2009.

Rhoda, S. (2001). *Gender in Irrigated Areas.* Paper Presented at the National Irrigation Conference, Held at the Tanesco Institute Morogoro, Tanzania, 20- 22 March, 2001. 16pp.

Rodriquez, G. and Kurkel, D. (1980). Model validation and the Philippine pogramming models. *Agricultural Economics Journal* 32 (4): 17-25.

Rosegrant, M., Cai, X., Clire, S and Nakagawa, N. (2002). *The Role of Rainfed Agriculture in The Future of Global Food Production: Environmental and Production Technology Division (EPTD).* International Food Policy Research Institute, Washington. DC. 105pp.

Rutabinga, P. (1992). *Transportation Economics, Policy and Management Research Information.* Mzumbe Publishing, Morogoro, Tanzania. 189pp.

Sahi, R and Craddock, W. (1974). Estimation of flexibility coefficients for recursive programming models alternative approaches. *Agricultural Economics Journal* 56 (2): 344-350.

Shephered, A.W. (1997). *Market Information Services: Theory and Practices*. FAO of UN. Rome, Italy. 19pp.

Santorum, A. and Tibaijuka, A. (1992). Responses to Food Marketing Liberalization in Tanzania. *Food Policy Journal* 17 (6): 431-442.

Seetharanman, S. P; Shingi, P. M. (1992). *Agribusiness Co-operatives*. Oxford & IBH Publishing Co. Ltd. New Delhi, Bombay, India. Calcutta.12pp.

Slee, R. W. (1991). Farm diversification an on farm processing. Scottish. *Agricultural Economics Journal* 6: 39-49.

TARP II SUA Project, (2004). *Irrigation Water Management in Farmers Managed Irrigation Systems: A guide for Farmer Groups and Extension officers*. TARP II SUA Project, Morogoro, Tanzania. 59pp.

Tewin, R. (2004). Introduction, In: *Cooperative; Issues and Trends in Developing Countries*. (Edited by Tewin, R) 24-25 March 2003, Perth, Australia pp 1-2.

URT, (1995). *Morogoro Statistical Abstract 1993*. Presidents Office, Planning Commission, Government Printer, Dare s Salaam. 40pp.

URT, (1997). *Tanzania Demographic and Heath survey*. Bureau of Statistics, Government Printer, Dare s Salaam. Tanzania. 156pp.

URT, (1999). *Morogoro Statistical Abstract 1993*. President's Office, Planning Commission, Government Printer, Dare s Salaam .Tanzania. 40pp.

URT, (2000). *National Microfinance Policy*. Government Printer, Dare s Salaam, Tanzania. 27pp.

URT, (2001a). *Crop Production. Trends in Tanzania*, Ministry of Agriculture and Food Security, Government Printer, Dare s Salaam. Tanzania. 86pp.

URT, (2002). *Morogoro Region Social Economic Profile*. (Second Edition) Government Printers, Dare s Salaam. Tanzania. 228pp.

URT, (2003).Tanzania 2002 Population and Housing Census General Report 2003. [*Http://:www.tanzania.go.tz]* site visited on 19/06/2009.

World Bank, (1990). *Poverty in Developing Country*. Oxford University Press, New York, USA. 130pp.

World Bank, (2000). *Agriculture in Tanzania since 1986 Follower or Leader in Growth*. Washington, D.C. USA. 167pp.

World Bank, (2001). *World Development Report on Attacking Poverty: Opportunity, Empowerment and Security*. John Hopkins Press, London. 12pp.

World Bank, (2002). *World Development Report: Development of Rural Savings Institutions.* Oxford University Press, New York, USA. 30pp.

Wright, G. A. N. (2000). *Microfinance System Designing Quality Financial Systems for the Poor.* Zed books Ltd. New York. 52pp.

Zablon, E.H. (2002). The Contribution of improved small scale irrigation scheme to poverty reduction: A Case study of Mkindo irrigation scheme in Morogoro Rural District. The unpublished Special Project Report Submitted in Partial Fulfillment of the Requirements for the BSc of Sokoine University of Agriculture, Morogoro. 79pp.

Zaman, H. (2000). Assessing the Poverty and Vulnerability Impact of Micro Credit in Bangladesh; A Case Study by BRAC [*Http://:www. worldbank.org /html/dec/publishions/workpaper/wpc2000 series/wpc2145.pdf*] site visited on 11/07/2009.

# APPENDICES

## Appendix 1: Questionnaire for Smallholder farmers

Village ________________________________

### 1.0 BACKGROUND INFORMATION

1.1 What is your name ________________________________

1.2 Sex ...........................................................................

1.3 What is your age? ........................................................................ ( ) years

1.4 What is your marital status ..........................................................

1.5 What is your level of education? ......................................................................

### 2.0 HOUSEHOLD CHARACTERISTICS

2.1 Who is the head of household? ........................................................................

2.2 How many people live in your household? ...... ......................................

### 3.0 LAND

3.1 What is the mode of land ownership? ......................................................................

3.2 How much of your land is used for irrigated agriculture? ........................ (acre)

3.3 If you own or rent how much hectare for each categories? Own (.........acre) and Rent (.............(acre)

3.4 If rented, how much do you pay the owner of the land per season per hectare? (Tshs)..............................

3.5 How far is your farm from home? State time spent to walk to the farm in hours/ minutes .............................Kms

3.6 How long have you been cultivating in the same irrigated farm area? (.......) years

3.7 How much land is used in respect to ownership in irrigated area?

| Crop | Ownership (ha) | | Cost | Total |
|---|---|---|---|---|
| | Owned | Rent | Rent/ha | |
| 1. Rice | | | | |
| 2. Maize | | | | |
| 3. Beans | | | | |
| 4. Onions | | | | |
| 5. Tomatoes | | | | |
| 6. Others | | | | |
| 7. | | **Total** | | |

3.8 Apart from the Maize, Onion, Beans Paddy and Tomatoes what other crops do you grow?

1) ..........................................................

2).................. .......................................

3)...........................................................

4)........................................ ...............

3.9 What are your major activities in priority?

1. Agriculture ( )
2. Livestock keeping ( )
3. Off farm activities ( )
4. Employment ( )

**4.0 GENERAL FARMING INFORMATION**

4.1 How many years have you been doing farming in irrigated area? ( )

4.2 What kind of farming are you dealing with?

1. Improved irrigation farming ( )
2. Rain fed farming including upland ( )
3. Tradition irrigation e.g. (basin making for easier harvesting) ( )

4.2.1 If Irrigation state the condition of water availability in months per seasons

..............................................................................................

4.3 How many times do you cultivate your farm per year?

..............................................................................................

4.4 What are the type of seeds and their costs for one hectare?

| Types of seeds/ Varieties | Require ments / hectare | Cost/kg Per /ha | Yield Differe nce | Maize | Onion | Beans | Rice | Tomatoe s |
|---|---|---|---|---|---|---|---|---|
| 1. | | | | | | | | |
| 2. | | | | | | | | |
| 3. | | | | | | | | |

4.5 What are the Agronomic/Cultural practices and their cost per one hectare?

| Type of Cultural practices | Maize | Onion | Beans | Rice | Tomatoes | Total |
|---|---|---|---|---|---|---|
| 1. Nursery prep & mn'gnt | | | | | | |
| 2. Land preparation<br>i) Ploughing (one)<br>ii) Harrowing (one)<br>iii) Pudding | | | | | | |
| 3. Transplanting/sowing | | | | | | |
| 4. Weeding/chemical control | | | | | | |
| 5. Fertilizer application | | | | | | |
| 6. Bird scaring | | | | | | |
| 7. Harvesting | | | | | | |
| 8. Threshing | | | | | | |
| 9. Transporting | | | | | | |
| 10. Irrigation cost/ha | | | | | | |
| Total | | | | | | |

4.6 Where do you obtain inputs for Crop production ..........................................................

4.7 What is the input usage for each Crop in irrigated areas in Tshs?

| Crop/Inputs | Maize | Onion | Beans | Rice | Tomatoes | Total |
|---|---|---|---|---|---|---|
| 1.Seeds | | | | | | |
| 2.Fertilizers | | | | | | |
| 3. Pestcides | | | | | | |
| 4. Herbicides | | | | | | |
| 5. | | | | | | |
| 6. | | | | | | |
| **Total** | | | | | | |

4.8.1 What problems do you encounter in getting them?

1. .................................................................................................
2. .................................................................................................
3. .................................................................................................
4. .................................................................................................

4.9 What kind of implements do you use on your farm in irrigation?

| Implement/equipment type | Use | | Ownership | | Cost | Total |
|---|---|---|---|---|---|---|
| | Yes | No | Owned | Hired | Hired/ha | |
| 1. General tractor | | | | | | |
| 2. Hand tractor | | | | | | |
| 3. Ox-plough | | | | | | |
| 4. Hand hoe | | | | | | |
| 5. Rake | | | | | | |
| 6. Push- weeder | | | | | | |
| 7. Threshing frame | | | | | | |
| 8. Knapsack | | | | | | |
| Others (specify) | | | | | | |
| | | | | **Total** | | |

4.10 What is your source of labour?

1. Family labour (.......................) how many (..................................)
2. Hired labour (.......... ............) how many (..................................)
3. Both family and hired labour. (.......... ............) how many. (............) ii (..............)

4.11 What is the labour availability in different months used as a growing Season?

| Labour requirements/Months | Own (ha) | Rent (ha) | Maize | Onion | Beans | Rice | Tomatoes |
|---|---|---|---|---|---|---|---|
| 1. | | | | | | | |
| 2. | | | | | | | |
| 3. | | | | | | | |
| 4. | | | | | | | |
| 5. | | | | | | | |
| 6. | | | | | | | |
| 7. | | | | | | | |
| 8 | | | | | | | |
| **Total** | | | | | | | |

4.12 What is the cost of labour usage for each Crop in irrigated areas for both Owned and Rent per acre?

| Crop/labour requirements | Own (ha) | Rent (ha) | Maize | Onion | Beans | Rice | Tomatoes |
|---|---|---|---|---|---|---|---|
| 1. Land Preparation | | | | | | | |
| 2. Nursery Prep. | | | | | | | |
| 3. Planting | | | | | | | |
| 4. Weeding | | | | | | | |
| 5. Chemical Application | | | | | | | |
| 6. Irrigation | | | | | | | |
| 6. Harvesting | | | | | | | |
| 7. Marketing | | | | | | | |
| **Total** | | | | | | | |

4.13 How much do you harvest per season for the grown crops?

| Crops grown | Cultivated area (ha) | Yield in tons/ (ha) | Harvesting price/bags | Revenue By H/ price | Post Harvest price/bag | Revenue By P/H price |
|---|---|---|---|---|---|---|
| 1. Rice | | | | | | |
| 2. Maize | | | | | | |
| 3. Beans | | | | | | |
| 4. Onions | | | | | | |
| 5.Tomatoes | | | | | | |
| 6. | | | | | | |
| 7. | | | | | | |

4.14 What is the trend of yield or return in three past years? (Since 2004-2007)

| Years | Yield/ acreage | Average yield /ha | Price | Average yields/tone | Revenue (Tsh) |
|---|---|---|---|---|---|
| **2004/2005** a) maize | | | | | |
| b) Onion | | | | | |
| c) Rice | | | | | |
| d) Beans | | | | | |
| e) Tomatoes | | | | | |
| **2005/2006** | | | | | |
| a) Maize | | | | | |
| b) Onion | | | | | |
| c) Rice | | | | | |
| d) Beans | | | | | |
| e) Tomatoes | | | | | |
| **2006/2007** | | | | | |
| a) Maize | | | | | |
| b) Onion | | | | | |
| c) Rice | | | | | |
| d) Beans | | | | | |
| e) Tomatoes | | | | | |
| **2007/2008** | | | | | |
| a) Maize | | | | | |
| b) Onion | | | | | |
| c) Rice | | | | | |
| d) Beans | | | | | |
| e) Tomatoes | | | | | |

**5.0 SOURCE OF INCOME**

5.1 What is the household's source of income?

| S/NO | Source | Amount | Price | Estimated income/ year |
|---|---|---|---|---|
| 5.1.1 | **Crop sales** | | | |
| | 1.Rice | | | |
| | 2.Maize | | | |
| | 3.Beans | | | |
| | 4. Onions | | | |
| | 5.Tomatoes | | | |
| 5.1.2 | **Livestock sales** | | | |
| | 1.Cow | | | |
| | 2.Goat | | | |
| | 3.Sheep | | | |
| | 4.Pigs | | | |
| | 5.Chickens | | | |
| 5.1.3 | **Other Source of income** | | | |
| | 1.Salary | | | |
| | 2.Business | | | |
| | 3.Crafts | | | |
| | 4.Casual labor | | | |
| | 5.Assistant/remittance | | | |
| | 6.Charcoal making | | | |
| | 7.Brews local beer | | | |

5.2 Can you explain your household expenditure per year?

| Item | Total expenditure |
|---|---|
| 1) Food | |
| 2) Education | |
| 3) Health | |
| 4) Investment in non farm activities | |
| 5) Investment in farm activities | |
| b) Investment in other activities e.g. Social | |

## 6.0 MARKETING AND COSTRAINTS

6.1 Where do you sell your crops?

a)................................b)........................c)....................d).....................

6.2 To whom do you sell your crops?

a)................................b)........................c).....................d).....................

6.3 What are the packaging terms for the irrigated crops in Malolo Irrigation Scheme?

| Crops grown | Packaging During Harvesting period | Packaging During Post harvest period |
|---|---|---|
| 1. Rice | | |
| 2. Maize | | |
| 3. Beans | | |
| 4. Onions | | |
| 5. Tomatoes | | |
| 6. | | |
| 7. | | |

6.4 When do you sell your crops? Mention season/months and their related prices offered

| Crops grown | Harvesting period | Prices offered | Post harvest period | Prices offered | Other Times |
|---|---|---|---|---|---|
| 1. Rice | | | | | |
| 2. Maize | | | | | |
| 3. Beans | | | | | |
| 4. Onions | | | | | |
| 5. Tomatoes | | | | | |
| 6. | | | | | |
| 7. | | | | | |

| | |
|---|---|
| 1. Rice | |
| 2. Maize | |
| 3. Beans | |
| 4. Onions | |
| 5. Tomatoes | |
| 6. Others | |
| 7. | |

**THANKS VERY MUCH FOR YOUR COOPERATION**

## Appendix 2: Checklist for Key informants

### 1.0 Crops and land ownership and Labour

How many crops are grown by farmers in the irrigated area?

What is the land ownership in the irrigated area?

What are the sources of labour in irrigated area?

What are the costs for renting land in irrigated agriculture?

### 2.0 General Farming Activities

What are the agronomic practices for crops grown in the irrigated area?

What are the related costs for each cultural practice encountered in the irrigated area?

What types of agricultural inputs used for crops grown in the irrigated area?

Where do farmers get agricultural inputs? i.e. seeds, herbicides

Please can you sketch/draw a season crop calendar for crops grown in irrigated area?

### 3.0 Source of income and expenditure

What are the major sources of income for irrigated agriculture?

What are the major expenditures for the different source of income?

### 4.0. Marketing of the Crops

What are the packages of the crops before selling?

What are the marketing areas for the crops grown in irrigated agriculture?

What is the common range of crop prices during harvesting time?

What is the most average peak post harvest price of the crops grown in irrigated area?

What is the minimum and maximum average yield of the crops grown in irrigated area?

**THANKS VERY MUCH FOR YOUR COOPERATION**