ECONOMIC IMPACT OF RAIN WATER HARVESTING ON CROP PRODUCTIVITY AND POVERTY REDUCTION IN SEMI-ARID AREAS OF TANZANIA: THE CASE OF WESTERN PARE LOWLANDS IN KILIMANJARO REGION

BY

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ABSTRACT

Rainwater harvesting for crop production is promising and generally appropriate measure in improving agriculture in the semi-arid tropics. It is especially interesting given the fact that farmers experience crop failures more often due to inadequate and poor rainfall distribution. Erratic and unreliable rainfall in semi-arid areas results in frequent dry spells which often results in serious reductions of crop yields and persistence of poverty. This means that water harvesting can function as an entry point for farming systems modernization in the semi-arid areas of East and Southern Africa. This study aims on assessing the economic impact of rainwater harvesting on crop productivity and poverty reduction in semi-arid areas of Western Pare Lowlands in Kilimanjaro region. Specifically this study aims (i)To analyze households' poverty focusing on incomes, assets value and consumption expenditure under 'with' and 'without' RWH (ii) To determine the contribution of RWH to the household income, and the productivity of major crops under 'with' and 'without' RWH (iii) To determine gross margins for maize enterprise among under 'with' and 'without' RWH (iv) To determine and compare income from crops, consumption expenditure to the government minimum wage under 'with' and 'without' RWH (v) To identify major determinants of gross margins and consumption expenditure as indicators of household welfare. The data were collected from primary and secondary sources. Primary data were collected using structured questionnaire administered to sample of 120 respondents, 30 out of them were households practicing under 'without' RWH

DECLERATION

I, RAYMOND NKWERA, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and has neither been submitted nor being concurrently submitted for a degree award in any other University.

Signature...

Date......28th June, 2004.

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LIST OF SYMBOLS AND ABBREVIATIONS

ANOVA	Analysis of Variance
ASDS	Agricultural Sector Development Strategy
ASDP	Agricultural Sector Development Programme
ERB	Economic Research Bureau
GDP	Gross Domestic Product
GM	Gross Margin
GNP	Gross National Product
GHI	Gross Household Income
HADO	Hifadhi Ardhi Dooma (Dodoma Conservation Programme)
HBS	Household Budget Survey
HIPC	Highly Indebted Poor Countries
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agriculture Development
ILO	International Labour Organization
MTEF	Medium-Term Expenditure Framework
NPES	National Poverty Eradication Strategy
OLS	Ordinary Least Square
PRGF	Poverty Reduction and Growth Facility
PRSP	Poverty Reduction Strategy Paper
PSAC	Programmatic Structural Adjustment Credit

PSRC	Public Service Reform Programme
RDS	Rural Development Strategy
RWH	Rain Water Harvesting
SADC	Southern African Development Community
SSA	Sub-Saharan Africa
SSIPDO	Small Scale Irrigation Project-Dodoma
SUA	Sokoine University of Agriculture
SWMRG	Soil-Water Management Research Group
SWMRP	Soil-Water Management Research Programme
TAS	Tanzania Shilling
TRP	Turkana Rehabilitation Project
UNDP	United Nations Development Programme
URT	United Republic of Tanzania
USAID	United States Agency for International Development
WDR	World Development Report
WPLL	Western Pare Lowlands
^0C	Degree Celsius
%	Percentage

CHAPTER ONE
INTRODUCTION

1.1 Background

In Tanzania semi-arid areas experience environmental and agricultural problems, including soil erosion, decreasing soil fertility, de-vegetation and appreciable risk of crop failure associated with low and unreliable rainfall (SWMRP, 2001). Pandey (1991) reported that, due to high variability of rainfall in semi arid tropics, rainfall figures are of little use for crop planning purposes. High run off and evaporation losses also cause the problem of poor availability of soil moisture, resulting to low food supply, and food insecurity which leads to poverty. Low crop production mainly due to low and unreliable rainfall contributes to low crop productivity, food insecurity and poverty in semi-arid areas.

Since rainfall is a constraint to successful agricultural production in semi-arid areas, it is crucial that every effort be made to conserve and efficiently utilize the scarce rainwater. This requires an improved soil water management techniques that maximize water-holding capacity of soil coupled with cultural practices, which ensure the most optimum use of the available soil water, by crops. Instead of being left to cause erosion, flooding and other hazards, run off water then can be harvested and used to solve the problem of soil moisture deficit on cropped land (SWMRP, 2001). Rainwater Harvesting (RWH) can play an important role in increasing productivity and reducing income poverty in semiarid areas.

In view of the importance of RWH technology in semi-arid farming, the government and many other international organizations such as UNDP have been intervening to promote the technology. A number of RWH projects have been initiated and implemented since 1950's. One of those projects is "Hifadhi Ardhi Dodoma" (HADO) which was started in 1973. Another project was Rift valley Rice Project with USAID and IFAD support where farmers adopted rainwater-harvesting technology on rice production, in Dodoma Region (Mbegu and Mlenge, 1973).

Of interest to this study is the Rain Water Harvesting (RWH) project, which started since 1992 at Sokoine University of Agriculture. The main purpose of the programme is to develop, test and promote appropriate and socio-economically viable management interventions for optimising the capture and utilization of rainfall in semi – arid areas of Tanzania (SWMRP, 2001). Among other areas the project operates in the Western Pare Lowlands (WPLL) of Mwanga and Same districts in Kilimanjaro Region. This study aims at assessing the economic impact of RWH technology in terms of crop productivity and poverty reduction to the people being involved specifically in Makanya village in Same district.

Beforehand, it is important to define the concept of 'with' and 'without' RWH as used in this study. This is technically indispensable to make the basis of using the 'with' and 'without' RWH situation more clearer. Western Pare Lowland (WPLL) is a semi-arid area characterized with water stress making production of crops without

RWH virtually impossible especially those which are drought intolerant such as maize. In Makanya, farmers have been using traditional RWH techniques in farming for several decades. RWH involving a distant run-off through a waterway (natural canal) seems to be more developed and effectively utilized. Virtually, under this situation the 'without situation' is when crop production becomes a reality under a typical rain-fed system. In view of this, farmers under RWH were considered to be under 'with situation' and those practicing crop production depending on rain-fed were considered to be under 'without situation'.

Moreover, RWH for livestock mainly done through construction of charcodams was not considered under 'with situation', this is because of the difficulties associated with working out the financial benefits from the use of charcodams. Effective use of charcodams in the farmers' vicinity still depends on pasture availability around. During critical dry period pastoralist experience partial migration of herds in search of pasture irrespective of assured supply of water by the charcodams around their locality. This situation complicates the calculation of net benefit stream associated with RWH in the livestock sub-sector. Given limited time and resources the scope of the study narrowed to RWH in a sense of crop sub-sector.

1.2 Problem statement and Justification

Tanzania is basically an agricultural country with the majority of its people being poor. More than 85% of the Tanzanians are rural dwellers and overwhelmingly dependent on agriculture. According to the World Bank (1995) study the rural households account for

92% of the poor Tanzanians. Agriculture, like in most developing countries, is an important sector for the country's overall development (Luvanga and Shitundu, 1998). But among the main problem facing the sector especially in semi-arid areas is unreliable rainfall for crop production. The associated problems include high daily and yearly temperatures, low humidity, intense sunlight and high winds which limits availability of adequate soil-moisture for plant growth (Hatibu, 2000).

These factors encourage very high rates of potential evapotranspiration in many parts of the country, to the extent that rainfall amounts exceed potential evapotranspiration only in very few and scattered days. The most critical factor that makes most of the country semi-arid is the dry spell, which occurs during the growing season, (Venalainen and Mhita,1998). This dry spell occurs with significant variation from season to season in the same place and from place to place within the same season. In most cases therefore, a lot of rain is received at the wrong time and/ or place, this results to low and unreliable crop production.

Since a large number of Tanzanians involved in agriculture are small farmers who use mainly primitive or rudimentary technologies such as hand-hoe, ordinary seeds, little or no manure or chemical fertilizer, poor husbandry practices and much depend on rains which is in most cases erratic and sometimes inadequate. These have contributed to low productivity and subsequently the low incomes, low standard of living and other associated characteristics which contributed to poverty in Tanzania (Shitundu and Luvanga, 1998).

An alternative way of enhancing crop production is to improve rainwater harvesting. Rain water harvesting techniques offer several advantages among them are; maximises soil water availability to the crops as a result of each rainfall event; optimises crop yields per unit of the available soil water resource; maximises yield in normal rainfall years; and stabilizes crops production (Hatibu *et al.,* 1993). Better management of rainwater harvesting does not only enhance crop production but also protects the environment through controlling water run off instead of being left to cause erosion, flooding other hazards.

The technology of RWH in Tanzania has been considering as party of key element of the Agricultural Sector Development Strategy (ASDS) and has received high attention from both policy makers and planners. Despite the fact that rain water harvesting technologies have been used for quite sometime now and positive results in terms of crop diversification and yield has been attained, their impacts to the people involved are not clearly known.

The study aims at filling this knowledge gap through evaluating economic impacts to the beneficiaries of SUA-RWH project interventions in WPLL in Same District where most of land is now being converted into maize and other field crops through RWH.

1.3 Objectives of the study and assumptions

1.3.1 General objective

The general objective of this study is to assess the economic impact of RWH technology on crop productivity and poverty reduction in semi-arid areas of WPLL in Kilimanjaro region.

1.3.2 Specific objectives

1. To analyze and compare household's poverty focusing on incomes, assets value and consumption expenditure under 'with' and 'without' RWH.
2. To determine the contribution of RWH to the household income and the productivity of major crops 'with' and 'without' RWH.
3. To determine and compare gross margins for maize enterprise under 'with' and 'without' RWH.
4. To determine and compare income from crops and livestock and consumption expenditure to the government minimum wage under 'with' and 'without' RWH.
5. To identify the major determinants of gross margins and consumption expenditure as indicators of household welfare

1.3.3 Assumptions

1.3.3.1 General assumption

Rainwater harvesting has a potential of improving crop productivity and reduce poverty in semiarid areas of Tanzania. This calls for a need of interventions deemed to improve RWH technologies in semi-arid and other dry land area to revamp agricultural productivity. Given other factors, such as efficient input and output marketing systems, increased productivity would improve both household food self-sufficiency and incomes, hence reduce poverty.

1.3.3.2 Specific assumptions

Some pertinent specific assumptions posed by this study include:

1. Basing on the level of incomes, assets value and consumption expenditure as welfare indicators, the households practicing sound RWH are better-off than their counterpart households.
2. The contribution of RWH to the gross household income is relatively high compared to other sources.
3. Households under RWH are better-off than those without in terms of incomes and consumption levels scaled to the prevailing official minimum wage.

CHAPTER TWO
LITERATURE REVIEW

2.1 The concept of RWH

Various authors have defined rainwater harvesting as the process of collecting water from prepared catchments for beneficial use (Frasier, 1975, 1994; Pandey, 1991; Laryea, 1992). Dutt *at al.* (1981) defines RWH as the interception and concentration of local rainfall runoff from a catchment area for various purposes. Although there have been several other definitions, all of them indicate the common components which includes inducement, collection, storage and conservation of local surface runoff. The harvested water can be used for agricultural or domestic purposes.

2.2 Historical perspective and importance of RWH

RWH system for crop production consists of the catchment or water collection area and cropped area where the collected runoff is used to grow crops (Reij *et al.,* 1988). However, RWH is feasible at any place where surface water run-off could be collected. RWH is of great interest in arid and semi-arid region where agricultural production is limited primarily by low and erratic rainfall.

Reports on rainwater harvesting for agricultural purposes and human consumption covering areas in arid and semi – arid regions dates as far back as the first half of bronze age (von Oppen, 1975). Archaeological evidence shows that, rain water-harvesting systems were used in the Middle East by the ancient Israelites, Nabaleans, Romans and Byzantines (Evanari *et al.,* 1971). It is currently practised in different forms in semi arid regions of Middle East, India, Australia, Central and North America and sub Saharan Africa, (Pandey, 1991).

2.2.1 RWH in the Middle East

Middle East is one of the first comprehensive description of an agricultural system based on rainfall collection for the past 400 years, the most famous old site is in the Nagev desert in Israel (Dutt *et al.,* 1981). Other archaeological sites of ancient water harvesting system have been found in Libya, Iraq, Syria, Jordan and the Arabian Peninsula, especially Yemen (Evanari *at el.,* 1971). At the site of the "Great Dam" near Marib in North Yemen, flow diversion, albeit on more modest scale than in the past, is still being practised. Ancient sites were thought to have been abandoned due to the fall of rulers who could guarantee the strong organization required for construction and maintenance. The advent of pump irrigation in recent times prevented the revival of ancient flow diversion technique. Other techniques such as terraced wadis have survived through the years and are still applied in the Middle East. Some terraced wadis were rehabilitated and integrated in soil and water conservation projects (Reij *et al.,* 1988).

2.2.2 RWH in India

In India since 1975 considerable research on rainwater harvesting has been undertaken notably at the Center for Arid Zone Studies in Jodfur and by International Crops Research Institute for the Semi- Arid Tropics (ICRISAT) in Hyderabad. While the research in Jodfur focused on the size and shape of the catchments and yield of runoff, ICRISAT's farming system research programme aimed at the development of improved method of soil, water and crop management (von Oppen and Ryan, 1987).

2.2.3 RWH in China

In China, one very old but still common flood diversion technique is called "warping". This involve harvesting water as well as sediment and is extensively applied in China's loess areas. UNDP (1983) cited by Reij *et al.* (1988) observed in a case study in Shanix Province that the total yearly sediment yield of 2.7 million cubic meters is stored by warping.

2.2.4 RWH in Africa

RWH in Africa can be discussed as follows; In West Africa, the drop in annual rainfall since the late 1960s has caused emphasis to shift from simple soil cultivation towards moisture conservation and water harvesting. For example in Burkinafaso, Yatenga province an Agro-foresty Project (PAF) has developed and popularized contour stone bunding for rain water harvesting. In another system farmer dig planting pits ("Zay") between bunds. The spacing of the "Zay" is approximately 80 cm, which corresponds to usual planting density. The "Zay" are about 20 cm wide and 20 cm deep where runoff is concentrated. With this system it was possible to increase yields of sorghum by 40 %. Sometimes barren land is rehabilitated to an extreme where a 1.2 t/ha crop become possible where nothing was harvested before (Reij *et al.*, 1988).

In Kenya, Hogg, (1986) cited by Critchley *et al.* (1992) reported on semi-circular hoops water harvesting technique used in Turkana , Baringo and Kitui districts in Kenya for improving regeneration of grass or fodder species in dry areas. These hoops were in fact semi octagon in shape. The Turkana Rehabilitation Project (TRP) introduced on a wide scale RWH in 1983. In 1984 "Trapezoidal bunds" replaced contour bunds as the principle system for food crops, the best of sorghum yield recorded was 1300 kg/ha. While microcatchments techniques have been used for a number of years for tree planting.

Sudan has probably the most extensive and diverse heritage of traditional water harvesting and water spreading of any country in Sub-Saharan Africa. The system range from the utilisation of wadi flow by bunding within flood plains, variation of which can be seen throughout the semi-desert areas, to traditional small scale "teras" construction in eastern plains (Critchley *et al.,* 1992).

In Southern Africa, little or no traditional small scale RWH system for plant production is known. It is only recently that the Department of Research and Specialist Services in Zimbabwe has begun experimentation with various techniques. At Matopos research station in Zimbabwe, trials on RWH treatments for rangelands rehabilitation, and at Chiredzi research station, small scale water concentration techniques based on ridging are being tested (Lameck, 1994).

2.2.5 RWH in Tanzania

In Tanzania farmers are practicing some kind of rainwater harvesting through valley farming, which involves intensive cultivation of valley floors, where runoff from slopes is concentrated. In parts of Tabora, Shinyanga and Mwanza regions farmers have developed a system of water harvesting which involves diversion of water from ephemeral streams, to valleys where fields are subdivided by bunds of 25-100 cm height to form cultivated reservoirs (for paddies). The collected runoff is stored in these reservoirs for use by transplanted paddy crop production (Mwakalila, 1992; Hatibu, 1993; and Lameck, 1994). However there is no record to show how the system started, but farmers have been developing it on a trial and error basis since early 1940's for paddy production. Currently Rain water harvesting is conducted in Dodoma, Mbeya, Shinyanga and Kilimanjaro regions and its use is not only for paddy but also for maize and other crops production.

2.3 Crop production in semi-arid areas.

Semi arid climate is generally characterized by high evaporative demand, low annual rainfall amount, high rainfall intensities and poor rainfall reliability. The atmosphere evaporation demand usually exceeds rainfall in 5 to 10 months in a year and rainfall never exceeds potential evapotranspiration on long-term averages (SWMRG, 1993). For example, total crop water demand for optimum production of maize in semiarid areas is between 500m to 800mm (LWMRP, 1989 and Doorembos and Kassam, 1981) while the average rainfall amount during the growing period in semi arid areas of Tanzania is 350mm (Kingamkono, 1994; Kassase, 1992). Apart from evapotranspiration a considerable amount of rainwater is lost through surface runoff from cropped fields. Studies in runoff losses conducted in semi arid areas of the SADC region reported runoff losses from cropped field of up to 10% of the effective rainfall (Miller, 1990).

The length of effective growing seasons in semiarid areas is usually shorter than the growing period of many crops. Kassase (1992) and Kingamkono (1994) studied the characteristics of rainfall during the growing seasons in Tanzania and showed that the average effective length of the growing period in semi arid area was 45 days for short rains and hardly 60 days for long rains. This is less than the growing period of maize varieties that are mostly preferred by farmers in semi arid areas. They also found that there is a high probability of occurrence of dry spells of longer than 10 days during the growing seasons. Hatibu *et al.* (1997) obtained similar results from four season rainfall characteristics study in the WPLL and Morogoro.

Combinations of these characteristics make soil moisture deficiency inevitable during growing periods of many crops grown in semi arid areas. Crop performance in general is very low compared to the soil production potential. It has been estimated that moisture deficiency of more than 50% of the crop water requirement during the flowering stage of maize may cause yield reduction of more than 70%, It is reported that soil moisture deficiency account for more than 80% of crop failure in semiarid areas (LWMRP, 1992 and Doorenbos and Kassam, 1979).

The government and other concerned institution in Tanzania have been appealing to people in semiarid areas to adopt cropping system that involves crop with low crop water requirement like sorghum, millet and cassava. Although there has been some considerable success, more than 60% of the cropped land in semi-arid areas in Tanzania is still grown with maize. The crop is also still a major staple food for the majority of Tanzanians. Since available soil moisture is still a major constraint to the production of this crop in these areas it follows therefore that more efforts have to be directed to soil moisture conservation and supplement any irrigation through RWH.

2.4 RWH reduces the risk of crop failure.

Tanzania is characterized by its variety of environmental conditions (i.e. rainfall, temperature, altitude, topography, vegetation, and soils) which vary enormously within the country. About 80% of Tanzania receives less than 1,000 mm of seasonal and unreliable rainfall which is not adequate for food security and self-sufficiency (Hatibu *et al.*, 1993; Lameck, 1994).

The rainfall variability and unreliability in semi-arid areas varies between locations and between season on number of rain days and dry spells. With long dry spell for example 10 to 20 days (which is common in arid and semi-arid areas) most of the annual crops cannot tolerate such a long moisture stress and die before the coming of next rainfall event. But, by either building earth bunds around the cropped area or constructing storage pits or canal, the collected and stored rainwater can be applied directly or indirectly to the crop. In that way moisture stress can be prevented if not eliminated and thus reducing the risks of crop failure.

In arid and semi-arid regions farmers sow seeds by trial and error even four times before obtaining good establishment. This consumes growing season time as a result the rain season ends when the crop is still young. But if the first rainfall is harvested, water can be applied to the cropped area to enable seeds to start up comfortably. Therefore, it is rational that efforts should be made to capture, conserve and efficiently utilize the scarce rainwater. To accomplish this, there is a need for improved soil management techniques that maximize water holding capacity in the soil, together with cultural practices that ensure the most optimum use of the available soil water by plants. Better management of rain water especially in the semi-arid areas is not only necessary for enhancing plant production and thus, reducing the impact of prevalence of hunger, but also, promotes the household income of resource poor inhabitants in these areas by selling their surplus produce.

A particular example is response observed in India on an alfisol, when a 30-days period coincided with the grain-formation stage (ICRISAT, 1975). A supplemental irrigation of only 5 cm on sorghum and maize maintained yields near optimum levels, which were double the yields of rain-fed crops. Thus the direct effect of improved water utilization technology becomes substantial in years of ill-distributed rainfall or in producing a second crop in the dry seasons. Also reduced risk provides the basis for greater and assured responses to other inputs such as improved seeds and fertilizers.

The present policy of Tanzania government is to encourage people to shift from the highly populated highlands and slopes to the low semi-arid lands (Hatibu *et al.,* 1993). The success of this policy will however depend on increased water supplies in the semi-arid lowlands to enable farmers to grow the crops they need. Rainwater harvesting is one of the important tool, which can be used to manage the scarce rainfall.

RWH therefore, has a potential of increasing production per unit of land and hence improving food security by increasing household food self-sufficiency and income poverty reduction in semi-arid areas.

2.5 Macro and Micro catchments.

Two different runoff irrigation systems are used, depending on the slope of the terrain. Where the catchment area is located on slope with terraced fields usually at the foot of the slope, it is known as macro-catchment system. Macro catchment systems have the advantage that no potential arable land is lost since the catchment areas are located on slopes which are usually unfavorable for agriculture.

In the case of micro catchment system the ratio of water harvesting area to cultivated area is generally between 1:1 and 5:1. The main disadvantages are that the catchment basins are also potentially arable land and that the terrain should preferably be even (Tauer and Humborg, 1992).

2.5.1 Internal (micro) catchments

2.5.1.1 Major characteristics

This system is mainly used for growing medium water demanding crops such as maize, sorghum, groundnuts and millet. The major types of the system include:

(i) Pitting

These are small semi-circular pits dug to break the crusted soil surface (Figure 1). In West Africa where they are called 'Zay', the pits are about 30 cm in diameter and 20 cm deep. The same system is called Katumaini pitting in Kenya. They are used in areas with rainfall of between 350-600 mm.

(ii) Strip catchments tillage

This technique, also known as contour strip cropping, involves alternating strips of crops with strips of grass or cover crops. Cultivation is usually restricted to the planted strips. The uncultivated strips release runoff into adjacent crop strips (Figure 2). The system is used in gentle slopes (up to 2%) with the strip width being adjusted to suit the gradient. The system is widely practiced in many semi-arid areas, although farmers and extension workers may not recognize it as a RWH measure. It is suited to most crops and easy to mechanize.

(iii) Contour bunds

This system consists of small trash, earth or stone embankments constructed along the contour lines. The embankments trap the water flow behind the bunds allowing deeper infiltration into the soil (Figure 3). The height of the bund determines the net storage of structure. The water is stored in the soil profile and above ground to the elevation of the bund or overflow structure. This is a versatile system for crop production in a variety of situations. They can be easily constructed but they are limited to availability of power (for earth moving), stone and trash.

(iv) Semi–circular bunds

These are constructed in series and in staggered formation as shown in Figure 4. Runoff water is collected within the hoop from the area above it and impounded by the depth decide by the height of the bund and position of the tips. Excess water is discharged around the tips and is intercepted by the second row and so on. Normally the semi-circles are of 4-12m radius with height of 30 cm, base width of 80 cm, side slopes 1:1.5 and crest width of 20 cm. the percentage of enclose area which is cultivated depends on the rainfall regime of the area.

(v) Meskat-type system

In this system instead of having Catchment Area (CA) and Crop Basin (CB) alternating like the previous methods, here the field is divided into two distinct parts, system, the CA is treated either by removal of vegetation and/or compaction in order to increase the generation of runoff. The cropped basin (CB) is enclosed by a U-shaped bund to pond the harvested water (SWMRG, 1995b).

Figure 1: Layout of pitting RWH

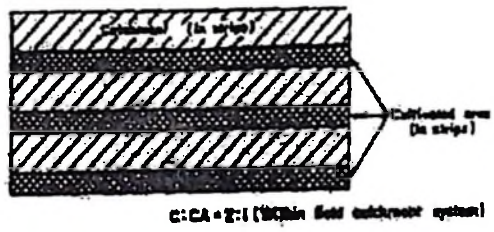

Figure 2: RWH with strip catchment tillage

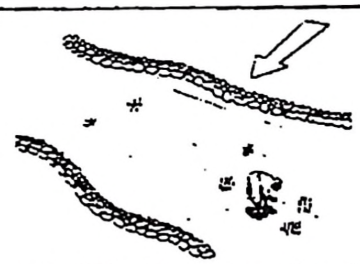

Figure 3: RWH with contour bunding

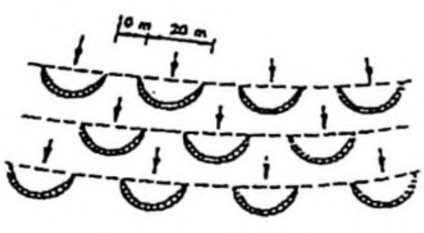

Figure 4: RWH with semi-circular bunding

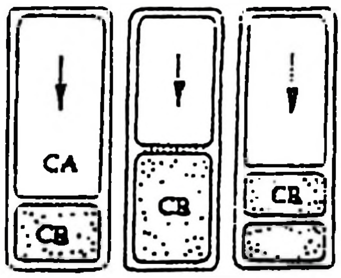

Figure 5: RWH with Meskat-type bunding

2.5.2 External (Macro) catchments RWH

2.5.2.1 Major characteristics

This system involves harvesting of water from catchments of areas ranging from 0.1 ha to thousands of hectares either located near the cropped basin or in long distances away. The catchment areas usually have slopes ranging from 5-50% while the harvested water is used on cropped areas, which are either terraced, or on flat lands.

When the catchment is large and located at significant distance from the cropped area the runoff water is conveyed through structures of diversion and distribution networks. The most important system include the following:

(i) Hillside sheet/rill runoff utilization

In this system, runoff which occur on hill-tops (with stone outcrops), sloping grounds, grazing lands or other compacted areas flow and naturally collect on low lying flat areas. In many areas farmers grow their crops on wetted part of the landscape and use the runoff without any further manipulation or management. However, where the runoff is not high, bunds are constructed on the cropped area in order to from earth basins, which assist in holding the water and increasing infiltration into the soil.

These bunds are important when the cropped area is not at the bottom of landscape. However earth basins are used to facilitate the distribution of the water even if the cultivated area is on flat land. Several designs of these earth basins are used and sometimes are mentioned as types of RWH systems by themselves. These include for example trapezoidal basins bunded on three sides, rectangular basins bunded an three sides e.g. Teras (Figure 6), and cultivated basins bunded on all the four sided with only small inlets and overflow spillway, e.g. 'majaruba'.

(ii) Floodwater harvesting within the stream bed

This is the system that uses barriers such as permeable stone dams to block the water flow and spread it on the adjacent plain and enhance infiltration (Figure 7). The wetted area is then used for crop production.

(iii) Ephemeral Stream Diversion

This system involves means for diverting water from its natural ephemeral stream and conveying it to arable cropping areas. There are two main methods of diverting and distributing the water. In the first system, the cultivated field close to the ephemeral stream is first divided into open basins using either trapezoidal, semi-circular bunds or rectangular.

By means of a weir, water is diverted from the stream into the top most basins. The water fills this basin and the surplus spills to the next basin and so on until the whole farm is fully wetted. In this system (figure 8) one intake point can only be used by single farm that must be relatively close to the source.

In the second system, the field is divided into close rectangular basins such as "majaruba" and the water is diverted using a weir and a series of channels to deliver the water to the basins (Figure 9). The system works using the same principles of surface flood irrigation and it can therefore serve several farms, which may be located far away from the intake.

(iv) RWH with storage

Sometimes macro-catchment RWH, produces high volume of runoff that can not be stored in the soil profile. In such circumstances, the harvested water is stored in dams or holes. Small dams are normally constructed in rolling topography where creeks can be found and dams are put/constructed across them.

Water hoes are storage ponds dug in flat terrain and they are normally referred to in their Spanish name "charco dams". In India they are called 'tanks' while in Tanzania they best known as 'malambo'. They are normally used to store runoff generated from hillside catchments with sheet or rill flow. The system requires methods for controlling siltation especially if the area is prone to soil erosion, evaporation, and seepage losses especially if the subsoil is sandy.

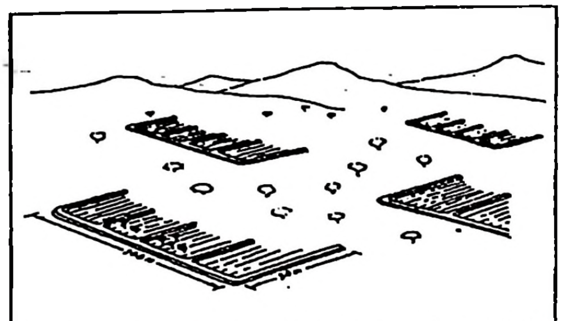

Figure 6: Examples of hill-sheet flow RWH

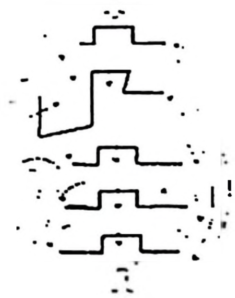

Figure 7: Flood harvesting with the stream bed

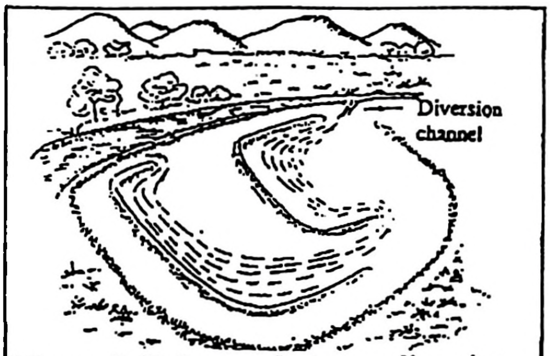

Figure 8: Ephemeral stream diversion

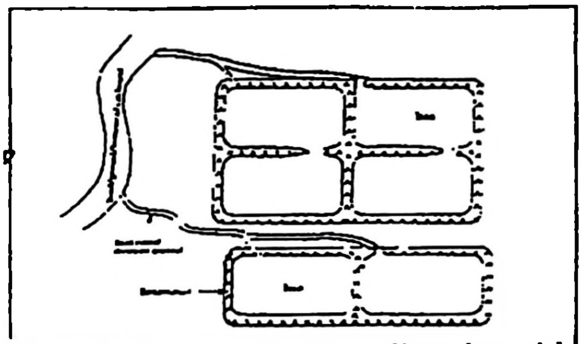
Figure 9: Ephemeral stream diversion with distribution canals

2.6 Extent of use in Western Pare Lowlands

(i) Hillside sheet/runoff utilization

This system is the most widely used through exploitation of the valley bottoms and plains where the runoff collects, by growing high water demanding crops. Farms in these areas are called "Mashamba ya Mbugani" and are common in many parts of the WPLL. These are mainly used to grow maize, onions, fruits and different types of vegetables. The majority of the farmers have at least one "shamba la mbugani" which indicates that most of the maize is produced by the method of water supply.

These areas are also attractive to many farmers due to their high fertility levels, which is a result of fertility enrichment from the up-slope areas where nutrients are transported and deposited in this plain during seasonal flooding. One of the most important characteristics of this system is the lack of control measures. Thus this system does not use large investment of labor to manage the water. If anything is done at all is to level the catchment area uncultivated in order to generate more runoff. However, few farmers collect the runoff and lead it into bunded fields . In some villages there is high demand of the low lying areas, which receive runoff to an extent that there is land marketing and renting of valuable pieces of land.

(ii) Ephemeral Stream Diversion

The most common used stream diversion system is the one with closed bunded basins (majaruba) and elaborate diversion and conveyance channels. This is the system supporting the increase of maize production in the WPLL especially in Makanya village where most of the farmers are using ephemeral streams, which are diverged to their fields.

The main problem with this system is initial capital investment because diversion of floodwater from the river requires structures such as a weir and distribution canals to divert the water into the fields. Apart from the initial costs, flood diversion scheme are also faced with problems such as damage to the diversion works during flash floods, siltation of weirs and canals resulting from deposition of sediment carried with flood water and problems of control and distribution of the flood water.

(iii) RWH with storage

This is also a widely used in WPLL including Makanya where the study was conducted, storage ponds dug in a flat terrain and there are normally referred as "charco dams". They are normally used to store runoff generated from hillside catchments with sheet or rill flow. Dug out ponds collects water and villagers exploit this for domestic, but mainly for livestock production.

The major problem facing storage schemes has been the lack of maintenance. Most of them are silted up and their cost of rehabilitating is prohibiting. Silting is caused by poor utilization of catchment areas and lack of protection of reservoirs. Further to this livestock walk directly into reservoir to drink water this increases the damage to the reservoir by puddling.

2.7 Land conservation aspect

Micro-catchment approach to RWH has a high potential for improving land conservation while **macro-catchment** RWH system conderm one part of the land (the catchment) for the benefit on another (the cropped basin). This is occurring naturally on the catena, where fine particles, nutrients and organic matter are disproportionately lost in the eroded fraction from catchment areas. This referred to as the "enrichment factor" and is the amount by which the eroded material is richer in nutrients than is the soil from which is taken.

2.8 Food security and poverty in Tanzania

2.8.1 Food security

2.8.1.1 The concept and attributes of food security

The problem of food insecurity is not just about food alone but also about the general problem of poverty and unequal distribution of purchasing power among and within regions and nations. As in many other countries, food insecurity in Tanzania is mainly a problem of poverty.

Food security is defined as access by all people at all times to enough food for an active, health life (World Bank, 1986). But the concept is actually employed in different ways depending on the level of human organisation (Chen, 1994). Haddad, (1997) define food security as the condition in which all people at all time have enough food for a healthy and productive life. It involves three components: food availability, food access, and food utilization. Food availability implies sufficient production or imports to meet the food needs of the population. Food access refers to the ability of people to obtain food, either through their own production or by purchasing it with money earned through other activities. And food utilization means that the nutrient intake associated with food consumption is not impeded by inadequate nutritional information, poor sanitations, or problems of intrahousehold distribution.

Food security can be defined at the regional/national level or at household level. At regional/national level, food balance occurs when there is sufficiency of the available food supply to meet the food requirements regional/national populations. These requirements are calculated based on the minimum population nutritional requirements measured in per capita dietary calories for a year (Chen, 1994). The available supply is determined principally by the current level of food production and releases from food stocks within a country, balanced by net food trade and aid flows, and carryover of food stocks from year to year.

At the household level, food security is determined by the size of household food entitlements, that combination of food production resources, income available for food purchases and gifts or assistance available to the household and whether it is sufficient to meet the aggregate food requirements of all household members. This means that food security in a particular household is determined by what the particular household is able to produce, purchase (food markets and prices) transport, store, process and prepare. In turn these are determined by the agricultural productive resources available to that household such as the amount and quality of land, the amount and division of labour, the availability of productive assets, the level and type of technology, as well as climate and ecology, plus the household's cash income from employment or sale of output. The relative importance of these elements will depend on whether the household is rural or urban, in the agricultural or non-agricultural sector.

Food security has for long been a concern in Tanzania, both at the national level and at the level of the household. In practice, measures of household food security have been difficult to identify and attention has been focused on the extent to which communities and households are able to provide food for themselves from their own production.

2.8.1.2 Spatial food security situation in Tanzania

Spatial food security situation can be assessed basing on agro-ecological zones. The consideration of the agro-ecological zones stems on the fact that food production is the central prerequisite of food security in poor countries like Tanzania. Regional, national and household food security depends on local production rather than food exchange markets. In the first place, agricultural production is a function of ecological characteristics mapped in agro ecological zones.

Tanzania has diverse agro-ecological areas and vast land of high, medium and low potential. Therefore there are significant differences in agricultural potential, population and incomes across regions. The connection between poverty and low productivity in agriculture is shown in the regional mapping of poverty, which indicates that poor regions are characterized by low rainfall, poor soils and distance from markets and minimal infrastructure (World Bank, 1993). Less than 40 percent of the populations are below the poverty line in Arusha, Kilimanjaro, Kagera and Mara. Over 90 percent of the populations are poor in Shinyanga and Lindi. While income levels more or less reflect the availability of land of good agricultural potential, its access to markets and inputs coupled with the availability of land of good potential, which actually determined incomes (World Bank, 1993).

2.8.2 Poverty in Tanzania

2.8.2.1 The concept of poverty

Poverty is commonly understood as a condition of being without adequate food, money, health, education, shelter or assets. Poverty is therefore broad phenomenon that there is no generally accepted definition of it to date. The World Bank report (1990) has attempted to define it using monetary and non-monetary measures of welfare. Two broad categories of the non monetary measures of poverty are basic needs and social services. The former category contains food, shelter (housing) and clothing. With regard to this category, people with access to high quality and quantity of these needs are said to be non-poor. The category of social dimensions of poverty includes good or poor access to health, education, water, sanitation and employment.

Monetary measures of poverty mainly concentrate on income, expenditure and consumption levels. The non-poor people have large amounts and quality of these, while the poor have less of these in quantity and quality. Therefore poverty may be defined as deficiency in various spheres of human life; including nutrition, education, housing, clothing, health, water, sanitation, employment, expenditure, income and consumption.

Current literature describes poverty as a situation that emanated from lack of necessary capabilities and entitlements to satisfy human basic needs. This situation limits a person from acquiring security and assets, or from having power for decision making (Jazairy *et al.*, 1992; Kasimila, 1996). Poverty however can always exist in a society where some (or all) of its members fail to attain a certain level of well being considered by that society as reasonable minimum standard of living (Bagachwa, 1994). Again it is argued that although this latter definition accommodates basic needs, norms and traditions, as well some acceptable social thresholds, it is also operationally difficult to address poverty (Mtatifikolo and Mabele, 1999).

Poverty as measured by income tends to be at its worst in rural areas (World Bank, 1990). For example in 1982, more than 90% of all the absolutely poor people of the world lived in rural areas, and the main reason is that the majority of the population in developing countries live in rural areas (World Bank, 1982), cited by Hemmer (1987). Within rural areas the poor are located in areas where arable land is scarce and agricultural productivity is low (World Bank, 1990). Moreover, severe poverty is found where rainfall is unreliable, physical infrastructures are poor and people have poor access to markets (Bagachwa, 1994).

The poor have low levels of living whereas the non-poor enjoy higher standards of living, the less poor have low standards of living and get inadequate supply of basic needs and have less income. But they lead life worthy of a human being, unlike the absolutely poor who are said to be unable to lead life worthy of human being (Hemmer, 1987).

The Tanzanian government defines poverty as a state of deprivation prohibitive of a decent human life. Accordingly this is caused by lack of resources and capabilities to meet basic human needs as seen in many but often mutually reinforcing parameters which include malnutrition, illiteracy, the prevalence of diseases, squalid surroundings, high infant and maternal mortality, low life expectancy, low per capita incomes and expenditures, poor quality housing, inadequate clothing, low technological utilization, environmental degradation, unemployment, rural-urban migration and poor communications (URT, 1996).

The various definition of poverty have been generally grouped into two main categories the "absolute" and "relative" (Semboja, 1994). In this study the absolute definition is adopted whereby the poor means households and individuals that cannot earn enough to meet their basic needs. Poverty defined in this way focuses on the absolute economic well-being of the poor and requires some knowledge of the minimum standard of living referred as to as the poverty line.

The World Bank report (1993) estimated the poverty line for Tanzania at about Tshs 46,173 per capita per year adjusted for household composition. A more recent World Bank study (1995b) puts the poverty line at Tshs 73,177 per person per year taking into account exchange rate of 1995 and inflation. Thus all people living below this poverty line are considered to be poor. The current existing results from Household Budget Survey (HBS) 2000/01 show the proportion of the population below the food poverty line to have declined from 22 percent in 1991/92 to 19 percent in 2000/01. With regards to the basic needs poverty line, the proportion of the poor has declined from 39 in 1992/93 to 36 percent in 2000/01 (Servacius, 2002).

Fighting poverty successfully is very difficult. But World Bank (1990) asserts that countries which have succeeded in combating poverty promoted efficient use of the poor's labour along with policies which harnessed market incentives, social and political institutions, infrastructure and technology and provided basic social services to the poor, including nutrition, family planning, primary health care and education.

Ways of combating poverty have been a lively debate in the views of various writers. Clayton (1983) presented that, an effective attack on poverty can be made by going directly to the rural poor and providing them with food, clothes, shelter, education and health services. But, this would encourage prolonged dependency among the poor and idleness of their labour. So, means to help them help themselves using their labour seems logical and viable. Wonnacott (1984) argued that, the general increase in production may be one of the most effective way of fighting poverty. This can help to reduce poverty only if the poor are given access to resources so that they can use their labour to produce.

2.8.3 Poverty profile in Tanzania

2.8.3.1 Overview

Tanzania is regarded as on of the poorest countries in world, ranked by the World Bank Development Report (1993) as having a per capita GNP of US $ 100 in 1991 which according to the World Bank Development Report (1995) seems to have fallen to US $ 90 in 1993, being the lowest in the World, however information of (URT, 1997) shows an improved situation of per capita income which stands at US $ 200. Nevertheless even with improvement in per capita income the majority of Tanzanians are poor or live in condition of poverty.

The per capita income for Tanzania and the SSA as a whole are, thus, far below the US $ 370 (in 1985 purchasing power parity dollars) per capita, which is, according to the World Bank, a cut-off for absolute poverty. In fact is a very poor country because her people's consumption levels fall below poverty line of US $ 275 which is also used by the World Bank. Thus, the strategies for poverty alleviation are very important for Tanzania.

2.8.3.2 Incidence and Extent of Poverty

Various efforts in analysing poverty in Tanzania have shown that poverty is almost entirely rural. Initial efforts in analysing poverty in Tanzania were done by van Ginneken (1976), who used 1969 data and found that 65% of the rural household were living in poverty. Later on, the ILO in 1982 calculated poverty line by costing three different subsistence diets for 1980. The result indicated that 15% of the urban households and 25% to 30% of rural households were below the poverty line which was calculated to be Tshs 600 per month for family of five (Bagachwa, 1994). The Cornell-ERB project (1991) also established that poverty was a rural phenomenon where 59% of the people were poor with around 85% of the national incidence of poverty being accounted for by rural residents. The World Bank (1993) poverty profile of Tanzania indicates that rural Tanzanians are poor than urban counterparts probably reflected through having bigger families and lower incomes.

From the World Bank poverty profile in Tanzania, 85% of the rural people are considered poor spending and consuming less than an absolute poverty level of US $ 1.00 per day per capita. Further, 90% of those spending or consuming less than US $ 0.75 per day per capita also lives in rural areas. The expenditure measures which were drawn from a National household survey (The Tanzania Human Resource Development Survey, 1993/94) estimated household incomes at levels about 30% higher than those of GDP per capita drawn from National Accounts. In 1993, GDP per capita for rural people was estimated to be about US $ 90 per capita whereas consumption per capita was about US $ 180. This compares to a national average of US $ 110 GDP per capita for the same year. What is important however is that even the US $ 180 per capita is still far below the World Banks poverty line of US $275 and hence even these measures Tanzania rural people are quite poor.

Kigoda and Mwisomba (1995) estimate poverty in Tanzania Mainland to be 42.7% in 1994. World Bank (1995b) point out that in 1983, 65% of rural Tanzanians lived below poverty line. The percentage declined to 50.5% by 1991. Therefore, since Tanzania is basically an agricultural economy, poverty in regions is attributed to low agricultural productivity. In that respect, regions with low rainfall, poor soils, poor road infrastructure and long distance to markets have higher poverty incidence than better off regions (Amani, 1996).

2.8.3.3 Income Poverty: Current Status and Recent Trends in Tanzania

The assessment of poverty level and trends is complicated by the lack of consistent information. It has been seen that since the early 1980s, a number of household surveys have been conducted and came up with different poverty lines depending on samples and method used. Thus, " lower lines" denote basic food needs, based on specific assumptions about eating habits, nutritional requirements, and costs; and "upper lines" cover, in addition to such food requirements, other essential needs, such as clothing, housing, water and health. Moreover, a poverty line of one US dollar per day in real terms (using purchasing power parity exchange rate) has been used to facilitate comparisons. In the rural areas, incomes are lower and poverty is more widespread and deeper, than in the urban centers.

2.8.4 Effort made by Tanzania on poverty reduction

The government effort to bring about economic and social developments as the strategy on poverty reduction in the country continues to record success. The economy is growing at accepted rate although the rate is still below the level required to rapidly eradicate abject poverty. It also encouraging to note that macro-economic stability has been sustained for quite sometime and investment continue to rise in various sector of the economy. Improvements in social and economic sectors are on going, new road are being constructed while the existing road are being repaired. The implementation of Poverty Reduction Strategy has started to register successes particularly in primary education, healthy, water and road sectors. Manufactured goods are now available at reasonable prices and in sufficient quantities compared to 1990s.

Despite the achievements attained to date, the rate of growth is still not high enough to ensure a rapid reduction of poverty. The productive sectors, especially agriculture which contribute about 50 percent of GDP and employs about 80 percent of

Tanzanians, is still weak and requires immediate transformation. The Government has taken several measures to revamp the agriculture sector, including the establishment the Agricultural Sector Development Programme (ASDP) and the Rural Development Strategy (RDS).

2.8.5. Policy Planning Process for poverty reduction in Tanzania

More recent efforts to tackle poverty and the other development problems have been pursued under relatively decentralized, but largely complementary policy initiatives as shown below.

Table 2.1: Policy Planning Process for poverty reduction in Tanzania

Policy Planning Initiative	Objective
Vision 2025	National vision of economic and social objectives to be attained by the year 2025.
National Poverty Eradication Strategy (NPES)	National Strategy and objectives for poverty eradication efforts through 2010.
Tanzania Assistance Strategy	Medium-term national strategy of economic and social development, encompassing joint efforts of Government and the international community.
Poverty Reduction Strategy Paper (PRSP)	Medium-term strategy of poverty reduction, developed through broad consultation with national and international stakeholders, in the context of the enhanced Highly Indebted Poor Countries (HIPC) Initiative.

(i) Policy reforms aimed at ensuring macroeconomic stability and market efficiency, being supported partly by the International Monetary Fund and the World Bank under the Poverty Reduction and Growth Facility (PRGF) and the Programmatic Structural Adjustment Credit (PSAC-I), respectively.

(ii) Reform of the public sector (including central and local Government), being supported under PRGF, PSAC-I, Public Service Reform Programme (PSRC) and by other initiatives supported by international partners.

(iii) Development of sector-specific strategies, being supported by many international partners.

Vision 2025 lays out the long-term developmental goals and perspectives, against which the strategy for poverty alleviation (NPES) was formulated. The Tanzania Assistance Strategy is the result of a mutually felt need by the Government of Tanzania and its international partners for a comprehensive development agenda, around which issues pertaining to ongoing activities can be regularly discussed and assessed. As such, the Tanzania Assistance Strategy covers all the development areas that have characteristically been supported by the international partners, both within and outside the framework of the central Government budget. It is hoped that the Tanzania Assistance Strategy will provide a useful framework for organizing periodic consultations and dialogue among all development partners. The PRSP is an integral part of the HIPC process, focusing mainly on poverty alleviation, subject to a relatively hard (central Government) budget constraint, and was started in 2000/2001 financial year. Nevertheless, the PRSP encompasses poverty-oriented extra-budgetary activities, and various non-financial considerations that have an important bearing on poverty reduction. The elaboration of the PRSP has entailed broad consultation among the stakeholders that has contributed to underlying consistency in the country's development policy objectives, including the strategy for poverty alleviation (PRSP, URT 2000).

This notwithstanding, the national policy planning process has features that call for continuous review and reassessment. First, substantial efforts toward poverty reduction by international partners are still being implemented outside the framework of the central Government budget. To ensure maximum progress toward poverty reduction and improved predictability of budgets, these efforts would need to be rationalized and realigned progressively, to reflect the PRSP priorities. Second, a large amount of international resources is being channeled through specific donor driven projects, sometimes entailing duplication. An effective struggle against poverty requires continued efforts to channel these resources in the context of sector-wide development strategies.

Third, a key step in the area of public sector reform, notably the Medium-Term Expenditure Framework (MTEF), preceded the formulation of the PRSP. The priority objectives of the latter were, therefore, needed to be reflected more fully in the MTEF for 2001/2002 and the subsequent years. Finally, major reforms in key areas, especially local Government, education, and agriculture, are still being formulated, and their implication for poverty reduction and resource requirement cannot be assessed accurately now. The Government is, therefore, continued to review and adjust the poverty reduction strategy, in order to reflect the ramification of these reforms (PRSP, URT 2000).

2.8.6 Policy Framework for RWH in crop production in semi-arid areas

The goal of Tanzania's overall agricultural policy is the improvement of the well being of the people whose principal occupation and way of life is based on agriculture. In the past, the problems of semi-arid areas were simply viewed as drought and erosion. The pursued policies, strategies and programmes therefore put a lot of emphasis, efforts and funds on drought-resistant crops and erosion control. Over-emphasis on erosion control led to strategies and programmes, which focused more on the land rather than the land users. These programmes were designed to stop soil erosion without due concern of the direct or opportunity benefits. Destocking, which was implemented by HADO as a way of conserving the Kondoa Eroded Area (KEA), is a good example (Mbegu and Mlenge, 1983). Erosion control approaches of the past had focused more on the amount of soil lost rather than the effect of this loss on soil productivity (Stocking,1988). This led to the promotion of strategies such as cut-off drains, which were mainly designed to dispose run off and tree planting which most of the time decreased the amount of water available for crops due to high soil water consumption by the trees. These approaches are inappropriate for the semi-arid areas where plants suffer more from water rather than nutrient constraints.

It has now been realized that shortage of soil-water for plant use is the major problem, and it can be mitigated by approaches other than drought-resistant varieties. The necessary policy framework needed for dealing with the problem as a key solution is the good management and effective use of rainwater. However, farmers in many parts of the semi-arid areas are ahead of such policies and strategies. They have realized and adopted different land uses in various units of landscape to over-exploit the valley bottoms where rainwater and soil nutrients accumulate. This lands are commonly referred as to as "mashamba ya mbugani" (Hatibu, *at el.*, 2000).

The efforts sustained by SWMRG and its partners, over 12 years, have significantly influenced policy. RWH is now a common feature in the development plans of several district councils and NGOs. In 1997, the Agricultural and Livestock Development Policy contained six policy statements on drought resistant crops and none on soil-water management on croplands. By 2001, the Agricultural Sector Development Strategy (ASDS) recognised integrated soil-water management including rainwater harvesting as the solution to the drought problems of semi-arid areas. In June 2001, following a seminar given by SWMRG and distribution to Members of Parliament (MPs) in Dodoma of the handbook entitled RWH for Natural Resources Management: a planning guide for Tanzania, parliamentary debate included significant statements on RWH. The first MP to speak in the debate on the budget speech stated: 'We must do away with the notion that droughts that we face from time to time in many parts of the country are caused by shortage of rainfall, with a good programme of harvesting rainwater we can avoid droughts even in times or places considered to have low rainfall.' Another MP stated: 'Rainwater harvesting should be the starting point in our agricultural strategy as without adequate supply of water, even if we provide credit, mechanisation and extension, there will be no development in agriculture' (Hansard Records for June, 18th, 2001).

In response, the Prime Minister of Tanzania stated: 'Starting the 2001/2002 financial year, the government will strengthen and promote the use of rainwater harvesting technology, in both urban and rural areas' (Hansard Records for July 2nd, 2001). Then, the Minister responsible for water development elaborated the strategy stating: 'In order to ensure that RWH technology is widely used in rural areas, my Ministry will work with District Councils to ensure that RWH is included in development plans of the councils'.

This is now official policy. The ASDS approved in October 2001 states that: 'The Government in close collaboration and consultation with the private sector, will enhance the efficiency of water utilisation, especially rainwater, through the promotion of better management practices.' This will be achieved by developing and implementing 'a comprehensive programme for integrating soil and water conservation, rainwater harvesting and storage, irrigation, and drainage'. Furthermore, the water policy, approved in July 2002, sets a goal of 'making more water available to rural communities through rainwater harvesting technologies'.

Therefore the change in perception, policy and strategies towards rainfall runoff has been nothing short of remarkable. There is now a real demand for the rainwater harvesting technology. SWMRG and its partners are continuing to work on the subject, especially to develop institutional arrangements for ensuring that there is social and environmental equity in the capture and use of the scarce rainwater resource.

2.9 Importance of agriculture sector for food security and poverty reduction in Tanzania

As already mentioned above, the Household Budget Survey finding for (1991/92) in Tanzania also reveal that, the majority of the poor were in rural areas, where agriculture is the mainstay of livelihoods. Agriculture has dominant role in the economy that is the most critical of the sectors which have been identified as the priority poverty reduction sectors in the Poverty Reduction Strategy Paper (PRSP, 2000).

The importance of agriculture to Tanzania's economic and social development goals was due to following reasons. First, studies by the World Bank (2000) and other indicate that about 50 percent of Tanzanians can be defined as poor. This means that they have a per capital income of less than US$ 1 per day (national average per capital GNP in 1997 was US$ 210). The studies also conclude that over 80 percent of poor are in rural areas and depend on agriculture for their livelihood. Thus according to the finding it can be seen that, the percentage of Tanzania rural poverty situation in the 2000's is better than in the 1980's. For that matter it can be concluded that the percentage change of poverty reduction emanates from the improvement of agriculture sector and one example can be cited is the use of RWH technique.

Second, food insecurity is often a manifestation of poverty. Recent studies on the state of food security in Tanzania indicate that satisfactory indicators at the national level may mask severe food insecurity at household and individual levels, largely due to lack of access to food, poor nutritional quality and biases in intra-household food distribution. The current estimate was that, around 42 percent of households regularly have inadequate food. Localized food insecurity and hunger are common and reflect in adequate resource endowments at the household level. Food price fluctuations put the poor (as producers or customers) in a more precarious condition. These factors suggest that any strategy to address food security must involve actions to improve agricultural production and farm incomes to ensure availability and access to food respectively (World Bank, 2000).

However, poverty reduction has been the concern of many developing countries since the 1950s. Various policies, strategies and technologies are being used to alleviate poverty with different results. Only to find that, majority of the people, in developing countries, continue to suffer from low income, low life expectancy, illiteracy, malnutrition and poor health services (Shitundu and Luvanga, 1998).

Third, over the years, agriculture has been the single largest contributor to gross Domestic Product (GDP) and foreign exchange earnings (FEE) in Tanzanian economy (refer Figure 10).

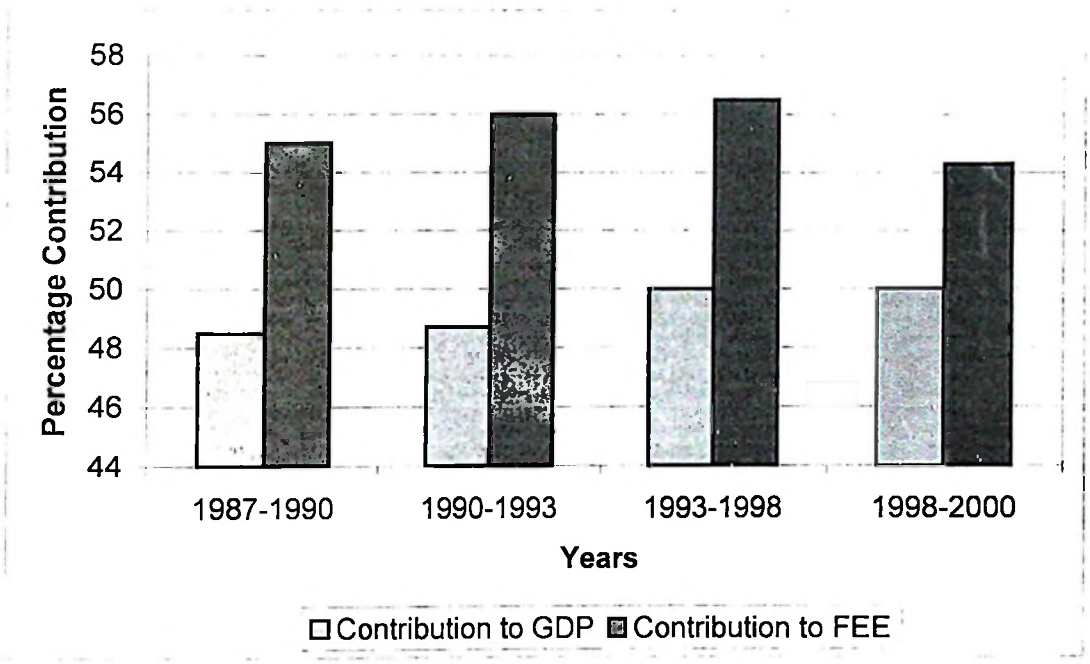

Figure 10: Agriculture's share to real GDP and Foreign Exchange Earnings

Source: URT/World Bank. Tanzania Agriculture: Performance and strategies for sustainable growth.

Furthermore, recent studies concluded that agriculture's growth linkages (Multipliers) in Tanzania were higher than those of the other sectors and are felt in both rural and urban areas. Because of these factors, agriculture remains the engine of economic growth. Accordingly, agricultural development is the key to the country's overall economic development now and in the near future (ASDS, 2001).

2.10 Major findings and conclusion.

The literature presented above suggest that from quantity point of view rainfall in semi-arid areas is not low but the major problem arises from high variability from season to season of amount, starting dates, cessation dates and distribution. The effect of this distribution is worsened by the high rates of evapotranspiration and surface runoff losses commonly occurring in these places. From this point of view it is obvious that use of RWH is an important strategy for crop production in semi arid areas. The Agriculture and Livestock policy of 1997 also put much emphasis on development and introduction of new technology which increases not only the productivity of labour and land but also assured basic food security for the nation, and improvement of national standards of nutrition by increasing output, quality and availability of food commodities.

In this chapter the literature has clearly demonstrated the potential role that can be played by RWH in improving crop production and food security in semi arid areas. Implicitly the literature asserts that RWH has a profound impact on improving crop productivity and poverty reduction in semi arid areas. Testing of these assumptions forms the core of this study.

CHAPTER THREE
METHODOLOGY

3.1 Conceptual framework

The theoretical framework underlying this study is systematically presented in figure 11. The framework elaborates a range of impacts that can be realised from adoption of RWH technology in maize production. There are numerous types of impacts that can result from the use of RWH; these are broadly organised into three major forms of impacts namely social, economic and environmental. Each forms of impacts can result into either positive leading to poverty reduction or negative resulting into increasing poverty.

Social impact of using RWH in maize production can be manifested in several areas including improved food security and rural livelihoods, better nutrition status, improved health, improved access to social services and a general improvement in social welfare. The conceptual framework assumes that although most of the social impacts have a positive effects in poverty reduction. It should be noted however that negative social impact of RWH might also exist. For example, better food security may result in over nutrition, which is basically a negative impact. However, these are either minor or not obvious and because of this they are not explicitly shown in the framework.

Economic impact of RWH can be evidenced in increased gross margins, increased crop productivity, increased material assets, increase in household financial ability and increase in some other profitability factors. Like the case of social impact, all the economic impacts mentioned are assumed to have positive effect in poverty reduction. The focus of this study is to examine the positive effects of RWH in poverty reduction. Three major forms of environmental impact have been shown in the diagram. These are siltation, over cultivation and reduced land pressure. Obviously, reduced land pressure resulting from the use of RWH is a positive effect and it results in poverty reduction. Unlike the case of economic and social impact in which case no negative effect of using RWH is indicated, for this case siltation and over cultivation are explicitly shown to increase poverty. It is important to note that, these major impacts may be expected at both the individual/household level or at community and national level (NECTAR – Programme, 1993).

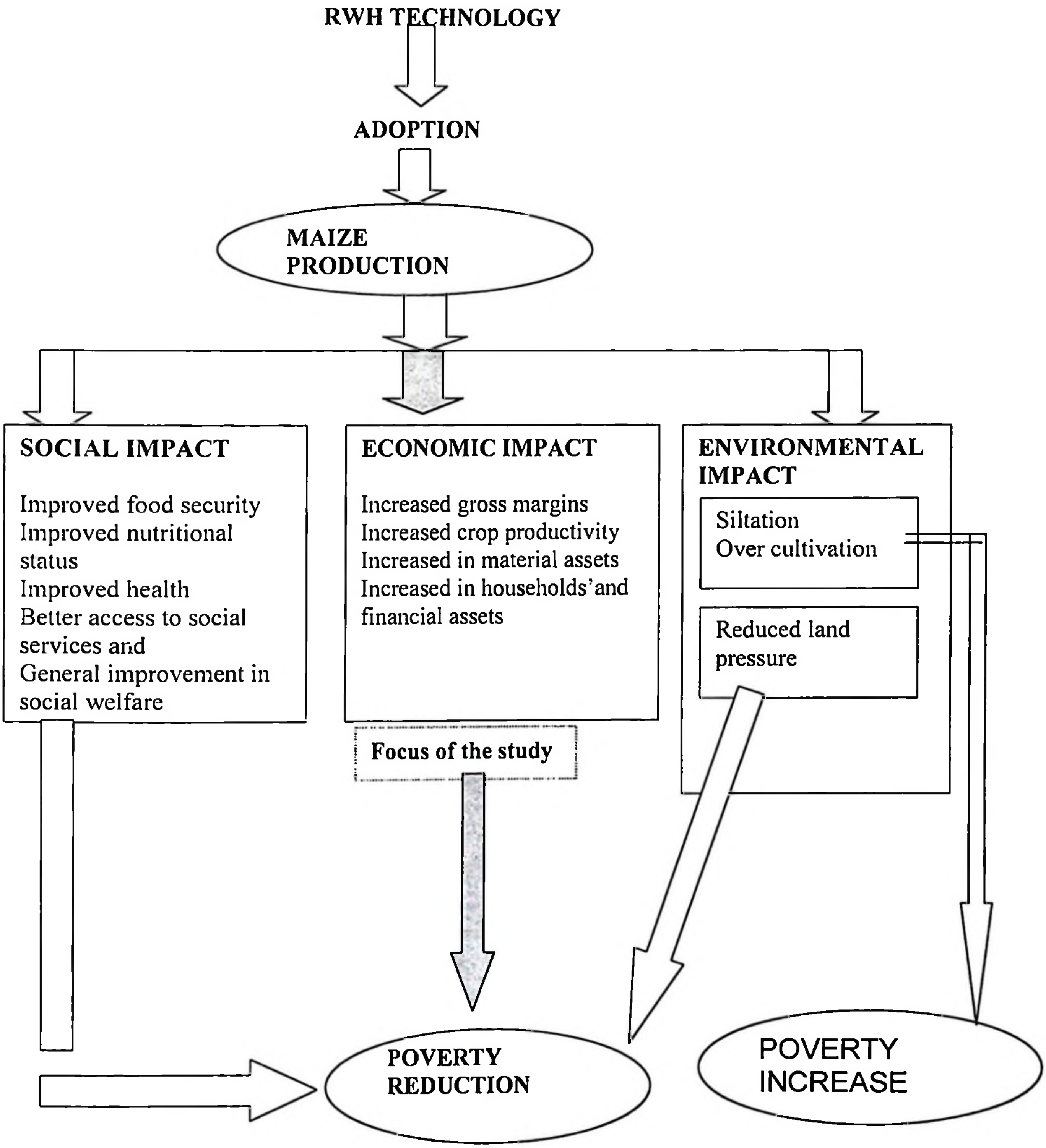

Figure 11: The conceptual framework

3.2 Data sources

Both primary and secondary data were collected from relevant sources. Primary data were obtained from the farmers practicing RWH technologies and those who do not in the maize dominated farming system. Primary data collected include the socio-economic characteristics of respondents, crop acreage, crop yields, household assets, annual consumption expenditure, variable farm costs over the past three years (both short and long rainfall seasons), distance to potential commodity markets, crop stock inventory, income sources and major constraints to the use of RWH technologies. Secondary data was compiled from relevant sources especially the Sokoine National Agricultural Library (SNAL) and the SWMRG at Sokoine University. The secondary information provided a wider insight into the results from survey findings.

3.3 Questionnaire design and sampling technique

Structured questionnaires were designed to collect data from farmers. Stratified random sampling technique was used to generate the survey sample. The central stratification criterion was the situation 'with' and 'without' RWH as defined earlier. Chankoko sub-village which is not served by the macro-catchment run-off provided the 'without' RWH sample farmers. The 'with' RWH population was further categorized into three sub-samples depending on location along the main canal. The three locations included the head, middle and tail. This aimed to capture locational effect as the access to adequate water varies with location depending on the amount of run-off and rationing arrangements down the stream. Farmers with plots located at the head are likely to have more access to water than middle plots and the farmers on the tail are disadvantageous. A total of 120 farming households was selected with 30 from 'without' RWH, and other 90 proportionately from the three categories of head, middle and tail located farmers under RWH.

3.4 Questionnaire administration

A structured questionnaire was administrated to a stratified random sample of 120 respondents. The survey was preceded by a one-day pre-test with six respondents in the study area involving three respondents. The composition of the six respondents used in the pre-survey was made to include the characteristics of the respondents to be used in the actual survey. Of the six respondents three were those under 'with' where as the other three were those under 'without' RWH. One of each of the three respondents under 'with' RWH was selected from one area along the canal i.e. upper, middle and lower tail of the canal.

Like all other pre-test exercises, the major purpose of doing the pre-survey in this study was to examine the applicability of the questions set in the questionnaire so that proper adjustments could be done prior to the main survey. It was also the purpose of this pre-testing to identify appropriate household assets to be covered in the actual survey whose values need to be compared between households under 'with' and 'without' RWH. The identified household assets which were thereafter incorporated in the actual survey were house, machete, bicycle, hand hoe, radio and spryer. Aftermath the survey was conducted between mid of November to the end of December 2002. The author himself and other three ward extensionists assisted in the data collection exercise. The farmers were very cooperative as the interviewers enjoyed the trust Sokoine University of Agriculture based Soil Water Research has built in the study area.

3.5 Methods of data analysis

3.5.1 Descriptive and qualitative analyses

For descriptive analysis means, frequencies, cross-tabulation and related statistics were used. Research variables analysed descriptively include the distribution and characteristics of respondents' households, crop stock inventory and major constraints associated with RWH and/or farm production. To supplement the descriptive analysis, some of the information generated was assessed qualitatively based on sound judgment and economic rationale.

3.5.2 Quantitative analysis

Quantitative analyses that were used in this study included graphics, ANOVA, and regression models. These included analysis of household welfare based on incomes, assets value and consumption expenditure, graphical analysis depicting the contribution of RWH to the gross household income (GHI), crop productivity, determination of maize enterprise gross margins, and per caput incomes and consumption expenditure with subsequent comparison to the government minimum wage. Furthermore, multivariate regressions were used to identify critical determinants of maize enterprise gross margins, incomes and consumption expenditure. Also, ANOVA was used to test the extent of variation of incomes, assets value and consumption expenditure under the with and without RWH situations.

Beforehand, it is important to present some pertinent assumptions made concerning computation of the gross margins. Being drought prone area, WPLL as like other semi-arid areas in Tanzania, is the food grain deficit. As a result, farmers experience seasonal fluctuation of output mostly with yields sufficing for subsistence consumption leaving very little marketable surpluses if any. As a result all the maize output including marketed and non-marketed was valued at the average mean annual market price. This value was considered to be equivalent to the gross returns from which variable costs were deducted to obtain respective gross margins. The gross margins attributes were collected along the past three consecutive years including main and second seasons. This aimed to make the task of yielding a construct of average gross margins entailing the average situation at least for the past three years. The three years-based average gross margins were summarized in maize enterprise budgets. Furthermore, multivariate regression model was used to identify important determinants of the average gross margins in all years combined.

a) Analysis of household poverty or welfare

The household welfare implies the level of standard of living of the household manifesting as household's command over resources in terms of aspects such as food, money, health, schooling, housing, assets and means of transport and communication. Virtually, poverty and welfare are closely inter-linked concepts. This inter-linkage is reflected in the fact that increased welfare reduces the poverty situation. On the other hand, poverty reduction means an increased welfare of the households. This study used level of incomes, assets value and consumption expenditure to portray the welfare of households practising sound RWH and those which do not. ANOVA was carried out to test if the welfare varied significantly under 'with' and 'without' RWH.

b) Analysis of the contribution of RWH to Gross Households Income

In order to show explicitly the share of RWH to the gross household income (GHI) graphical analysis was used. Graphical results show the contribution of each source of income to the overall income of the household. Such analysis tells the importance of RWH relative to other contributors of the total household income.

c) Crop productivity analysis

In economic theory productivity is related to technical efficiency where a given combination of inputs can yield a given level of optimal output. For the last year (long and short season), the yield per acre for the four most important crops as perceived by farmers themselves was identified. Also, the nature of farming and respective productivities of these crops depending on the system used was identified. Using one-way ANOVA the means of yield per acre in respective situations were compared to depict whether their variances were statistically significant.

Mathematical expression for crop productivity:

$CP_I = CO_i / CA_i$

Where;

CP_i = Crop i^{th} productivity either under 'with' or 'without' RWH, or for different location (bag/acre)

CO_i = Crop i^{th} output under 'with' or 'without' RWH, or for different location (bag)

CA_{ci} = Crop i^{th} acreage under 'with' or 'without' RWH, or for different location (acre)

d) Analysis of Gross margins for maize enterprise

Gross margin refers to the returns over variable costs and is an appropriate measure of the profitability for comparing enterprise performance in short run. Gross margin is the difference between gross value of output and the total variable costs used in the production process. The gross output includes the amount of product e.g. maize being sold, consumed and that given away to relatives. Variable costs consist primarily of seed, fertilizer, pesticides and labour (measured on per day basis) used specifically for crops (Hill, 1990). In this study, however, the family labour was imputed at the prevailing casual wage and added to the explicit wage costs to obtain the overall labour costs.

Gross margin usually involves representative farm models for generating gross margins for enterprises (crops), which are used to compare the situation "with" the "project" and that of 'without' the 'project'. Gross margin analysis is static, and does not take into consideration the time value of money. This is a deficiency when analyzing RWH structures, which produce benefits over number of years. However, it is useful tool, which can assist in improving the overall management of the farms as it addresses resource productivity in a given period of time.

In this study gross margin was used to assess the profitability of maize enterprise under 'with' and 'without' RWH for different locations along the main canal. The gross margins are presented in average terms for respective counts of farmers 'with' and 'without' RWH, and for various locations along the main canal. The average gross margins for consecutive past three years were scaled on the World Bank absolute poverty line and the government minimum wage.

The mathematical expression of gross margin used;

$GM = TMOV_i - TVC_i$

Where;

GM = gross margin (Tsh/acre)

$TMOV_i$ = total maize output value (Tsh/acre)

TVC_i = total variable costs (Tsh/acre)

Moreover, some consideration made for the components of the formula needs to be clarified as;

$TMOV_i$ = *total maize output value (Tsh/acre):*

These were calculated by multiplying volumes of maize output by the average selling market price for respective year (including main and second season).

- $TAVC_i$ = *average total variable costs (Tsh/acre):*

These were also obtained directly from the sampled maize farmers. The costs involved here included: variable production costs, packaging and marketing costs.

e) Comparison of incomes and expenditure to minimum wage

In order to depict explicitly the role of RWH on poverty reduction, crop incomes under 'with' and 'without' RWH, and respective consumption expenditure were scaled on the prevailing official monthly minimum wage of 35,000 TAS. For comparison in the per caput terms, the monthly wage was converted into annual value of 420,000 TAS then adjusted to the average household size of 6 and 7 people for 'with' and 'without' RWH respectively. The global one-dollar poverty line was not considered, as it is more unrealistic compared to local poverty thresholds like the minimum wage. The minimum wage was chosen over the national poverty line of 73, 877 TAS adjusted to 1995 prices, as the former is more recent and the later is prone to money illusion.

f) Multiple Regression analysis

Regression analysis was used to identify major determinants of the profitability of maize enterprise in terms of gross margins and consumption expenditure (models I and II respectively). All regression models were estimated using OLS method. Identification of critical determinants of profitability of maize enterprise, and poverty expressed in terms of income and consumption levels, is important for informed policy formulation and targeting. The models are specified in the following sections.

i) Model I: Gross margins regression

$$GM_i = b_o + b_1DRWH + b_2HWAF + b_3EDU + b_4FEXPH + b_5MCP + \mu$$

Where,

GM_i = Gross margin for maize enterprise for i^{th} farmer (TAS)

b_o = Intercept

$b_1 \ldots b_5$ = Parameters to be estimated

DRWH = Dummy for RWH (value of '1' with RWH and '0' without RWH)

HWAF = Number of household members working always on the farm

EDU = Education of the household head (years in school)

FEXPH = Farming experience of the head (years)

MCP = Productivity of maize (bags/acre)

μ = Error term

ii) Model II: Consumption expenditure regression

$$CE_i = b_o + b_1DRWH + b_2HHS + b_3NAHM + b_4HWAF + b_5EDU + b_6FEXPH + \mu$$

Where,

CE_i = Household consumption expenditure for i^{th} household (TAS)

b_o = Intercept

$b_1 \ldots b_6$= Parameters to be estimated.

DRWH = Dummy for RWH (value of '1' with RWH and '0' without RWH)

HHS = Household size

NAHM = Number of abled household members

HWAF = Number of members working always on the farm

EDU = Number of years in school for the head

FEXH = Farming experience of the head (years)

μ = Error term

g) Expected signs for the explanatory variables are presented as follows:

i) MCP: Crop productivity (for maize)

The increase in crop productivity is expected to increase the gross margins hence profitability. A positive sign is expected for the parameter attached to the variable. The predictor was not included in the income and consumption models as it is of no relevance in these models.

ii) ACM: Acreage under maize last season

This variable was included in the income model and not in other models. Exclusion in the gross margins model was to avoid inter-correlation with the productivity variable and was not relevant in the consumption model. Given level of productivity of maize as other crops, input use, crop management, and producer prices, increased acreage is expected to increase the household income of which the maize enterprise contributes to.

iii) DRWH: Dummy with RWH or otherwise

In this case a dummy was constructed where the GM will bear a value of '1'for 'with' and '0' for 'without' RWH. The maize gross margins, household incomes and expenditure level are expected to be positively related to this predictor variable. The probability of realizing increased profit margins is expected to increase with the intensity of practicing RWH. The parameter attached to this dummy is expected to bear a positive sign in all three models. Furthermore, under 'with' RWH scenario had three different locational aspects i.e. upper, middle and lower (location variables), which upon attempting to incorporate it in this model, most values were rendered insignificant thus the researcher decided to drop the location dummy variable.

iv) HHS: Household size

This variable was included in all models except that of gross margins for the maize enterprise. In the gross margins model, the variable for a number of household members working always on the farm was more relevant than a mere household size. However, the household size may influence the level of income and consumption. The positive direction of causality is expected in both models.

v) NAHM: Number of abled household members

In the household poverty and welfare analysis, the number of abled members comprises the active workforce of the household. Abled people will be working both on and off-farm to sustain themselves and disabled (sick, physically handicapped, infants etc) in a household. This variable was relevantly included in the income and consumption models. The positive sign of the coefficients in these models is expected.

vi) HWAF: Household members working always on the farm

This variable was fitted in all three models. Given the labour quality in terms of knowledge, and efficacy of working tools this variable is expected to be positively related to the maize gross margins, incomes and consumption. Where farm household rarely use hired labour, routine input of family labour would downsize labour constraint and increase farm production, incomes and the capacity to command more consumable items.

vii) FEXPH: Farming experience of the household head (years)

Farming experience would improve the performance of farmers through a learning-by-doing process. Indigenous technical know-how will be improving along with increased farm experience especially of the head who also is the opinion leader in the decision making process in the context of the rural farm sector, especially in Africa. The farming experience would positively lead to increased farm profits, incomes and consumption.

viii) EDUH: Education of the household head (years in school)

This predictor variable is relevant in all three models. More years in schooling as an indication of formal literacy, is expected to improve the human capital in terms of skills and confidence. Improved human skills may improve farm productivity and marketing strategies, which would lead to, increased farm profitability, household incomes and consumption. The coefficient attached to this variable is expected to bear a positive sign in all three models.

Regression equations generated by ordinary least square are associated with a number of problems depending on the type of data used and the nature and form of regression model employed in the analysis. The common problems encountered in regression analyses include multicollinearity, heteroskedasticity and autocorrelation (Gujarati, 1988). Cross-sectional data used in this study are likely to have problems of heteroskedasticity and multicollinearity. The main problem of heteroskedasticity is that ordinary least squares estimators while still linear and unbiased, can no longer provide minimum variance. This makes the ordinary least squares estimators unreliable, *i.e.* the variance will be large leading to small t-values. Natural logarithm transformation will be adopted to reduce the problem of heteroskedasticity by improving statistical normality.

The problem of multicollinearity exists where there is linear relationships among the explanatory variables. A part from several tests for diagnosing presence of multicollinearity existence of very high coefficients of determination (R^2), illogical signs of parameters of the variables included in the model and F-ratios being highly significant but most of the individual t-ratios insignificant. In this study the researcher ran a correlation matrix between variables in the model (excluding dummy variables).

Those that were found to be highly correlated (p>0.01) were dropped from the model or combined/collapsed to one variable. Since multicollinearity is a sample problem then increasing sample size is known to reduce the likelihood of encountering the problem. In this study the multicollinearity problem will be partly addressed by the large sample size.

3.6 Description of study area

3.6.1 Location

The study was conducted in Makanya village in Same district, located about 194 km from Moshi along the Moshi-Dar-Es-Salaam main road in Kilimanjaro region. Administratively, Same district has six divisions, 25 wards and 83 villages. Its population is 212,325 of which 103,520 were males and 108,805 were females (URT-Population and housing census, 2002). The WPLL is mostly inhabited by the Pare and Maasai practising both crop production and livestock keeping. The agricultural land is estimated at 45,000 ha of which 38000 ha is under cultivation out of which 7,500 ha is irrigated. The district has 170,000 of cattle, 186,000 sheep/goats and 7,000 donkeys. Makanya village has 1,937 households with a total number of 4,502 people (URT-Population and housing census, 2002).

3.6.2 Climate

Makanya falls under the Western Lowland which is one of the driest areas in the District. The climatic condition range from 21^0C to 36^0C of temperature throughout the year, with 250 mm to 400 mm of rainfall per year which falls in two seasons, namely short rainy season (vuli) and long rainy season (masika). Short rainy season occurs between October to December and long rainy season normally falls between February and May. The driest period is in January and June to September. The rainfall amount in this area is too low to support agricultural production. This has led to development and adoption of various forms of rainwater harvesting to supplement rainfall (Joint publication by planning commission and Same district council, 1999).

3.6.3 Soils, vegetation and land use

Soil distribution in WPLL varies from sandy to clay-dominated types. The soil structure is of fine and fragile grains due to drier and windy climate. However, the soils are fertile due to run-off depositions from the mountains to the lowland. This situation limits the productivity constraint to be water stress. The vegetation are of semi-arid types including bushy, thorny and cactus trees. The WPLL together with the Eastern Lowland covers about 1/3 of the total main features of the district, the rest 2/3 of the land is in the Highland. Between the lowland and the highland plateau there is a steep slope area all round the Pare Mountain range which is not fit for any agricultural farming. Makanya village in particular has 33,518 ha for livestock reserve and 2182 ha left for cultivation, however it is only 184 ha (8.4%) which is under RWH practices, while 400 ha (18.4%) depends on rain-fed while the rest of the area 1598 ha (73.2%) is uncultivated.

3.6.4 Economic activities

Agriculture (crop and livestock production) is the major activity in the WPLL. Cultivation of drought resistant crops such as sorghum and millet is also pronounced. The production of maize, legumes and horticultural crops is possible under RWH systems. Large scale farming in the WPLL includes sisal estates providing wage employment for Makanya and nearby residents. The main crops grown at Makanya in particular includes maize, lablab beans, beans, sweet potatoes, peas, sorghum, sunflowers, fruits and vegetables. Cash crop grown is cotton which also has failed due to poor marketing systems. Livestock keeping is also a major economic activity in the WPLL where relatively large herds of cattle, goats and sheep are kept in a dominantly agro-pastoral system. The gypsum mines is the main off-farm venture providing returns to capital for investors and wage incomes for casual labourers in the area (Joint publication by the Planning Commission and Same District Council, 1999).

3.6.5 Justification for selection of Same district (WPLL)

The choice for WPLL in Same district and Makanya village in particular, is mainly based on the fact that the area has a historic of practice of RWH due to existence of serious drought which causes crop failure and food shortage. This led some farmers through their own initiative to direct the surface run off to their fields for irrigation and harvested some crops compared to farmers who depend only on rainfall. Given the main focus of this research as assessing the role of RWH on poverty reduction, the area becomes empirically ideal.

3.7 Conclusion

This study attempts to establish the economic impact of Rain Water Harvesting to poverty reduction and crop productivity in Western Pare Lowlands of Tanzania. The study anchors at exploring the differences in status of household welfare of those households under 'with' and 'without' RWH. The parameters used in exploring the differences are nominal values of household income, asset values, expenditure on various items and maize gross margins. In addition, comparison between households under 'with' and 'without' RWH is made on their per capital contribution of maize gross margins to official poverty thresholds. On the other hand the study employs regression models to identify the determinants of poverty in the study area. The major purpose of identifying the determinants of poverty in the study area is to assess as to whether use or disuse of macro-catchments RWH is an important determinant of poverty in the area; establishment of this fact has an important policy implication.

Methodological issue presented in this chapter elaborates the procedure used in collection and analysis of data. It has already been mentioned that this study is comparative in nature implying that similar data need to be collected from different households at the same point of time. In order to make this possible, cross section household survey was used in data collection, the major survey instrument being a structured questionnaire. Structured questionnaire was found the most appropriate survey instrument due to the nature of data required in the survey being quantitative. The decision on sample size (120 households) was especially made on grounds of time and resource constraints. This sample size was found to be both representative enough and not too big to overstretch resources available for the study. Motivated by the underlying motive of the research i.e. making of comparison, the representative households for the study were chosen using two stages stratified random sampling technique. This sampling method has enabled the research to successfully collect data from all categories of respondents. These categories are users and non-users of RWH as well as households practicing RWH at different places along the canal.

It will be shown in later chapters that this study has successfully managed to clearly establish the impact of RWH in crop production and poverty reduction in the study area. Basing on the obtained findings of the study, it is very comforting to note that methodology used is sound enough. However, this is notwithstanding some inherent limitations observed. Section 5.2.3 highlights some obvious shortfalls of the adopted methodology. Basing on these observed shortfalls, section 5.4.2 discusses some possible remedies of the methodology with the purpose of highlighting areas for further research

CHAPTER FOUR
RESULTS

4.1 Socio-economic characteristics of the respondents

4.1.1 Gender, age and marital status

Socio-economic background has a direct bearing to the livelihood of a given household in shaping the productivity of human capital. Aspects like education level, age, gender, farming experience, farm dependence ratio and access to extension services influence the capacity of the household to command other resources – natural, physical, financial and social assets - to lead a given standard of life. Studying these characteristics is thus important in order to understand the welfare of the studied farm households in the study area.

Table 4.1 indicates that, of all respondents, 52.5% were males while only 47.5% were females. Such closeness in the proportion of males and females in the sample of respondents implies more or less equal representation of ideas along gender lines. It should be noted that, the interview aimed at questioning the head, but in his/her absence another informed household member was asked on behalf of the household. In view of this, the sample of respondents includes both the heads and non-head members of the farm households.

The age structure of the sample was that, 73.3% of respondents had ages ranging from 18 to 60 and 26.7% had ages over sixty years in the two RWH systems. This means, most of the respondents fall in the economically active age. For the case of marital status, the results in table 4.1 shows that the majority (90.8%) of all the interviewed respondents were married where as only 9.2% of the respondents were single. This observation is not surprising because the survey targeted at interviewing household heads. By mere characteristic of being household heads makes most of the interviewed respondents to fall under married category. When disaggregated by 'with' and 'without' RWH results of marital status still indicate that for each category the majority of respondents were married. The results show that 79 out 90 (i.e. 83.3%) of the interviewed respondents under with RWH were married. On the other hand the results show that all (i.e. 100%) of the interviewed respondents under the without RWH were married.

Table 4.1: Gender, age and marital status of respondents

Items	Under RWH		Without RWH		Total	
	n=90	%=75.0	n=30	%=25.0	N=120	%=100.0
Sex of respondents:						
Male	45	37.5	18	15.0	63	52.5
Female	45	37.5	12	10.0	57	47.5
Age category:						
18 to 60 years	59	49.2	29	24.2	88	73.3
Over 60 years	31	25.8	1	0.8	32	26.7
Marital status:						
Married	79	65.8	30	25.0	109	90.8
Single	11	9.2	-	-	11	9.2

4.1.2 Education level, farming experience and occupation of respondents

In African context, head of the household plays a very central position in the decision making process. As a result, his/her level of education would have a significant influence on the welfare of the household headed. Apparently, Table 4.2 indicates that, the level of non-formal education was relatively high among those under without RWH than those under RWH (8.3% versus 6.7% of all respondents). The findings show that, 10 out of the total of 30 respondents under 'without' RWH (33.3%) did not attended any formal education compared to only 8 out of 90 respondents under 'with' RWH (8.9%). Formal literacy for respondents from households under 'with' RWH system is higher than those from 'without' RWH situation. In the study area, households under 'with' RWH are conventional farmers as opposed to their counterparts.

Table 4.2: Education level of respondent

Items	Under RWH		Without RWH		Total	
	n=90	%=75.0	n=30	%=25.0	N=120	%=100.0
Education level of head:						
Not gone to school	8	6.7	10	8.3	18	15.0
Standard four	23	19.2	4	3.3	27	22.5
Standard eight	19	15.8	1	0.8	20	16.7
Adult education	2	1.7			2	1.7
Primary education	30	25.0	15	12.5	45	37.5
Secondary education	3	2.5	-	-	3	2.5
College education	5	4.2	-	-	5	4.2

In most of semiarid areas of Tanzania, inherently pastoral communities' manifest lower school enrolment rates than those in high potential areas. Among other reasons for this situation has been linked with very inadequate school infrastructure. Public investments in service provision in pastoral areas have been frustrated by migratory nature of pastoral societies in search of pasture and water. However, nowadays there is a transition from migratory pure pastoralists to semi-permanent or permanent settling agropastoralists. Although, all the studied factions are found in the semi arid ecosystem, sound RWH harvesting has made a great difference between them.

In this study, the farming experience referred to the period the respondent started farming as independent household or as a full actor for the case of non-head respondents. The findings in Table 4.3 show that most of the respondents (55%) in under RWH situation had more farming experience (over 20 years) as compared to their counterparts (10%). Contrary to agropastoralists, this implies early entry into farming business among crop-based farming families.

Table 4.3: Farming experiences of the households

Item	Under RWH		Without RWH		Total	
	n =90	% =75	n =30	% =25	N= 120	%=100
Farming experience:						
Up to 5 years	7	5.8	5	4.2	12	10.0
6 to 10 years	7	5.8	7	5.8	14	11.7
11 to 20 years	21	17.5	6	5.0	27	22.5
Over 20 years	55	45.8	12	10.0	67	55.8

Furthermore, the findings in Table 4.4 indicate that, households under RWH had a more diversified array of livelihood options than the counterparts of which most of them were agropastoralists. The agropastoralists consider crop production to be risky as they do it on infertile and more fragile land. The extent of diversification income options tells the potential for a given household to lessen livelihood risks and vulnerability to shocks. According to the livelihood theory, a diversity of livelihood options guarantees high security and less vulnerability. In view of this argument, farm households under RWH seem to be less vulnerable in terms of income poverty. However, further analyses would tell the contribution of RWH system to capital formation, which might have enabled entry into more diversified income options.

Table 4.4: Occupation of respondents

Item	Under RWH		Without RWH		Total	
	n = 90	% = 75	n = 30	% =25	N =120	%=100
Other occupations:						
None apart from farming	43	35.8	-	-	43	35.8
Herding/stocking	12	10	30	25	42	35
Salaried employment	8	6.7	-	-	8	6.7
Business (petty)	25	20.8	-	-	25	20.8
Herbalist	1	0.8	-	-	1	0.8
Masonry	1	0.8	-	-	1	0.8

4.1.3 Settlement, migration reasons and extension services

Table 4.5 indicates that, for both categories almost half of them (48.3% of total respondents) immigrated into the village. Of interest, for respondents under RWH the two top most immigration reasons include marriage and search for RWH opportunities (29.8% and 26.3% of the total respondents respectively). For the counterparts the main two equally important immigration reasons included marriage and search for pastures (15.8% of total respondents).

Delivery of extension services was captured as the number of times a farm household was visited by extensionists purposely for delivering agricultural education message in the last season. Table 4.5 indicates that, delivery of agricultural services in the study area as a whole was poor about 54.2% of the total respondents were not visited at all, 35.8% were visited once to twice. However, the delivery of extension visits in the agropastoral areas was relatively poor (only 8 out of 30 respondents were visited at least once in the last season) than for counterpart farmers under with RWH situation.

Table 4.5: Settlement, migration reasons and extension services

Items	Under RWH		Without RWH		Total	
	n = 90	% = 75	n = 30	% = 25	N =120	% =100
Settlement status:						
Born Makanya	51	42.5	11	9.2	62	51.7
Not born in Makanya	39	32.5	19	15.8	58	48.3
Reasons for migration:						
Marriage	17	29.8	9	15.8	26	45.6
Seek RWH	15	26.3	-	-	15	26.3
Employment transfer	1	1.8	-	-	1	1.8
Seek wage work	-	-	1	1.8	1	1.8
Accompanied parents	5	8.8	-	-	5	8.8
Seek pasture resources	-	-	9	15.8	9	15.8
Extension visits:						
Not visited	43	35.8	22	18.3	65	54.2
Visited once to twice	39	32.5	4	3.3	43	35.8
Visited over twice	8	6.7	4	3.3	12	10.0

4.2 Description of assets, expenditure and income structure

4.2.1 Assets possession by households

The inventory of assets presents the level of accumulation of wealth and the solvency in case of liquidation to meet emergency obligations. Table 4.6 indicates the six most important assets possession for household under 'with' and 'without' RWH situation respectively. Focusing on housing, the findings in Table 4.6 reveal that, households under RWH situation possessed exorbitantly high value houses (1 232 899 Tshs) than their 'without' RWH counterparts (326 759 Tshs). Inherently, pastoralists exercise more or less migratory livelihood as opposed to permanent settlements. This may make them decide rationally to build low value dwellings just for temporal services. Also, household under RWH possessed more expensive radios (30 694 Tshs) than counterparts (15 691 Tshs). Apparently, on average every household in agropastoral area had a bicycle.

Table 4.6: Assets possession inventory

Item	With RWH		Without RWH	
	n	Mean value(Tshs)	n	Mean value(Tshs)
House	89	1 232 899	30	326 759
Radio	87	30 694	30	15 691
Sprayer	79	44 400	30	37 667
Bicycle	84	40 933	30	45 403
Machete	90	1 800	30	2 567
Hand hoe	90	4 837	30	5 310

4.2.2 Assets value

In poverty and welfare analysis the value of assets possessed by the household indicates its wealth in terms of material well-being. Material assets are also a reflection of the capacity to absorb livelihood shocks in case of uncertain future where the assets can be liquidated to meet obligations such as food purchases or immediate cash needs. The households with little assets base are more vulnerable and may be considered poorer than those with large stock value of physical assets.

The housing quality either being reflected in terms of its nominal (costs of construction) or real value (current market value), is a good indicator of welfare. In view of this, the value of a house was analysed in line with the value of other assets in total. Figure 12 indicates that, households under RWH system possessed higher value of both the house and other assets. The nominal values of these categories of assets for households under RWH were much over twice that for counterpart households. However, the livestock asset which comprised the wealth base for most of the pastoralists respondents under the "without" situation were not included in the valuation. This was deliberately done for two reasons. Firstly, this study focused at analyzing the impact of RWH to poverty reduction through its improvement on maize productivity. Basically therefore, it was obviously found that investigating the impact of RWH in poverty reduction through its role in livestock keeping was out of focus of the study. In addition, it was clearly found during the pre-survey that RWH in Makanya village only to a less extent used for livestock keeping, mainly were used for crop production purposes. Nevertheless, this exclusion of livestock values necessitates thc findings of this study to be interpreted with care. This is particularly because pastoralists prefer to build their assets in form of livestock herds and would have scaled better if livestock had been included in the valuation.

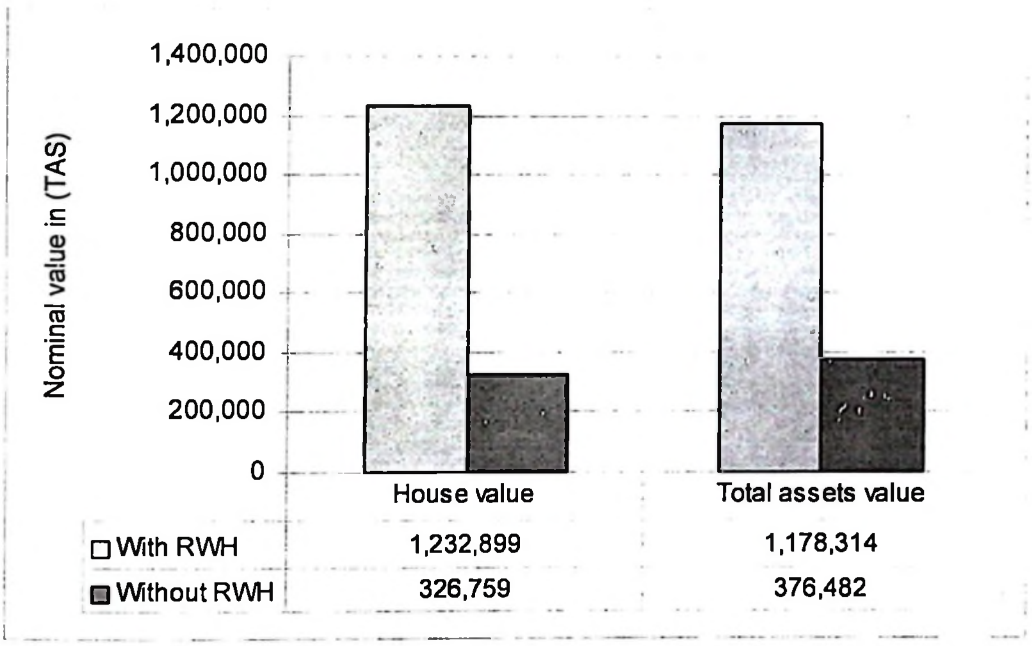

Figure 12: Household assets value in nominal terms

Furthermore, Figure 13 indicates that, for households with RWH the house value was 82.5% of the total assets value compared to 65.3% for those under without RWH. Building of low value houses may be due to the nature of settlement of pastoralists who comprised all respondents under without RWH situation. They experience semi-permanent settlement involving them to move from place to place in search of water and pasture. Under such situation it seems to be uneconomical for them to build high-value permanent dwellings. However, improvement in RWH for home use and their livestock could make them invest in constructing quality permanent structures. However, empirical judgement stays to hold that RWH would have contributed to the welfare of farming households under with RWH situation.

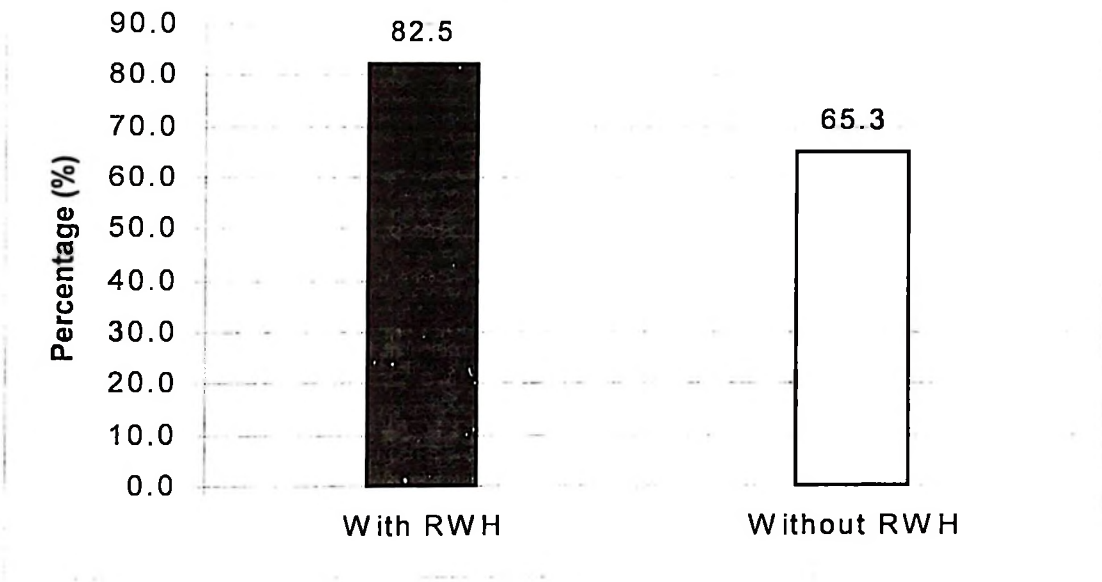

Figure 13: Proportionate house value of all assets value

4.2.3 Consumption expenditure

4.2.3.1 Food expenditure

Given household size, expenditure on food depicts the level of nutrition welfare. It should be noted that, on average, the household size of both with and without RWH was 7 and 6 persons respectively. Maize and rice are the two major energy staples in rural and urban Tanzania. On this basis, analysis of food expenditure on Table 4.7 indicates that, three food items that attracted relatively high expenses include rice, meat and fish for households under RWH; and maize, meat and bananas for counterpart households.

Table 4.7: Annual expenditure on food items (Tshs)

Item	With RWH		Without RWH	
	N	Mean value	n	Mean value
Maize	77	41 142	30	73 833
Cassava	36	16 206	6	7 667
Sorghum	22	4 309	0	-
Rice	87	71 985	22	32 398
Bananas	59	24 831	11	36 245
Sweet potatoes	54	17 230	11	9 255
Irish potatoes	59	20 363	8	7 650
Vegetables	76	19 487	21	12 378
Fruits	82	16 987	30	5 599
Meat	85	52 271	9	47 067
Milk	57	54 153	2	22 800
Fish	89	37 301	30	25 653
Beans	38	36 784	3	22 933

Of interest, mean value is relatively higher on maize by households under 'without' RWH situation than households under 'with' RWH situation. This is because sound practices of RWH system have enabled farmers to produce some maize and reduce purchases from the markets. Apparently, this is the evidence signifying the contribution of RWH to food self-sufficiency and reduction of food poverty. However, all the households were net buyers of grains (maize and rice in particular).

4.2.3.2 Non ood expenditure

Like for the case of food items non-food items indicates the level of consumption capability. Table 4.8 and Figure 14 show that households under 'with' RWH situation most of the expenses were made on clothes and foot wear (56 329 Tshs), while for 'without' RWH most expenses were on water use (65 120 Tshs). However, households under without situation spend relatively little income on medical/health services, village government contribution/taxes and drinks/refreshments as compared to their counterpart, this situation can be due to the nature of agro pastoralists who experience semi-permanent settlement in need of water and pasture and hence being not often in touch with social services and government obligations.

Table 4.8: Annual expenditure on non-food consumables (Tshs)

Item	With RWH		Without RWH	
	n	Mean value	n	Mean value
Clothes, footwear	89	56 329	30	61 600
Medication/health services	89	26 769	30	16 917
Village Gov. contribution, taxes etc	78	46 073	28	13 718
Social occasions (funerals, weddings)	89	20 171	29	20 059
Drinks and refreshment	47	46 874	5	22 560
Remittances	62	11 810	19	19 842
Transport	84	39 774	26	19 385
House repair	34	32 094	8	23 750
Fishing gears	25	1 980	0	-
Water	56	3 863	15	65 120
Fuel	89	48 352	30	25 193
Education	76	51 060	28	22 793
House rent	2	36 000	1	10 000

Moreover, households under RWH spend more money on education than those under without situation. Of interest, expenses on domestic water are relatively exorbitant for households under without RWH situation. This implies the absence and thus the urgent need for improving RWH for both domestic and farm purposes in the area.

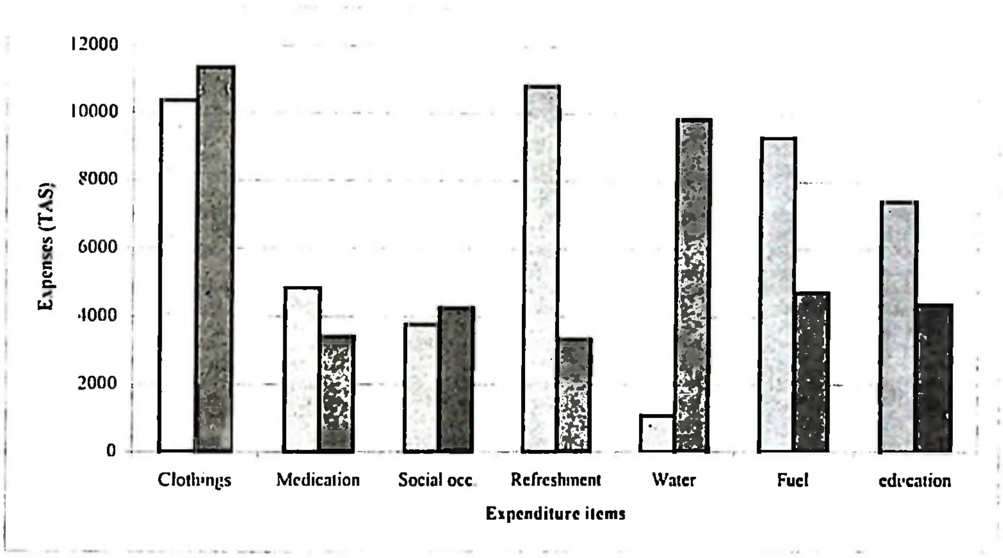

Figure 14: Household expenditure on selected non-food items

In assessing expenditure on food items, the annually purchased food baskets were categorized into three types including energy, protein and vitamins rich foods (Figure 15). Analysts of nutritional welfare relate improved standards of living or reduced poverty with types of foods dominating the household diets. For example, the food menu in poor countries is dominated by starchy foods (energy rich) as opposed to dominance of protein-rich foods in rich countries. In all facets of food categories households under RWH had higher per caput consumption expenditure than counterpart's households. Spatial price differential is virtually non-existent as a common marketplace serves all surveyed areas. This means that households under RWH spent more on foods in real terms than counterpart households.

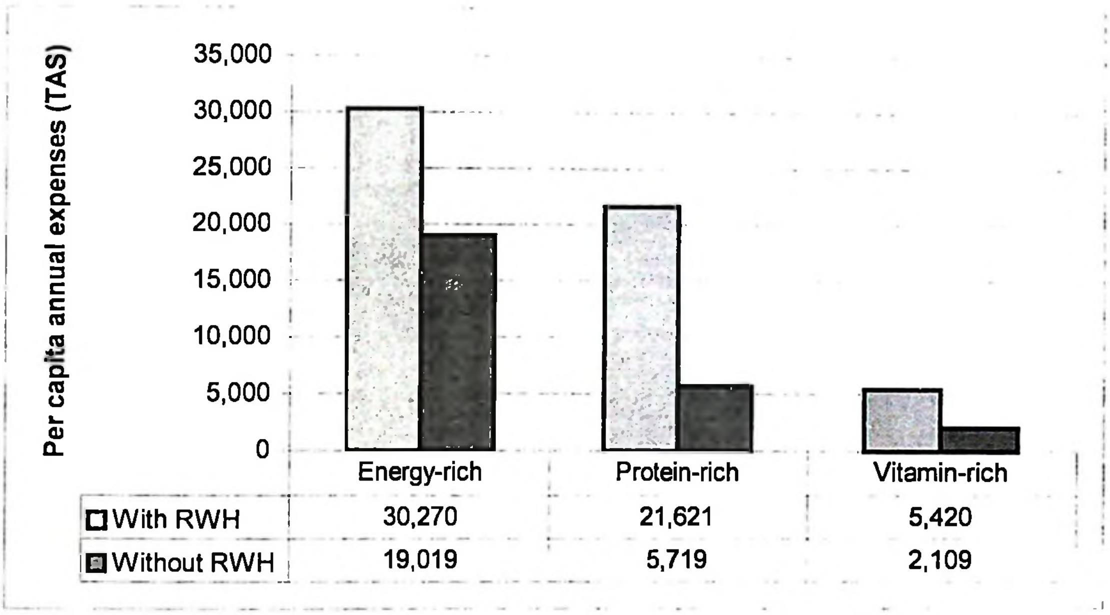

Figure 15: Household expenditure on categories of food items

4.2.3.3 Income expenditure

Further analysis related to food consumption is that of depicting the proportionate expenditure on food. In poverty analysis when the proportionate expenditure on food of the overall expenditure is large it means little is left for other purposes including investment expenditure. This means a household spending on food as much as over half of its total expenditure portfolio is highly vulnerable to poverty. Results in Figure 16 indicate that, proportionate expenditure on food comprised amounted to 56 % and 45 % of total expenditure for households under RWH and without RWH situation respectively. Such level of food expenditure indicates the existence of poverty among surveyed households; it may have set out as a result of understated incomes and exaggerated expenditure by respondents.

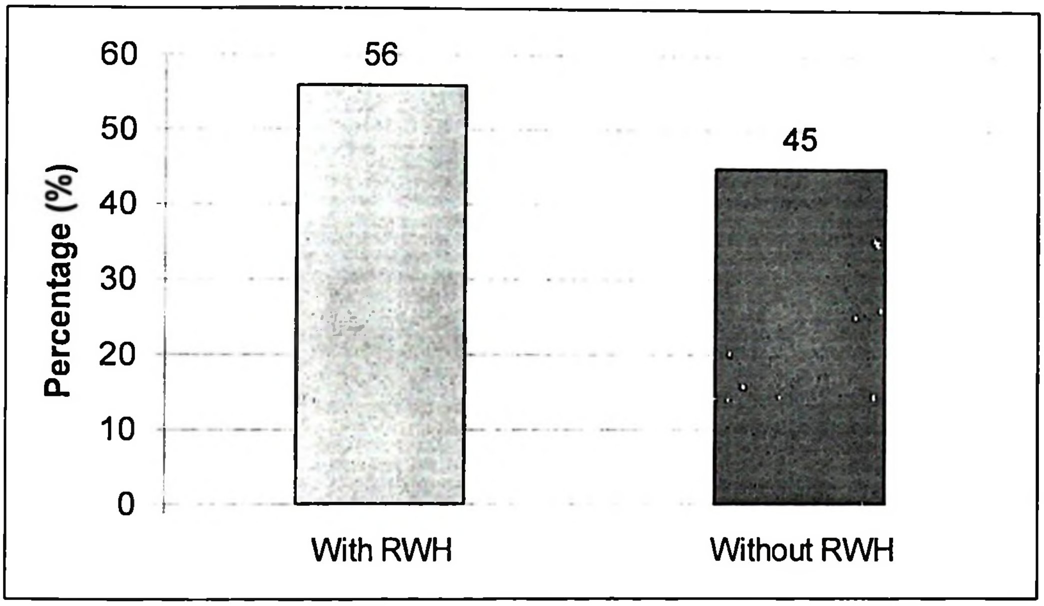

Figure 16: Proportion of food expenditure of overall expenses

ANOVA was used to make empirical judgment on the extent of variation of assets value and expenditure, this is because visual figures does not tell much on the extent of the variation.

Table 4.9: ANOVA results of welfare comparison (with and without RWH)

Assets value	D.f	F-test for equality of means	
		F-statistic	Significance
Assets value (Tshs)	118	2.371*	0.019
Annual expenditure	118	2.152*	0.033

* = Significant at 0.05

Table 4.9 shows ANOVA results for the test of equality of means of the welfare indicated by the level of nominal value of assets and the consumption expenditure for households under sound RWH and those which are not. The results show that, the variation of welfare in terms of levels of assets value and expenditure varied significantly (both at P = 0.05) between the two categories of respondents. Such ANOVA results indicate significant variability in the level of welfare among households under 'with' and 'without' RWH.

4.3 Contribution of RWH to households income and productivity of maize

4.3.1 Contribution of RWH to households income

Assessing the income sources and contribution of RWH to the overall household income tells its role in reducing poverty hence improvement of welfare. Apparently, Figure 17 indicates that, per capita from petty businesses and wage activities were relatively higher than incomes from other sources. Results in Table 4.10 reveal that, only a small proportion of population accounting for 24 % and 19 % of total households had income from business and wage activities. However, households who earned incomes from crops under RWH accounted for 75 % of the population implying the importance of RWH to the livelihood to the entire society. Therefore, disregarding business and wage activities the economic rationale of RWH-base crop sub-sector become apparent. Moreover in the per capita terms incomes from crop under RWH system exceeded that from without RWH situation. This implies that, RWH system had made a difference by contributing positively to the household income. Such reality suggests the potential RWH have for poverty reduction. Moreover, households under 'without' RWH systems got relatively higher income from livestock than the counterparts.

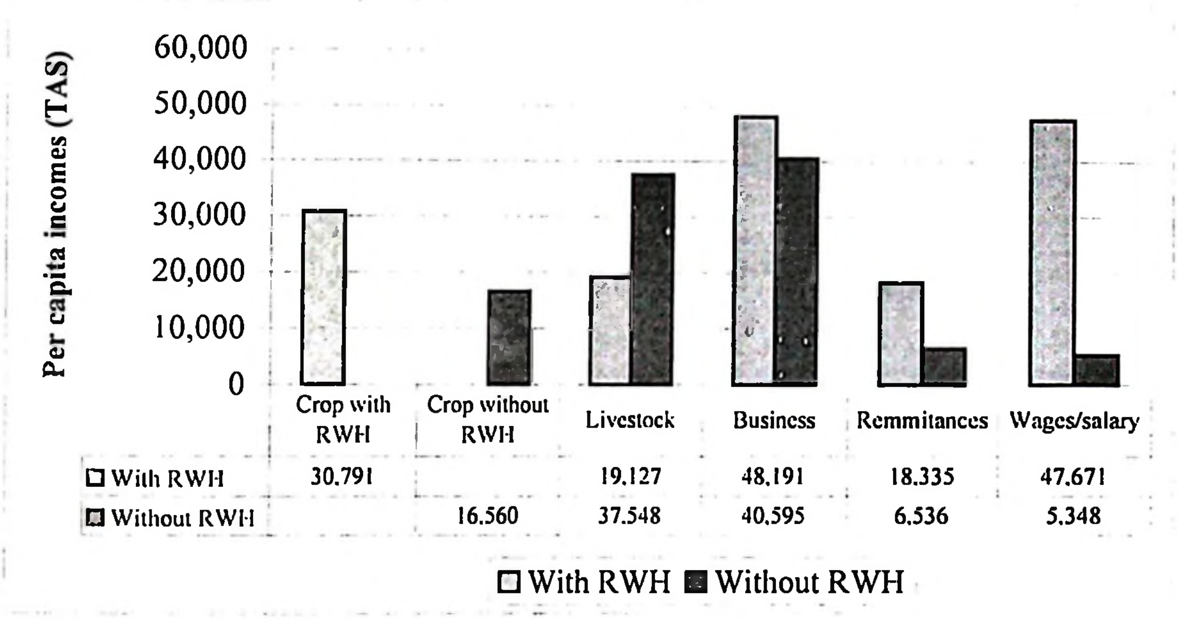

Figure 17: Average household incomes from different sources

Table 4.10: Proportions of households with incomes from different sources

Income sources	With-RWH		Without-RWH	
	n	%	n	%
Crop with RWH	90	75	-	-
Crop without RWH	-	-	30	25
Livestock	31	26	27	23
Petty business	24	20	5	4
Remittances	37	31	5	4
Wages	20	17	2	2

Of interest, the findings in Figure 18 show that, incomes from crops under RWH among other sources, contributed about 52 % of the overall income of households under RWH and 38% for the case of households without RWH. Such contribution is substantial indicating the importance of crop sub-sector and RWH in income generation relative to other livelihood options.

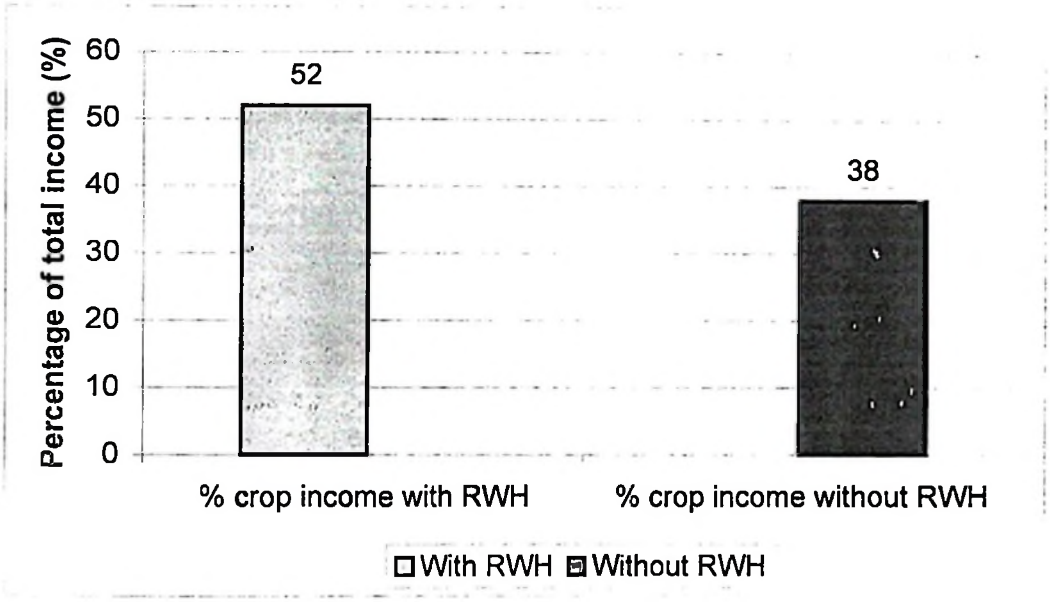

Figure 18: Percentages of total incomes from crop with and without RWH

4.3.2 Productivity of major crops by location along the catchment

Analysis of productivity aimed at portraying crop production per acre for farmers on different positions along the macrocatchment. Table 4.11 indicates that, in maize and lablab bean production, productivity significantly declined progressively along the catchment (X^2 value 34.19, p>0.05) and actually maize grown under RWH is followed by lablab (using residual moisture), thus they follow the same sequence. Farms located at the head seemed to have enjoyed location advantage in terms of accessing water with tail farms being the most disfavoured. However, for the case of cotton and beans the consistence is missing as yield showed mixed results. For cotton and beans middle farms had statistically significant higher productivity than farms on the head and tail locations (X^2 value 36.3, p>0.05). This implies that, productivity is not solely dependent on access to water but also on other factors such as agronomic and management practices.

Table 4.11: Productivity of important crops with and without RWH

RWH systems	Maize Bag/ac	n	Fiwi Bag/ac	n	Cotton Bale/ac	n	Beans Bag/ac	n
With RWH								
Head location	3.6	30	0.9	24	1.0	3	0.4	3
Middle location	2.1	30	0.7	29	4.6	5	2.0	1
Tail location	1.8	30	0.1	16	0.2	1	-	-
Without RWH	1.0	30	1.5	28	-	-	0.1	1

4.4 Comparison of maize gross margins to official poverty thresholds

In the study area, maize production was predominant practice under both 'with' and 'without' RWH systems. Gross margins as proxies of financial returns are compared to official poverty lines including a non-taxable national monthly minimum wage of 36 300 Tshs and a dollar poverty line. Such comparison tells the contribution of RWH-based maize production on poverty reduction. Table 4.11 indicates that, maize production contributed more to poverty reduction under RWH than for the 'without' RWH systems.

Table 4.12: Contribution of RWH on absolute poverty reduction

Item	With RWH Head	Middle	Tail	Average	Without RWH Average
Per capita annual GM	15,996	20,941	11,972	16,303	8,488
% minimum wage	22	24	16	21	14
% per capita dollar /day	5	6	3	5	2

The gross margins for middle locationed farms were a bit more than those for head and tail located farms. It is noted that, productivity is declining as you move down

(Table 4.11), but the gross margins is higher in the middle (Table 4.12) this may be due to the fact that productivity parameter is just the measure of physical efficiency, therefore it does not consider issue of cost and output price as opposed to gross margins.

4.5 Regression results

4.5.1 Regression results for maize enterprise gross margins

Results of the analysis of the determinants of maize enterprise gross margins are shown in table 4.13.

Table 4.13: Results of gross margins regression model

Independent variables	B-coefficient	t-values	Significance
Dummy for RWH	981.314	0.215	0.830
Number of years in school for head	-123.741	-0.190	0.849
Farming experience	175.329	1.446	0.151
Average productivity of maize	2105.809	3.713	0.000*
Number of household members working always in the farm	17951.309	10.015	0.000*

Dependent variable: Annual maize gross margin

Adjusted $R^2 = 0.551$

F-ratio = 29.252

Significance of F ratio = 0.001

* Significant at 0.001

The results in table 4.13 show that the value of adjusted R- Square is 0.551. The figure shows that the major part (55.1%) of the variations of the dependent variable is explained by the variation of the included independent variables. This implies that the effect of other variables in influencing gross margins is rather small signifying that the model is well explained by the included independent variables. This is further supported by the value of significance of F-ratio. Results of F-ratio ratio show that the model is highly significant at 1% (i.e. $p<0.01$).

Results in table 4.13 show that average productivity of maize significantly influences gross margin of maize. Farm productivity is a scenario manifesting farm production efficiency, which is what value of output is realized from a set of fixed and recurrent inputs. The fixed inputs include RWH structures (land and soil nutrients) and the recurrent one entail labour and other physical inputs. As proved by this study, high level of productivity guarantees higher financial returns, given other factors such as efficient marketing system. Another important determinant of maize gross margin is number of members working always in the farm. The higher the members working in the farm, the higher the manpower taking part in the production process. As manpower increases, the revenue increases as leading to the increase in gross margin. This observation means that numbers of members working in the farm significantly increase gross margin just reaffirm what we know that similar to many other places in Tanzania, crop production in Makanya village is still labour intensive and that more efforts need to be directed at introducing labour saving technologies.

Results in Table 4.13 also show that farming experience has positive effect on annual gross margins but was not significant. This was expected because farming experience increases farm production skills leading into higher production and gross margins. However, because of the insignificance of this variable it is suggested that farming experience is not an important determinant of maize gross margins in the study area.

Results in Table 4.13 show that education level measured by number of years of household head in school has no significant effect on maize gross margins. In other words the results suggest that education level is not an important determinant of maize gross margins in the study area. It is possible that very little skills from formal education are used in farming in the study area. This may particularly be true from the fact that the kind of agriculture practiced in the area is mainly for subsistence still using only traditional farming skills.

This being the case therefore it may not be surprising to find number of years of the household head in formal education having no significant effect on gross margins. Contrary to its expectation results of this study show that education level measured by number of years of household head in school reduces maize gross margins. This puzzle is explainable in two ways. Firstly, it is possible that because of their higher knowledge more educated farmers in the study area are more occupied with other activities apart from maize farming thereby reducing their attention to maize plots. Under this situation it may be the case that it is this lack of attention to maize farms, which causes educated farmers to realize lower maize gross margins. It can also be explained from the fact that most of the educated people in Tanzania do not reside in rural areas, thus most of the sampled farmers were lightly educated or un educated, looking from this point of view one may argue that effects of household head's education levels are rather negligible in maize farming and therefore the negative sign in the coefficient has been reached just coincidentally. This sounds especially true in view of the fact that household head is just one of the many household members working in the farm and that the skills of that single person has little to do in influencing gross margins.

Results of the significance of dummy variable for RWH are particularly relevant for this study. Results of significance of the coefficient predict that apparently whether one practices rainwater harvesting or not does not significantly determine the realized levels of maize gross margins in the study area ($p>0.05$). In other words the results suggest that the dummy variable whether one practices under 'with' or 'without' RWH is not an important determinant of maize gross margins. This observation implicitly suggest that there is no direct cause effect relationship between whether one practices RWH or not and maize gross margins. The observation proposes that there is only an indirect effect of using or not using RWH on gross margins. In other words the finding implies that using RWH only provides a favorable ground for other factors to act in positively influencing gross margins. On the other hand the finding suggest that disusing RWH in maize farming does not direct cause low gross margins but rather endow a poor farming environment leading into making it difficult for other factors to positively affect gross margins.

4.5.2 Results of regression for average annual expenditure

Results of the average annual expenditure model are presented in Table 4.14 below.

Table 4.14: Results of regression model for average annual expenditure

Independent variable	B-coefficient	t-value	Significance
Dummy for RWH	11287.287	0.245	0.807
Number of years in school for household head	8155.416	1.239	0.218
Farming experience	-173.267	-0.144	0.885
Household size	23576.179	3.825	0.000*
Number of household members working always in the farm	153710.84	8.310	0.000*

Dependent variable: Average annual expenditure

Adjusted R = 0.553

F-ratio = 29.469

Significance of F-ratio = 0.01

* Significant at 0.01

Results in the table shows that the overall model is highly significant (F ratio significant at 0.01). Furthermore the results show that the model is about 55.3% of the variation of dependent variable is caused by the variation of the independent variables, the rest 44.7% is unexplained.

Results of coefficients in the model show that household size and the number of household members working always in the farm are the principal determinants of average annual expenditure (P<0.01). The findings show that household size significantly determine expenditure seems to be logically true simply because as the number of household members increases in a given household their consumption needs also increase requiring more expenditure to meet them. On the other hand, the observation that the number of household members working always on the farm significantly determines expenditure also sounds logical. As the number of members engaged in farming activities increase production and revenue increases. It implies that households with higher members taking part in farming will have higher disposable income, which will enable higher expenditure levels.

Results of this research have conformed to the anticipated sign of coefficient for the variable named number of years in school for the household head. It was expected that as expenditure levels increase with number of years in school of the household head and therefore the coefficient would have a positive sign. The results indicate that the variable plays an insignificant effect in influencing expenditures.

Contrary to expected results, this model shows that farming experience negatively affects annual expenditure. It was anticipated that farmers with high experience would realize higher returns in farming leading into higher expenditure levels. It was thus expected that coefficient for farming experience will have a positive sign. Results of this study have proved otherwise. With this observation at hand one can argue that farming experience do have two sided effects. In one hand more experienced farmers are more skilful a factor which increases returns from farming and consequently expenditures. On the other hand it is true that experienced farmers are also older and less energetic. It is this factor, which reduces returns from farming a resulting into less consumption. From these two viewpoints one can argue that perhaps it is the later factor, which has outweighed the other and that is why in general it has been observed that farming experience has a negative affect on expenditure.

The most interesting variable in the analysis of the determinants of annual expenditure for this study is dummy for RWH. With respect to this variable results from this study show that apparently whether one practices rainwater harvesting or not does not significantly affect household annual expenditures. In other words the result suggests that the dummy variable whether one practices macro-catchments based RWH or not is not an important determinant of expenditure. Implicitly this findings suggest absence of direct cause effect relationship between expenditure and whether one practices RWH or not. The finding only suggests that perhaps using RWH only provides a favorable ground for other factors to act positively in influencing expenditure. On the other hand the finding prompts one to conclude that certainly not using RWH in maize farming does not directly cause low expenditures but rather endow a poor farming environment leading into making it difficult for other factors to positively affect expenditures.

4.6 Conclusion

Results of the current research summarized in chapter four above demonstrate the major achievements of the study. The chapters clearly show the conclusions reached in addressing each objective. The findings also show that all the objectives and assumptions set for this study have been validated. Overall the results demonstrate that RWH plays a major role in poverty reduction in the study area. Nevertheless, the findings of this study alerts on the fact that adoption of RWH alone is not a major determinant of poverty reduction.

CHAPTER FIVE

DISCUSSION

5.1 Overview

This study attempted to investigate economic impact of rainwater harvesting (RWH) on crop productivity and poverty reduction in semi arid areas of Western Pare Lowlands in Kilimanjaro region. This chapter presents the conclusions reached by the study. It is divided into three major sections. Section 5.2 presents a general discussion whereas section 5.3 shed light on conclusions reached. The last section namely section 5.4 summarizes some relevant recommendations suggested by the study.

5.2 General discussion

This section presents a general discussion of the study. The discussion anchors on highlighting reflections on four important areas of the research namely reflections on study approaches (section 5.2.1.), reflections on conceptual framework (section 5.2.2.), reflections on research methodology (section 5.2.3.) and reflections on results (section 5.2.4).

5.2.1 Reflections on study approaches

In order to observe the impact brought about by using RWH this study used a comparative analysis approach. The research anchors at making a comparison on various parameters for households practising RWH in farming and those, which do not. It is based on an assumption that use of RWH in dry land areas will result into poverty reduction which can be manifested in such parameters as annual average income, asset values, average annual expenditure and maize gross margins. The major task of this study was therefore to gather information from the farmers on those studied parameters. Because of its quantitative nature the study used a structured questionnaire in collecting primary data from the farmers. It is worthwhile to note that it is possible to compliment/extend this study by conducting a similar study by using participatory methods of data collection such as PRA. Though it may have weak base in providing a quantitative evidence of the impact, a study conducted using PRA may equally be very informative by rising up some of the impacts, which are difficult to quantify. Another way of complimenting this study is by changing the basis of making comparison. For example, instead of comparing 'with' and 'without' scenarios one may request the respondents to tell how do they compare some state of affairs before and after adopting RWH.

5.2.2 Reflection on conceptual framework

In order to earn their livelihood smallholder farmers are known to be simultaneously engaged in a number of activities both farm and non farm. The principal pre-occupation of these people is agricultural activities, which directly depend on precipitation. It is apparent that lack of rainfall is the principal constraint to agricultural activities in these areas, so it is assumed that use of RWH can act as an alternative by providing a suitable environment for undertaking agricultural activities. Theoretically, therefore it is anticipated that through its effects in agricultural sector RWH can yield several beneficial effects and few negative effects. An attempt to show these has been made in section 3.1 (Conceptual framework). When one looks at the framework an obvious observation is that the framework deliberately confines the analysis to maize farming as a representative of the agricultural sector. This is basically relevant because maize farming is the principal agricultural activity done in the areas. It follows that if the study is to be replicated to another area with a different major crop the framework may as well need to change to reflect that other crop. It is also important to note that the list of economic indicators shown in the conceptual framework is not exhaustive. It implies that this study can be replicated just by changing the indicators used. For example instead of using maize gross margins as an indicator of profitability in another study one may use net profit.

5.2.3 Reflection on study methodology

On behalf of other semi arid areas of Tanzania, this study deliberately analyse the impact of RWH in Makanya village located within Western Pare lowlands. The choice of a single study area is made notwithstanding the fact that there are many areas in the country which experience dry weather and climate like WPLL. This made it necessary to deliberately reduce spending on travelling to different areas for data collection. Previously it was intended that the study should cover two areas namely Western Pare Lowlands and Maswa district in Shinyanga Region. The second reason is that farmers in Makanya village have traditionally been using RWH in farming. This provides a very suitable ground for studying impact.

Despite the fact that disproportionate random sampling used in this study is quite appropriate to the study there is a room for improvement by using proportionate stratified random sampling. The study made use of 90 farmers who practises RWH and only 30 farmers who do not practise RWH. The study recognises the importance of making a balanced representation of both users and non-users of RWH in the research i.e. 90 respondents for each group, but because of financial limitations the research used unequal number of respondents from the two groups.

5.2.4 Reflection on results (extent of achieving study objectives)

The general assumption for this study was that RWH has a potential for improving crop productivity and reducing poverty in semi arid areas of Tanzania. With regard to reducing poverty the study was governed by an assumption that as a result of using RWH, households under RWH in WPLL are less poor than those which are not under RWH.

The study has shown for example that in Makanya village households that use RWH posses exorbitantly high value houses compared to those houses owned by households which do not use RWH. Apart from houses this study has also shown that households, which use RWH in Western Pare Lowlands, possess higher value assets than those, which do not use RWH. In addition to the differences in asset possession this study has also used several other parameters and come up with empirical evidence showing less poverty among households which use RWH relative to their counterparts. In this regard the following observations are worth to mention.

Households, which use RWH, spend higher amount of money in medical services and education of their children compared to those households, which do not use RWH. This observation is further supported by two other findings, which just confirms better financial position of households under 'with' RWH compared to those under 'without' RWH. For instance, the study shows that households under with "RWH" which are engaged in petty business realized more incomes than those households under 'without' scenario. The study further show that households under 'with' RWH scenario realized higher maize gross margin compared to those households under 'without' RWH situation. Another poverty parameter used in this study in comparing poverty levels was maize gross margin as a percentage of some official poverty thresholds. In this regard, findings of this study clearly show that households under 'with' RWH situation realized higher maize enterprise gross margin as a percentage of both government's minimum wage and the World Bank's poverty line ($ 1 per person per day).

With regard to increasing crop productivity this study was governed by the assumption that households under 'with' RWH will achieve significantly higher crop productivity than those households under 'without' RWH. Similarly the study was anchored on the assumption that households practicing RWH at different location along the canal will achieve differing crop productivity such that those households at the head of the canal will achieve the highest productivity followed by those farmers at the middle of the canal where as due to locational disadvantage farmers at the tail of the canal will achieve lowest productivity. Results of this study have actually proved both the two assumptions. On the first place the study has shown that farmers under RWH realized significantly higher crop productivity than those under 'without' RWH. On the other hand the study has proved that with exception of cotton, crop productivity decline progressively along the canal from head to tail.

On downside, results of this study explicitly show that mere practice of RWH does not play significant role in the reduction household poverty in the study area. This is clearly indicated by the insignificant t-values for dummy variable of RWH.

CHAPTER SIX

CONCLUSSION AND RECOMMENDATIONS

6.1Conclusion

This study has successfully brought into light the impact of RWH in poverty reduction and crop productivity in Western Pare Lowlands. The study has shown that the impact of RWH on crop production in Western Pare Lowlands is significant increase in crop productivity. On the other side, by using various poverty parameters this study has clearly indicated that households under rainwater harvesting in Western Pare Lowlands are better off than households under 'without' RWH situations. In other words, the study has shown that apart from increasing crop productivity, another impact of RWH in Western Pare Lowlands is significant reduction in poverty. With regard to poverty, this study alerts that regardless of insignificance of some of the variables in the due course of estimation, RWH has good impact in poverty reduction and has brought an important factor in WPLL in determining poverty levels in the area.

6.2 Recommendations

In view of the conclusions reached in this study, the research suggest recommendations in three broad areas namely recommendations in methods of analysis, recommendations in areas for further research and recommendations derived as part of policy implications of the study findings.

6.2.1 Recommendations on the methods of analysis

The current study provides important lesson on the applicability of comparative analysis in impact assessment studies. By comparing 'with' and 'without' scenarios using several parameters this study has successfully brought into light the impact of using RWH in semi arid areas. The study basically testifies and advocates comparative analysis of 'with' and 'without' situations in studying impacts of adoption of innovations and interventions. In addition, this study helps us to learn that by doing the following can help us do better comparative analysis. Firstly, by using other poverty parameters apart from those used in this study. Secondly, by using participatory methods of data collection and thirdly by tracing changes in the livelihoods of the farmers through making a comparison of before and other situations. These recommendations are described in section 5.4.2.

6.2.2 Recommendations on areas for further research

This study has brought up some important areas for further analysis including the following: -

(i) It is important to undertake a sister study to evaluate impact of RWH in semi arid areas using participatory methods. On one hand this is done in belief that there are certain information on impacts that are difficult to solicit quantitatively. On the other hand, one should also note that use of participatory methods might equally yield a good picture on poverty. It is therefore suggested for example that instead of using poverty parameters used in this study one can use PRA and request the respondents to set and use their own poverty measures in comparing poverty of households under 'with' and 'without' RWH situations.

(ii) The current study should be replicated to other study areas so that can observe if it will yield similar results. There are several other places in the country that are known to be practicing RWH in crop production. It is advocated that similar impact assessment studies be done in these other areas to evaluate if they will equally come up with similar picture i.e. better of households under 'with' RWH than those under 'without' RWH.

(iii) Another potential area for studying impact of RWH is through tracing changes in the livelihoods of the people before and after the introduction of RWH.

(iv) The current study also acknowledges that the list of poverty parameters used in this study is not exhaustive thus it may be relevant to compare households using other quantities poverty parameters other than those used in this study.

6.3 Policy implications

The following policy recommendations are made from this study: -

(i) Government authorities and other stakeholders concerned with agricultural development in the country should intensify efforts of introducing rain water harvesting in semi arid areas of Tanzania. Efforts should be increased so that more farmers adopt rainwater-harvesting technology and more land is put under rainwater harvesting in semi arid areas of Tanzania.

(ii) Apart from sensitizing adoption of RWH, efforts to increase gross margins from crops especially maize in semi arid areas of Tanzania should also concentrate at increasing crop productivity and human resource availability to the farming households. The latter can be achieved by assisting the households to own farm machineries, which can substitute human power.

(iii) More efforts should be directed at encouraging pastoralists in semi arid of Tanzania to make permanent settlements. This should be done by empowering the pastoralists so that they acquire a better ability to master their environment. This can be achieved by teaching the pastoralists agricultural skills including the use of RWH.

(iv) Youth policy intervention for rural–urban migration which requires multi-sectoral participation and implementation on youth development plan should be intensified so as to restrict the negative outcome brought by social, cultural, political and economic challenges. Among those sector are finance, agriculture and livestock, land and habitant development, healthy, industry and commerce, communication, natural resource and tourism, planning commission, education, local government, non-government organization and private sector. Ministry of labour and youth development will remain as a sole policy maker and directives in relation to youth policy development in Tanzania.

In agriculture sector more emphasis should be put on youth participation on crop production and livestock keeping. Strategies should be based on training in relation to production process and the use of right technology (including rainwater harvesting) on increasing crop productivity and income and hence reducing poverty among the people (Ministry of Labour and Youth Development, 1996).

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APPENDICES

Appendix 1: QUESTIONNAIRE

A: Background information

Respondent's Name________________________
Name of
enumerator____
1. Village name________________________
2. Ward______________________________
3. Division____________________________________
4. District_____________________________________
5. Do you practice RWH technologies irrigation? [__] 1= Yes 2= No
If Yes when did you started to practice RWH_________(year), and where is your RWH plot located [__] 1= Head 2= Middle 3= Tail

6. Were you born in this village? [__] 1= Yes 2= No
If No where did you migrated from ___________________________________
What was the main reason for migration [__]
1= Marriage
2= Farming in irrigation land
3= Employment transfer
4= Searching for wage work
5= Any other (Specify)__________
7. Are you married? [__] 1= Yes 2= No
If Yes give number of
spouses____

8. Fill in the following household roaster

Name of member	Relationship	Sex	Age	Health status	Working status	Education level	Years in education	Other Main occupation

CODES

Relationship with head	Sex	Health status	Working status	Education level	Other main occupation
1= Head 2= Spouse 3= Child 4= Father 5= Mother 6= Other relative 7= Non relative	1= Male 2= Female	1= Able 2= disabled sick old age very young	1= Do not work 2= work rare 3=Work always	1= None 2= Std 4 3= Adult education 4= Primary school 5= Secondary school 6= Collage 7= University	1= None 2= Herding stockman 3= Salaried employment 4= Businessman woman 5= Handcraft 6= Others (specify) ______

B: Farming/RWH experience and training

8. When did you start farming as an independent household____

____

9. Have you or any household member attended any training in agriculture RWH techniques?

[__] 1= Yes 2= No

If Yes fill in the following Table

Type of practice	Who attended	When attended (year)	Source of technology/institution	For which crop/livestock

Codes

Who attended?

1= Head
2= Spouse
3= Child
4= Other member

10. How many times your household was visited by extensionists or RWH expert last season? (Purposely for delivering extension RWH message)________________________

C: Household assets and expenditure based incomes

11. Please indicate type, number and value of major assets owned

Asset	Number	Year acquired	Total current value (TAS)
Houses			
Radio			
Sprayer			
Sewing machine			
Bicycle			
Vehicle			
Milling machine			
Matchet (Nyengo, panga)			
Hand hoe			
Plough			
Oxcart			
Other (specify)_______			

12a. Which of the following products do you purchase for home use annually?

Product	Period		Approximate quantities	Money spent
	From (month)	To (month)		
Maize				
Cassava				
Sorghum				
Rice				
Bananas				
Sweet potatoes				
Vegetables				
Fruits				
Meat				
Milk				
Fish				
Beans				
Sugar				

12b. Please estimate other household expenditure

Item	Amount
Consumer goods (Household items, clothes)	
Medical expenses	
Village govt. contributions (e.g. Development levies, taxes, cess licence fees)	
Social occasions (e.g. Contributions to funerals, weddings, ngoma and other cultural traditional events)	
Beer other refreshments	
Payment to relatives	
Transport	
House building & repair	
Expenditure on agricultural inputs	
Expenditure on Water	
Fuel for cooking lighting (kerosene, fuelwood, charcoal)	
Education expenses	

D: Land use, crop production, variable costs, marketing, prices and stocks (With RWH and without)

13. Production of four main crops (including maize) **[LAST SEASON–(Main and second season]**

Plot ID	Distance from home (Km)	Plot size (ha)	Crop planted	Farming style	Total yield (output)

CODES

Crop planted	**Farming style**
1= Maize	1= Irrigation farming RWH
2= Beans	2= Non irrigation farming without RWH
3= Onion	3= Other (specify)________________________
4= Vegetables	
5= Bananas	
6= Other (specify)	

14. Variable costs for Maize produced with RWH for LAST THREE seasons **[Main and second season]**

	2002		2001		2000	
	Tshs	Manday*	Tshs	Manday	Tshs	Manday
Land preparation						
Ploughing						
Using tractor						
Using hand hoe						
Harrowing						
Using tractor						
Using hand hoe						
Land Rent						
Harrowing						
Inputs						
Seed						
Fertilizer						
Chemicals						
Storage bags						
Seed						
Labour charges/operation						
Planting						
Fertilizer Appl.						
1st Weeding						
2nd Weeding						
Harvesting						
Transporting						
Harv.& Transporting						
Shelling						
Storage						

* Where labour input is considered

15. Variable costs for Maize produced without RWH for LAST THREE seasons **[Main and second season]**

	2002		2001		2000	
	Tshs	**Manday***	**Tshs**	**Manday**	**Tshs**	**Manday**
Land preparation						
Ploughing						
Using tractor						
Using hand hoe						
Harrowing						
Using tractor						
Using hand hoe						
Land Rent						
Harrowing						
Inputs						
Seed						
Fertilizer						
Chemicals						
Storage bags						
Seed						
Labour charges/operation						
Planting						
Fertilizer Appl.						
1st Weeding						
2nd Weeding						
Harvesting						
Transporting						
Harv.& Transporting						
Shelling						
Storage						
Marketing costs						
Others (specify)____						

* Where labour input is considered

16. What is the distance (in Km) from your home to the potential market where you always sell your maize________________________

17. Revenue from Maize under RWH and without RWH for LAST THREE seasons **[Main and second season]**

Year	**With RWH**				**Without RWH**			
	Acreage	**Output**	**Price**	**Revenu e**	**Acreage**	**Outpu t**	**Price**	**Revenue**
2002								
2001								
2000								

18. Estimates of the household income before and after adopting RWH

Source of income	**Income before RWH**	**Income after RWH**
Crop production		
Livestock production		
Business		
Remittances		
Wages salary		
Others (specify)		

19. Please quantify the income sources for the past 3 years

Source of income	**Value (Tshs)**		
	2002	2001	2000
Crop production with RWH			
Crop production without RWH			
Livestock production			
Business			
Remittances			
Wages salary			
Others (specify)			

20. Crop stock inventory for the last season (refer to four main crops including maize)

Crop	**Yield**	**Amount consumed**	**Amount marketed**	**Amount in stock**
1. Maize				
2.				
3.				
4.				

20: Major constraints associated with RWH use and adoption

21. Give the 4 most important constraints problems related to RWH use or non-adoption

1.____

2.____

3.____

4.____

Rank them in order of importance: [____] [____] [____] [____]

THANK YOU VERY MUCH FOR YOUR RESPONSE!