DETERMINATION OF PROFITABLE CROP PRODUCTION OPTIONS FOR BASHAY IRRIGATION SCHEMES IN MBULU DISTRICT, TANZANIA.

BY

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ABSTRACT

The study was conducted in Bashay irrigation schemes of Mbulu District. The main objective was to determine the profitable crop production options for Bashay irrigation scheme. A cross sectional single-visit survey involving 100 farmers from Mangisa and Diyomat villages was conducted representing up and down stream respectively. Descriptive Statistics, Gross Margin, Multiple Regression and Linear Programming model were used as analytical tools. The findings revealed that majority (68%) of household surveyed cultivate 0.1 to 0.4 ha. The analysis on crops profitable levels using GM revealed that garlic gives the highest GM of TZS 2 687 915 and 2 275 000 per hectare in the upstream and downstream respectively. Others crops in the order of decreasing GM was onion, potatoes, maize, and beans, with GM of TZS 1 678 010 > 383 312.5 >356 237.5 > 295 710, respectively, in the upstream while in the downstream the GM was TZS 515 835 > 285 857.5 > 282 715 > 133 010 for onion, maize, potatoes, and beans, respectively. The differences in GM in the two scenarios are mainly due to water availability whereby farmers at upstream have more access to water for irrigation. The multiple regression output results indicate that farm size, labour and capital input are the major factors that significantly ($p<0.05$) influence crop profitability. The LP results revealed that in the upstream garlic, onion and beans fall in the final optimum plan with maximum net revenue of 1 838 777.5 TZS/ha while in the downstream, maize and garlic are the profitable crops with maximum net revenue of 1 096 045 TZS/ha. The overall LP results revealed that for the Bashay irrigation schemes garlic and onion are the most profitable crops with net revenue of 1 891 117.5 TZS/ha. It is therefore, recommended that in order to maximize crop profitability, garlic, onion and beans are the best crops production in the upstream while garlic and maize are the best option in the downstream, but generally garlic and onion are the best production option to be adopted in Bashay irrigation schemes.

DECLARATION

I, **Yustina Arcadius Rahhi** do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor being currently submitted for a degree award in any other institution.

_____ _____

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The above declaration confirmed

_____ _____

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DEDICATION

I dedicate my thesis to my parents, Mr. Arcadius Rahhi and the late Mrs Juliana Arcadius who laid down the foundation of my education. Unfortunately, my mother is not with me to share the fruits of its accomplishment. May Almighty God rest her soul in peace.

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LIST OF ACRONOMY AND ABBREVIATION

BLUE	-	Best Linear Unbiased Estimator
DADPS	-	District Agriculture Development Plans
DALDO	-	District Agriculture and Livestock Development Officer
FAO	-	Food and Agriculture Organisation
FYM	-	Farm Yard Manure
GM	-	Gross Margin
GMA	-	Gross Margin Analysis
Ha	-	Hectare
ICRISAT	-	International Crops Research Institute for the Semi-Arid Tropics
IFAD	-	International Fund for Agricultural Development
IWMI	-	International Water Management Institute
JICA	-	Japan International Cooperation Agency
LP	-	Linear Programming
MDC	-	Mbulu District Council
NBS	-	National Bureau of statistics
NIMP	-	National Irrigation Master Plan
OLSE	-	Ordinary Least Square Estimator
PADEP	-	Participatory Agriculture Development and Empowerment Project
pH	-	Potential Hydrogen
PIDP	-	Participatory Irrigation Development Program
SACCOS	-	Saving and Credit Cooperative Society
SSA	-	Sub Sahara African

SWMRG	-	Soil and Water Management Research Group
t	-	Tonne
TR	-	Total Revenue
TVC	-	Total Variable Cost
TZS	-	Tanzania Shillings
UNEP	-	United Nations Environmental Programme
URT	-	United Republic of Tanzania
VEO	-	Village Executive Officer
WB	-	World Bank
WMO	-	World Meteorological Organization
WUA	-	Water Users Association

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Irrigated agriculture is undoubtedly one of the keys to achieve the much desired increase in global food production to meet the food requirement of the world's ever increasing population. According to FAO (2003a), irrigated agriculture contributes about 40% of food supply from 20% of the world's farm land, under irrigation. Yield obtained from irrigation is more than double the highest yield from rain-fed agriculture and therefore even low input used in irrigation is more productive than high input in rain fed farming.

The potential for irrigation development has not been effectively tapped in Sub-Sahara Africa (SSA). Out of a total arable land of about 874 million hectares (ha), the current area under irrigation makes a total of 12.6 million ha or 3.7% of the surface area of SSA (Mekuria, 2003). Despite of this potential and the demand for more dependable sources of water, the development of irrigation in SSA is insufficient. Although irrigation has the potential to boost agricultural yields by least 50%, food production in the region is almost entirely rain-fed (Mekuria, 2003).

Tanzania has a potential of attaining sustainable irrigation in order to assure basic food security, improve the national standards of living and also contribute to economic growth of the country, the opportunity to enhance these is due to availability of water resources such as small and big rivers and lakes, and provision of National Irrigation Master Plan and Agriculture Policy (PADEP, 2009).

Tanzania has a total irrigation development potential of 29.4 million ha of which 2.3 million ha are classified as high potential; 4.8 million ha as medium potential; and 22.3

million ha as low potential. However, only 289 245 ha are under improved irrigated agriculture as per June 2008 (NIMP, 2002). Irrigation development has the potential to transform the predominantly subsistence rain-fed systems into profitable mixed scales (small, medium and large) and commercial operations. Tanzania's agriculture sector has an unprecedented opportunity to transform itself from subsistence to a modern and highly commercial sector, to meet primary objectives of improving and sustaining crop production to meet the exponentially growing population in the country (URT, 2009).

According to World Bank (1994), about 96% of food crops come from rain-fed farming. However, due to high variability in rainfall over time and space, periodic crop failures have been reported from time to time affecting both farmer's income and livelihood. The government has initiated programmes to promote and encourage irrigated agriculture by developing a National Irrigation Master Plan (JICA/MAFS, 2002). The current agriculture and livestock sector policy (URT, 2006), and strategies through 'KILIMO KWANZA' have proposed ways in which the sector can be transformed to profitable ventures through effective land use and water resource management. Efficient irrigation water use and sustainable land use system are among the approaches advocated by the strategies (Mwandosya, 2008).

The current phase government has put special interest to increase production through use of irrigation as a technology that can contribute to increase and stabilize production of crops such as sugarcane, paddy, fruits, and vegetable for local and export market (Mwandosya, 2008). With the same spirit, Mbulu District Council (MDC) has invested in Bashay irrigation schemes through various projects implemented. These includes: Mbulu District Rural Development Program (MDRDP) (1980s); Participatory Irrigation Development Program (PIDP) (2000s); Participatory Agriculture Development and

Empowerment Project (PADEP) (2000s); and District Agriculture Development Plans (DADPs) (2000s). The initiatives undertaken by MDC include rehabilitation and construction of irrigation infrastructures such as a dam (Mangisa Dam), intakes and lining of the main canals. Other on-going efforts include farmers training on proper water management and assistance to the formation of Water Users Association (Mangisa and Diyomat WUA) for maintenance and sustainability of the scheme (DALDO, 2008). No doubt the good results were obtained but only the part of agricultural potentials was realized. In order to achieve the primary goal of farmers on profit maximization, the determination of most profitable crop to be produced is pre-requisite in considering the available scarce resources such as land, water, labour and financial resources.

Bashay irrigation schemes are endowed with an abundance of diverse agricultural environments, which favour varieties of crops. Some of the main crops produced include onions, maize, beans, potatoes, pigeon peas, chick peas and various vegetables such as garlic, tomatoes, cabbage, and amaranths (DALDO, 2008). This study was therefore intended to determine the profitable production options for Bashay irrigation schemes in Mbulu District.

1.2 Statement of the Problem and Justification

Bashay irrigation schemes occupy about 939 hectares and about 1 734 households earn their living by engaging in irrigation agriculture (DALDO, 2008). Elsewhere, in the semi-arid areas were irrigation has paved way for prosperity; the situation is not the same in Bashay irrigation schemes. Farmers are still trapped in poverty cycles as such water resource available for irrigation has contributed marginally to their livelihood.

The guru in irrigation economics and rain water harvesting posit that the efficiency use of water resource can be released if farmers plant high risk and high-value crops than other mix (Kadigi *et al.*, 2004; Temu, 2005; ICRISAT, 2007). It was further acknowledged that, where resource is scarce, pay off will be realized if high value crops are using that resource (Temu, 2005; Mwandosya, 2008; FAO, 2010). It is most likely therefore that, farmers are not aware which are the most profitable crops that would give them high return on best utilization of available scarce resources such as land, labour, capital and water for irrigation. Furthermore, it is likely that there was no adequate and extensive study that has been conducted to determine the profitable production options for Bashay irrigation schemes, or no proper extension advisory services were provided so that farmers can maximize their returns from the aforementioned scarce resources. It was for this matrix that this study was proposed to establish the profitable production options for the Bashay irrigation schemes in Mbulu District.

The analysis on the profitable crop production option can be used by farmers and extension officers as a guideline to choose the crops that will maximize their return per hectare. This study can be adopted in any irrigation scheme were water is appreciated as a scarce resource.

1.3 Objectives of the Study

1.3.1 General objective

The general objective of this study was to determine the profitable crop production options for Bashay irrigation schemes in Mbulu District.

1.3.2 Specific objectives

Specifically the study was sought to:

(i) Identify and characterize the production methods for the major selected crops in Bashay irrigation schemes in Mbulu District;

(ii) Determine profit levels for the selected crops under different production scenario;

(iii) Identify the key factors influencing profitable crop production options in study area;

(iv) Collate options for profitable crop production to be adopted in the study area.

1.3.3 Research hypothesis

This study is guided by the following hypothesis:

H_{01}: Profit level for major crops produced under different scenario are the same.

H_{02}: Key factors such as labour, capital for input, farm size, education level, extension services and credit have no influence on crops profitability.

1.4 Organization of the Dissertation

This study is organized in five chapters: Chapter one presents the introduction, chapter two presents the review of the literature related to determination of profitable crop production option. Chapter three explained in details the methodology used in the study, chapter four presents the result and discussion of the major findings of the study whereas chapter five presents the conclusion and recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Definitions of Terms

2.1.1 Irrigation

Irrigation means the application of a specific amount of water at a particular location in order to meet the requirements of a crop growing at that location in amounts that are appropriate to the crops stage of growth. It can also mean the application of water in amounts necessary to bring soil to the desired moisture level prior to crop planting (URT, 2009). Irrigation (in agriculture) is the replacement or supplementation of rainfall with water from another source in order to grow crops (Wordiq, 2010). It is associated with the artificial application of water to the soil for the purpose of improving crop production (URT, 2009). According to Ojungu (1992), irrigation is defined as a practice in which people deliberately supply water and store surplus water in a controlled manner so as to supplement rain or ground water and sustain or improve crop production in a cultivated field. It is important in such a way that irrigation assist in growing of agricultural crops, maintenance of landscapes, and re-vegetation of disturbed soils in dry areas and during periods of inadequate rainfall (Williams *et al.*, 2007).

2.1.2 Irrigation scheme

According to URT (2009), irrigation scheme means the area where crops are grown under irrigation through any method including flood recession; gravity or pump fed canal systems supplying either surface or groundwater; water harvesting and pressurized systems such as drip and sprinkler. Irrigation schemes include traditional schemes, rehabilitated or upgraded schemes, new smallholder investment and purely private commercial investment.

2.1.3 Irrigation potential

Irrigation Potential means the total area which is technically feasible, economically and financially profitable, socially viable and environmentally acceptable that has been brought under irrigation, plus that which can be planned for irrigation on the basis of water availability, land availability and suitability (URT, 2009).

2.1.4 Profitable crop

Profitable crop is one that will give farmers a positive net income after deducting the total costs from the gross income (Lukanu *et al.*, 2009). According to Hofstrand (2006), profitability is explained as the perception that crops produced under irrigation would reward the producer with excess income over expenditure. This is often viewed as the basis for a viable and profitable option. However, smallholders attached value not only to financial aspects of profitability but also to the means of obtaining a higher profit, such as higher yield, the result of access to inputs, access to extension and experience, market and price reliability.

2.2 Overview of Production Changes due to Irrigation in Tanzania

It is acknowledged that irrigation has increased crop yield by 2 to 3 times more than that of rain-fed farming (World Bank, 1994; Mwandosya, 2008). Interventions done in Tanzania on improved irrigation schemes have raised productivity of various crops substantially paddy increased from 2 t/ha to 4.5 t/ha (maximum 10 t/ha), maize from 1.5 t/ha to 5 t/ha, onion from 5 t/ha to 26 t/ha and tomato increased from 8 t/ha to 25 t/ha (Mwandosya, 2008). The study conducted by Rutatora and Mattee (2001) in Kitere – Mahurunga Rice Improvement Micro-Project (KMARIP) in Mtwara District on technology transfer on water management aimed at efficient utilization of water for improved rice production resulted in increased in yield of rice from 0.6 to 2.4 t/ha.

Irrigation efficiency has shown to contribute to more than the double yields under the management and smallholder irrigation improvement projects of Rufiji and Pangani river basins (URT, 2004). The average efficiency increased from 8% to 19% in the wet season, and from 11% to 27% in the dry season; Rice yields and total production increased in both Pangani and Rufiji basins with the average yield being doubled from 1.98 t/ha to 5.27 t/ha in Pangani River and from 1.46 t/ha to 4.06 t/ha in Rufiji River. Average maize yields increased from 1.06 t/ha to 4.86 t/ha in Pangani River and from 1.08 t/ha to 3.34 t/ha in Rufiji River. In Bashay irrigation schemes garlic yield increased from 3 t/ha to 7.2 t/ha between 2002 and 2005 whereas maize yield increased from 2 t/ha to 3.75 t/ha between 2002 and 2005 (DALDO, 2008).

2.3 Importance of Irrigation to Livelihood of Smallholder Farmers

According to Narayanamoorth (2001), the fundamental benefit from irrigation agriculture on livelihood of smallholders are numerous: (i) it enhances local and sustainable availability of food; (ii) it increases farmer's household income; (iii) it increases labour absorption and the consequent rise in wage rates; (iv) irrigation increases service opportunities leading to better quality of life and industrialization which increase economic activities and consequently, it improves the well being of farmers. Furthermore, irrigation increases the extent of cultivated area and the harvest frequencies to two or more per year (URT, 2009). Reliable source of water for irrigation especially in arid and semi-arid areas reduce risks and stabilize production levels of individual farm (Majule and Mwalosya, 2005).

The study conducted by Lema (2006) on smallholder irrigation farmers in Bato in Ethiopia revealed that the average household income obtained from irrigation cultivation constituted 69.18%, 76.15% and 75.92% during the three years period (2001 – 2003).

Moreover, it was reported by WB (2004) that in Pangani and Rufiji basins the annual household farm incomes has increased from an estimated US$425 to US$1,500 in Pangani, and from US$340 to US$1,100 in Rufiji, respectively from the year 2002 – 2004.

2.4 Theoretical Framework for Determination of Profitable Crop Production

According to Henderson and Quandt (1995), the production process is defined as the transformation of inputs into output. Producers use inputs like labour, land and input capital (seed, fertilizers and chemicals) to produce output (yield). Mathematically expressed as $Q = f(X_1,X_2,X_3,...,X_n)$ where: Q = quantity of output and $X_1,X_2,X_3,...,X_n$ = quantities of factor inputs such as capital, labour and land. A production process is cost efficient if it cost less of inputs to produce more of the output. This efficiency can be explained by optimization behaviour under assertion that a producer wants to maximize output for the given cost or minimize cost for a given output level. Output maximization is constrained optimization since the resources are limited. The maximization of output is a proxy for profit maximization. Profit is calculated from total revenue less total cost.

Mathematically profit is given by:

$$\pi = Pq - f_c(Q) - b$$

Where:

Pq = Revenue (price x quantity)

$f_c(Q) - b$ = cost function.

Profit is maximized by:

$$\pi = \frac{\partial \pi}{\partial Q} = P - f'(Q) = 0$$

Where:

$F`(Q)$ = Marginal cost (MC)

In determining the profitability of alternative production opportunities, the physical data have to be combined with price and cost information as well as data on the availability of

other resources in making production decisions (Boehlje and Eidman, 1984). The relevant variables to be included are labour, capital, land and cost of water for irrigation.

2.5 Crop Production Options in Bashay Irrigation Schemes

2 5.1 Crop production

The Bashay irrigation schemes have promising climatic condition and endowment of potential resources including a perennial river, Yaeda River, and the Mangisa Dam which are used by farmers for irrigation. These allow production of a wide range of both food and cash crops. Crops grown include maize, beans, garlic, onions sugar cane, round potatoes, and banana. Others include spinach, tomatoes, Chinese cabbages, pumpkins and other indigenous vegetables (DALDO, 2008). The common farming system practiced by farmers includes intercropping and monoculture. Majority of farmers cultivate garlic as first crop. Maize is grown as second crop after harvesting of garlic and mostly intercropped with beans. Plantain, sugar cane, pumpkins and various indigenous vegetables are sometimes grown in the same plot (DALDO, 2008). This is the appropriate technology in the area with limited farm size as it saves time resulting in more efficient land utilization (Massawe, 1992).

2.5.2 Maize (*Zea mays* L.) production

By 2020, the demand for maize in developing countries will probably surpass the demand for wheat and rice (Guelloubi *et al.,* 2006). This shift will reflect a 50% increased global maize demand for its 1995 level of 558 million tons to 837 millions tons in 2020. In developing countries alone the demand will increase from 282 million tons of 1995 to 504 million tons in 2020. According to Edmeades *et al.* (1992), the dominant constraint to bridging this potential gap is drought stress. However, in Tanzania most agricultural activities depend on rainfall which is reliable at only 22% (Hatibu *et al*., 1995). A

devastating drought in South African countries in 1991-1992 reduced maize production by 60% (Rosen and Scott, 1992). In Tanzania, the average yield losses due to drought are estimated at 50% but can be high as 100% in dry area (Nkonya *et al.,* 1991). Drought affect maize grain yield at three critical stages of plant growth; early in the growing season, at flowering and during mid to late grain filling (Scalter and Goode, 1997). Irrigation practice is a promoting alternative to sustainable maize production (Edmeades *et al.,* 1992).

The option to produce maize in the study area based on the criterion that the crop is the main staple food attributed to the potentiality of irrigation water, has guaranteed to its potential production (Muhammad *et al.,* 2009). Moreover, maximum yield of maize under irrigation is influenced by various factors including proper land preparation, proper planting time, use of improved agricultural inputs, and control of crop pest, diseases and weeds (Lymchai and Mmbaga, 2001; Muhammad *et al.*, 2009).

The yield of maize has been reported to increase under irrigation systems. The study by Balwois (2008) in Serbia on the effect of irrigation on yield performance of corn hybrids disclosed that irrigated corn increased from 9.2 t/ha in 2003 to 15.6 t/ha in 2005. The yields of maize in Bashay irrigation scheme range from 3.75 t/ha to 5 t/ha compared to yields from rain-fed with a range of 1.5 t/ha to 2.5 t/ha (DALDO, 2008). The sustainability of high yields is poor due to low soil fertility, poor extension services as a result of improper planting spacing and inadequate use of agriculture inputs especially industrial fertilizers (DALDO, 2008).

2.5.3 Potatoes *(Solanum tuberosum* L.) production

Potatoes are produced about 321 million tons all over the world (FAO, 2007). Potato is a temperate crop grown in highlands with suitable altitudes between 1,000 m – 2,000 m, the crop is short-term produced, harvested after three months. The crop serves as food as well as a cash crop (Gondwe, 1980). According to Bahramloo and Nasseri (2009), potato is sensitive to water stress at some growth stages, and thus, irrigation has become an essential component of potato production in arid and semi-arid regions. Moreover, Kiziloglu *et al.* (2006) reported that potatoes are moisture sensitive crop with a shallow active root zone compared to cereals and forages thus for suitable growth and optimum yield the crop needs frequent irrigation.

According to Thorton (2002) and Shock (2004), on their studies on effect of heat and water stress on physiology of potatoes at Idaho found that all growing stages of potato, especially tuber formation stage are very sensitive to water deficit. On the other hand Hassan *et al.* (2002) at his study on effect of deficit irrigation at different growth stage on the yield of potato in Pakistan concluded that the stolonization and tuberization stages were more sensitive than bulking and tuber enlargement stages.

Bahramloo and Nasseri (2009) studied on optimum irrigation events for potato cultivar, agria in Iran revealed that the average yield of potatoes under irrigation has significantly increased from 13 t/ha to 28.3 t/ha from 2004 – 2006. In North Dakota the average yield of potatoes under irrigation double that of dry land of 12.5 t/ha to 26 t/ha in 1997 (Thomas 1999).

2.5.4 Garlic (*Allium sativum* L.) production

Garlic is a perennial plant that requires a cold period to initiate growth, photoperiodic which is essential for proper cloves and bulb formation. The cloves is propagated vegetative, Garlic is a management demanding, labour and capital intensive crop production, thus producer has to strive to obtain maximum yield and quality (Banchman, 2008). According to Brewster (1994), garlic requires well drainage, friable soil with good organic content, adequate moisture and temperature. These soils allow the bulbs to expand without becoming misshapen. It will also aid in the soil water holding capacity, which is important due to the relatively restricted rooting characteristic of garlic. The ideal pH is between 6.5 and 7.0. Since garlic is a high-value crop and a heavy feeder, it deserves the best ground. It needs full sun and a full raised drainage (Gajete, 2004).

According to Hickey (2006), continuous irrigation is important, for optimum yields. Water stress should be avoided in garlic crops prior to the first signs of maturity. The fibrous root system is confined to the top 60 cm of soil and sufficient water should be applied to wet the soil to this depth. Consequently, irrigation needs to be light and frequent. Irrigation is supposed to be ceased when the first signs of maturity are evident. With sandy loam soil, it requires 8 – 12 times of irrigation throughout the growing period of the crop.

Garlic yields vary considerably and depend mainly on the planting rate, planting stock size and quality, the length of time the crop spends in the vegetative stage. Under good management practices yield of 6 – 8 t/ha could be obtained (Hickey, 2006). Unlike most vegetables, garlic can be stored for extended periods under a fairly broad range of temperatures. The main point is to have the cloves dry and well cured beforehand. Store in open-mesh bags loosely stacked for adequate ventilation in sheds or warehouses, or use

bulk bins. If the building is kept cool, dry and well ventilated, garlic will store for at least five months (Gajete, 2004).

2.5.5 Onion (*Allium cepa* L.) production

Onion is a vegetative crop grown almost all over the world; it is grown mainly for its bulb which is used in every home almost daily (Sani and Jaliya, 2004). It is main uses lies in flavouring and seasoning of wide variety of dishes. Its popularity is due to its aromatic, volatile oil and also has a role of medicine (Currah *et al.*,1990) Onion crop has shallow root system and need frequent irrigation after short intervals (Mateen *et al*., 2005). Onion is comparatively sensitive to waters stress and its growth can be inhibited well before bulb formation (Kanton *et al*., 2003).

According to Kumar *et al*. (2007), maximum onion root penetration is 0.76 m, and most function of moisture absorption take place at top 0.18 m to 0.31m. Irrigation water that moves below 0.76 m is most likely not available to the onion crop. Because of a shallow root system, the common practice, therefore, is to apply slight and frequent irrigation rates (Pelter *et al*., 2004).

Onion seed is raised in nursery for about 45 to 60 days in raised bed. The seedlings are transplanted to the well prepared plots normally 300 m^2 at two leave stage. Onion growing needs a well friable soil with high amount of organic matter, and good moisture-holding capacity. A suitable soil ranges from sandy, loams and muck soils with pH of 5.8 to 6.6 (Sani and Jaliya, 2004). Many field operations, such as land preparation planting, weeding and harvesting preservation and storage are labour intensive, hired and family labour are both used. According to Lupatu and Mattee (2001), a peasant farmer uses resources at its disposal, normally family labour.

Irrigation scheduling is one of the most important tools for developing best management practices for irrigated onion (Al- Jamal *et al.*, 2001; Pejic *et al*., 2008). With proper irrigation schedule, and taking into account the technological and biological characteristics of the crop, it is possible to achieve high and stable yields of 40 t/ha or higher (Meranzova and Babrikov, 2002; Kanton *et al*., 2003; Pejic *et al*., 2008). Many growers obtain much lower yields primarily because of inadequate irrigation scheduling (Mermoud *et al.,* 2005). According to FAOSTAT (2007), the yield of onion under irrigation in the leading onion growing countries has achieved 41.4 t/ha for Japan, 31.7 t/ha for Netherlands and 28.0 t/ha for Egypt.

2.5.6 Common beans (*Phaseolus vulgaris* L.) production

Common bean is the centrepiece of the daily diet for more than 300 million of the world's people (Ghassemi-Golezani and Mardafar, 2008). Common bean is the world's most important food legume; it is nearly perfect food because of its high protein content and generous amount of fibber, complex carbohydrates and other dietary necessities (Leterme, and Munoz, 2002). Drought stress is a worldwide production constraint of bean crop (Ghassemi-Golezani and Mardafar, 2008). The effect of drought can vary when it occurs during different stages of plant development (Costa-Franca *et al*., 2000). In general, drought has the greatest impact on bean seed yield when it occurs during reproductive development (Pimentel *et al*., 1999). However, severe drought stress has reduced yield by 92% in Iran in 1995 (Ghassemi-Golezani and Mardafar, 2008).

Common bean is considered as a sensitive crop to water (Nunez-Barrios *et al*., 2005; Munoz-Perea *et al*., 2006). The reliable water for irrigation, particularly at reproductive stages, is the most determinant of the crop yield (Costa-Franca *et al*., 2000). According to Ghassemi-Golezani and Mardafar (2008), on his study on effects of limited irrigation on

growth and grain yield of common bean at Tabriz in Iran concluded that common bean is a sensitive crop to water stress and high yield of this crop only can be obtained under sufficient irrigation conditions.

Generally, common bean is considered as short-season crop with most varieties maturing in a range of 65 to 110 days from emergence to physiological maturing wherever maturity period can continue up to 200 days amongst climbers (Katungi *et al*., 2009). The crop is not sensitive to soil type as long as it is reasonably fertile, well-drained and does not have conditions that interfere with germination and emergence (Wortmann *et al*., 1998). Irrigation water is critical during and immediately after the flowering stage (Allen, 1990; Xavery *et al*., 2005).

2.6 Other Studies Conducted on Crop Production Options Worldwide

Crop production option is influenced by various factors Lukanu *et al.* (2009) According to Das (2002), cropping options of a region are decided by large and by a number of soil and climatic parameters which determine overall agro-ecological setting for nourishment and appropriateness of a crop or set of crops for cultivation. Nevertheless, at farmers' level, potential productivity and monetary benefits act as guiding principles while opting for profitable crop option. The study conducted by Wamba (2008) on natural resource base and agricultural production option in East Ukiliguru Mountain indicates that the crop production option is influenced by different plot position being either at high or valley bottoms. Furthermore, a study by Hassan and Bashir (2006) in irrigated Punjab in Pakistan reveals that the optimum cropping patterns are determined by various price options.

The study by Otieno and Adeyemo (2010) on determining optimum cropping pattern in Lower Orange Catchments of South Africa where the intercropping are the common

farming, revealed that the best cropping option in terms of maximum total income generated from farm, irrigation water, and total man days gives total net benefit (TNB) of ZAR 36 737 t/ha, ZAR 37 787 t/ha, ZAR 38 288 t/ha and ZAR 44 815 t/ha from farm land of 60, 70, 75 and 135 ha, respectively, from intercropped legumes with cereals per hectare. According to Donna (2007), intercropping has proved successful and generally out performed monoculture in term of yield, weed, diseases and pest. Pea-canola intercrop yielded an average 21% higher than the crops grown alone.

According to Tsubo *et al.* (2005), Legume/cereal intercropping pattern is generally more productive than reference sole crop. Furthermore, the biological basis for intercropping involves complementarily of resources used by the two crops (Barhom, 2001). Increasing productivity of intercropped soybean and maize over the sole crop has been attributed to better use of labour, nutrients, and water (Tsubo *et al.*, 2005). Furthermore, the study by Oudar *et al.* (2007) on the effect of water stress on the yield of soybean and maize grown under different intercropping patterns showed that the highest yield was obtained under 1:2 soybean/maize intercropping pattern and using irrigation with evaporation pan coefficient equaled to 1.2, compared with either sole maize or sole soybean planting.

2.7 Factors Influencing Profitability

2.7.1 Labour requirement

Labour is the most important factor involved in irrigation production, most of the farm operations in crop production under irrigation are labour intensive (Cris and De Klein 1998). According to Monlruzzaman *et al*. (2009), human labour is the most important input in irrigation for crops production; it is required for land clearance and preparation, fertilizing, intercultural operations, irrigating, insecticide and weeding. Furthermore, Som (2004) found that labour is required for frequent cleaning and repair of canals for good

flows of water to the field and to reduce water logging which may result in salinity. This operation is more labour demanding for unlined canals. Most of the activities are performed by hand using a basic range of farm tools, such as hoes, Machete, slashers and axes. Land preparation using a hoe is very laborious and time consuming and this is common in fragmented farms where mechanization become difficult (Sherif and Papa, 1998).

Weeding is a critical activity and a major determinant of final yields. In irrigation this can be suppressed by application of mulch where it lessen labour requirement. According to Erenstein (2003), if sufficient layer of mulch is distributed homogeneous before sowing (at least 3 t/ha) weed pressure can be greatly reduced and labour required for weeding is reduced to three days per hectare with no tillage and 31 days per hectare with tillage.

Labour scarcity in irrigation threatens farmer's decision on crop production choice. Crops like garlic and onion are the most labour intensive thus household with labour shortage tend to avoid production of these crops or reduce area for cultivation (Banchman, 2008). Since most of farmers are fundamentally still subsistence oriented, they usually depend on family labour for the farm work (Masawe, 1992). The role of casual labour is indispensable for irrigated agriculture (Cris and De Klein, 1998). This is especially the case of garlic and onion where hired labour is required for seedbed preparation, planting whereby garlic is planted by sowing a single clove vegetatively, weeding which is done at least three to four times and harvesting which involves an uprooting of matured plant. According to Abu-Thallam (2003), the Jordan Valley plays a big role in the agricultural development, it absorbs about 26% of the total agricultural labour, and as a matter of fact irrigated areas employ more labour than rain fed areas in Jordan.

2.7.2 Capital

Capital plays crucial role in any production process particularly in irrigation agriculture, for which the lack of capital for purchasing inputs and technology are among the major factors affecting agricultural productivity (Senkondo, 1988; Ali *et al*., 2001). According to (WB 2002), irrigation and drainage systems require heavy investment and have traditionally been the largest subsector for World Bank agricultural lending, and they remain important to improving agricultural productivity and reducing poverty in many countries. The need of cash income in irrigation has potential important areas for investment these includes investment to irrigation infrastructure and improved agricultural inputs (WB, 2006).

Small scale irrigators need credit and financial services to enable them to pay for improved inputs timely which are primarily the determinant of the crop yield (Ali *et al*., 2001). It will also enable them to pay casual labour whereby due to competition during the weeding season the wage rate rises. Lack of capital is often highlighted as serious constrains to invest in new technology (Schechambo *et al.*, 1999). The study conducted by IWMI (2006) at Gujarat- India on poverty outreach of micro-irrigation technologies revealed that the largest groups of adopters were farmers that fall into the wealthier categories.

According to Kadigi *et al.* (2004), farmers in Usangu irrigation basin who have capital normally hire oxen to undertake ploughing and labour for pudding, transplanting and harvesting. But most farmers, who do not have enough money, resort to using their own labour in ploughing their fields by hand hoes. It costs approximately TZS 12 000 (US $ 11.65 per acre) (TZS 30 000 or US $ 29.13 per ha.) to hire oxen and/or labour for ploughing or transplanting work. Hiring labour for harvesting costs less at around TZS 8 000 (US$ 7.77) per acre equivalent to TZS 20,000 (US $ 19.42) per ha.

2.7.3 Land availability and tenure

Land is very scarce in Bashay irrigation scheme due to high population density, the area is heavily populated due to its high endowment and irrigation potential for production (DALDO, 2008). According to Jambiya (1998) the West Usambara is one of the most densely populated areas in Tanzania and estimated the arable land density at 254 persons per km^2. The high population density implies a high demand for land and water resources for irrigated agriculture (Hatibu *et al.*, 2002). Increase in population has made necessary to fragment the land into small pieces. This has resulted to small farm size available for cultivation by household. According to DALDO (2008), both rain fed and irrigation agriculture is practiced in Bashay. Although high yield is obtained under irrigation, but land is the limiting factor to expand agriculture under irrigation. Most of irrigation household owns an average farm size of 0.5 acre compared to an average of three acre pre household on rain fed (DALDO, 2008).

According to Kaiza and Marandu (1999), the large area of Tanzania agricultural land is still guided by traditional systems of land ownership. The system is gender biased whereby women and youths have no access and control to the land, thus, limits decision options on crop production. This situation is the same as that adapted in the study area where under the traditional system of inheritance in the Iraqw tribe, the entire farm was handed over to the youngest son. Due to the fact that most of small scale farmer own small farm size of 0.2- 0.4 hectare thus makes risk adverse farmers to be reluctant in adopting appropriate technology or new innovation (Hatibu *et al.*, 2002). This has also limited the decision to shift to more appropriate cropping pattern where water and other resources can be efficiently used. Double cropping is traditionally done for optimum utilization of the scarce land under irrigation (Nyangah, 2011). According to URT (2005), in order to achieve the objective of increasing grain production where the farming area is

limited, it is necessary to increase a land utilization rate by introducing the double cropping system, if water availability can be increased.

2.7.4 Water resource

According to Wordiq (2010), the water source for irrigation may be a nearby or distant body of liquid or frozen water such as a river, spring, lake, aquifer, well, or snow pack. Sources of irrigation water can be groundwater, extracted from springs or by using wells, surface water withdrawn from rivers, lakes or reservoirs or non-conventional sources like treated wastewater, desalinated water or drainage water (Lenntech, 2009). Depending on the distance of the source and the seasonality of rainfall, the water may be channelled directly to the agricultural fields or stored in reservoirs or cisterns for later use. In addition, the water can be increased by harvesting from local rain that falls on the roofs of buildings or on nearby unfarmed hills and its use to supplement the rain (Wordiq, 2010).

Several authors in the field of water management and utilization assert that water resources have the potential to improved economic benefits and rural livelihood. Lankford (2002) revealed that, in crop production water has significantly contributed to improve welfare among irrigation household. The requirement of water for irrigation is bound to increase due to population growth and increased demand for food. Over the next two decades, it is expected that the world will need 17% more water to grow food for the increasing population in developing countries and that total water use will increase by 40% (WMO, 1997; UNEP, 1999). This makes agriculture sector the largest water user accounting for about 70% of all water withdrawn worldwide (FAO AQUASTAT, 2005). In all the regions of developing countries, the proportion of use of water for agriculture is highest compared to other domestic and industrials uses, Africa account 68%, Asia 78%, and 65% in Central and South Africa (FAO AQUASTAT, 2005; Mwandosya, 2008).

Water as a vital resource in irrigation has been inefficiently used; the existing irrigation infrastructure in Tanzania is still poor and inappropriate causing the overall water use efficiency to be very low at an average of 15 – 20% as the losses in the systems are enormous amounting to 80 to 85% of total output (Mwandosya, 2008). This is because irrigated agriculture in Tanzania is mostly undertaken by smallholder farmers who do not produce crops substantially due to improper infrastructure (Mwandosy, 2008). There are however, a few large-scale farmers who undertake commercial agriculture using high efficiency pressurized irrigation systems such as drip, centre pivot and rain guns. The government is gradually intervening in rehabilitating infrastructure to improve water use efficiency and also to promote water saving technologies (MAFC, 2006).

In the Northern part of the Jordan Valley, Abu-Thallam (2003), has estimated the impact of water shortage on the planted area, and it was revealed that decreasing water supply by 20% will be followed by a reduction in the total cultivated area by about 14%. This will lead to a decrease in the total net income generated by 15%. As a matter of fact, the reduction in employment will be accompanied by a direct and indirect loss in income too.

2.7.5 Water resource in the study area

The main source of water for irrigation is Yaeda River. Water from this river is reserved at Mangisa charcoal dam which has a capacity of 350 000 m^3 (Appendix 1). Water resources of Bashay irrigation scheme is a limiting production factor as it is not enough to meet the requirements for irrigation, consequently, down-stream water users suffer from water shortage as amount of water flow decreases during the dry season (Gilba, 2008). Others constraints are related to occurrences of water conflicts over the direct extraction of water from canals between a farmer and a farmer, and farmers and livestock keepers as reported by (DALDO, 2002). Further the existence of corruption was reported where powerful or

rich farmers divert water to their farms, and to the detriment of the poor farmer, against the payment of a bribe to the canals' leadership and irrigation officials particularly during the dry season (DALDO, 2002).

2.7.6 Access to credit

According to Ronard (2007), credit is often considered to be a key element in irrigation agricultural sector. Credit is not only expected to remove a financial constraint, but also to accelerate the adoption of new technologies. Irrigation agriculture is a financial oriented enterprise as it involves high working capital for expensive input (seed, fertilizers and chemicals) and investment (Assefa, 1997). Many SSA countries have undertaken targeted credit programs to support irrigation projects because credit is an integral part of commercialization in agriculture and a vital instrument for economic development (World Bank, 1994). Ronard (2007) argued that in South Africa a major problem for small scale growers is access to loans for establishing and managing their fields, particularly when they need to irrigates their crops. Due to lack of collaterals the commercial bank retain resist lending of credit to farmers, though in irrigation the risk of loosing harvest can be avoided (Ronard, 2007).

According to Philip (2001), only 14.1% of Mtibwa out growers receive credit from bank. It was found that lack of credit causes under utilization of resources, thus in order to overcome this problem Mtibwa and Kilombero sugar estates supports sugarcane out growers on credit basis in provision of machinery to clear and prepare land for planting, provision of necessary inputs like fertilizer, pay for hired labour, weed control, harvesting and transport cane during peak season. The study conducted by Joshua (2008) reveals that about 95.7% of wheat growers in Karatu District have no access to credit facilities, and

those who have access to credit had high yield of an average of 2.4 t/ha compared to 1.7 t/ha for none access to credit.

Lyatuu (1994) found that despite its importance, many credit institutions are, however, not accessible to small farmers this is due to lack of tangible collaterals. He pointed out that many credit institutions have found it difficult to deal with smallholder's farmers mainly because of lack of adequate collateral, the high incidence of default and administrative costs associated with small loan. For example, in Tanzania, out of thousand holders only five get agricultural credit (Lyatuu, 1994).

2.8 Review of Analytical Techniques Used in the Study

2.8.1 Gross margin analysis

Traditionally the goal of small scale irrigation farmers is to maximize profit by increasing farm productivity (Mutayoba, 2005). Farmers have to keep records of their expenditure and sales, thus can identify the crop resulted with high gross margin (GM) to be decision criteria to opt for the profitable crop production. In this study GM is defined as the difference between total revenue and total variable cost (Msangi, 2000). Gross income (revenue) can be measured by total receipts received from the sales of produce plus the value of any retained output. Variable costs are those cost that increased or decrease as output changes (Cramer *et al*., 2001). Common example of variable costs in crop production includes seed, fertilizers, pesticides, cost of hired labour and transportation. The most important fixed cost is land, family labour, farm structure and farm machinery.

2.8.2 Advantages and Limitations of Gross Margin Analysis

The gross margin analysis (GMA) is very useful in case whereby the fixed costs are difficult to calculate. Calculation of depreciation have very often been difficult to

undertake due to the ambiguity nature of estimating the lifespan of fixed assets, appreciation and salvage values in many firms, thus necessitating the use of GMA rather than normal profit margin models. The GMA requires proper records such as inputs cost, quantities sold and prices received (Msangi, 2000). By undertaking a GMA, one can find out whether an enterprise makes a profit or not so GMA can be used to compare the profitability of different enterprises. The fundamental advantage of the GMA as an economic tool is that it is simple to understand and does not involve tedious calculations, it uses logical interrelation of economic and technical parameters forecast of operational structure of an enterprise.

Gross margin analysis makes no allowance for complementary and supplementary relationships, which often exist between enterprises, output and cost change with the scale of enterprise. Consequently, if an enterprise is increased, the gross margin per unit is likely to change; Gross margin of an enterprise is not necessarily an indication of its profitability. Other limitation is that small scale farmers are not only confined to profit maximization but they have other objective to achieve, for example farmers must grow maize and beans although less profitable but aim to secure them for food. According to Ferris and Malcon (2000), gross margin can vary widely from one year to another, due to differences in market prices, weather condition, and efficiency. In irrigation agriculture GMA can also differ considerably from up stream to down stream this is due to difference in level of water availability and requirement per crop and performance in production methods.

Several studies have employed GMA including the study done by Mutero (1998) who compared profitability of traditional and modern irrigation system in Banchi states of Nigeria and reveals that GM for all crops where higher in modern irrigation than in traditional irrigation system. Also the model was used by Myenyelwa (2008) to determine

profitability of crops production enterprises with and without traditional irrigation system in Same District. In this study GM model was used to determine the profit level of the selected crops at different scenarios in the Bashay irrigation scheme.

2.8.3 Multiple linear regression model

According to Cohen *et al.* (2003), regression analysis involves techniques for modelling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. More specifically, regression analysis helps us understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. Regression analysis is widely used for prediction and forecasting, it is also used to understand which among the independent variables are related to the dependent variable, and to explore the forms of these relationships. Regression analysis can also be used to infer causal relationships between the independent and dependent variables.

In this study, the single equation model was employed and expected that the farm profitability of a household being described as income per acre, obtained by multiplying quantity produced by prevailing market price. The income is expected to be influenced by factors includes labour in man-days, cost of inputs (seed, fertilizers and chemicals), land in acres, age, education level, access to extension services, and access to credit. According to Gujarati (1995), in estimating linear regression model, the Ordinary Least Squares Estimation (OLSE) is commonly used this technique is appropriate for single equation model. The Ordinary Least Squares (OLS) was employed to examine the impact of different factors influences profitability. The OLS estimation approach needs to select the population parameter such that the ordinary sum of square of errors is minimized. Thus OLS estimation leads to Best Linear Unbiased Estimator (BLUE). The advantages of

using OLS estimation techniques is that it is simple to use, eloquent and gives the best estimator, and it does not require the knowledge of the probability distribution of the underlying population being studied (Gujarat, 1995). Some of the limitations are: OLS are bias upon violation moreover OLS methods may give inconsistence estimate of the parameter β since the residual is correlated with independent variable.

2.8.4 Linear programming analysis

According to Hazell and Norton (1978), Linear Programming (LP) refers to a family of mathematical programming techniques that can be used to find solutions to optimisation problems whose objective function and constraints are linear expressions of decision variables. Linear Programming enables decision makers to find optimal solutions for problems in which the solution must satisfy a given set of requirements, or constraints. The model is used in estimating optimal profit, by maximizing return or minimizing cost, given specified constraints (Murugan, 2009). In recent years LP has played an important role in providing guidelines for decision making in various economic activities as it indicates the best way to use resources once a judgment has been made as to a given prices, constraints and objectives (Murugan, 2009).

According to Worldiq (2010), advantages of using LP model are numerous: First LP technique helps to make the best possible use of available productive resources (such as time, labour, land, machines etc). Second in a production process, bottle necks may occur. For example, in a factory some machines may be in great demand while others may lie idle for some time. A significant advantage of linear programming is highlighting of such bottle necks. The third advantage is that the quality of decision making is improved by this technique because the decisions are made objectively and not subjectively, and the fourth

advantage is that by using this technique, wastage of resources like time and money may be avoided.

Some of the limitations of using LP techniques were explained as: LP is applicable only to problems where the constraints and objective function are linear i.e. where they can be expressed as equations which represent straight lines. In real life situations, when constraints or objective functions are not linear, this technique cannot be used. Another limitation are the factors such as uncertainty, weather conditions etc. which are not taken into consideration.

Several studies have applied this model for instance, Ishtiaq *et al*. (2005) used LP model to calculate the crop acreage, production and income at Punjab province division and revealed that crop like cotton gained optimal crops acreage at the expense of others. Philip (2006) used LP model when studying an exploration of the potential of producing biofuels and the prospective influence of biofuels production on poverty alleviation among small-scale farmers in Tanzania and revealed that the cost of producing biofuel from feedstock is the best option to alleviate poverty among small holders in Tanzania. Mlambiti (1992) used LP model to develop the planning for regional agricultural development in Kilimanjaro region. The study shows that LP model can give optimum plans according to any policy change. Hassan and Bashir, (2006) used LP model to determine the optimum cropping pattern under various price option a case of Pakistan, and revealed that income increased by 1.57 %. When price increased by 10% it registered a rise of farm income by 30%. In this study, LP model was used to determine the profitable crop production option for Bashay irrigation schemes.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Conceptual Framework

The conceptual framework was designed to illustrate irrigation water scarce gap and the means to bridge the gap (Fig. 1). It illustrates enhanced profitable crop production options depend on socio-economic characteristics such as: water for irrigation, labour, land, capital, age, sex, household size, and education level. These are in line with institutional inspiration and organizational structures leading farmer's decisions on the profitable crop production options. These factors have been considered to stimulate acceptance of the best production options in a way worthwhile to the scarce resource of irrigation water. According to Hassan and Bashir (2006), the most decisive option would comprise selection of optimum cropping patterns as a prerequisite to efficient utilization of available resources of land, water and capital.

However, the optimum efficiency of irrigation water gives clue to appropriate water allocation to the different crops which lead to increase in yield of crops cultivated in the study area, thus, expected to increases income and the livelihood of the entire community. Production options in the study area differ slightly from up-stream and down-stream resulting in different profit levels. This is probably because farmers at up-stream have advantage of adhering to irrigation schedule and to a large extent satisfy the water requirement per crop. The stream flow decreases down the stream, a situation which dictates farmers on the appropriate crops and cropping patterns in the area.

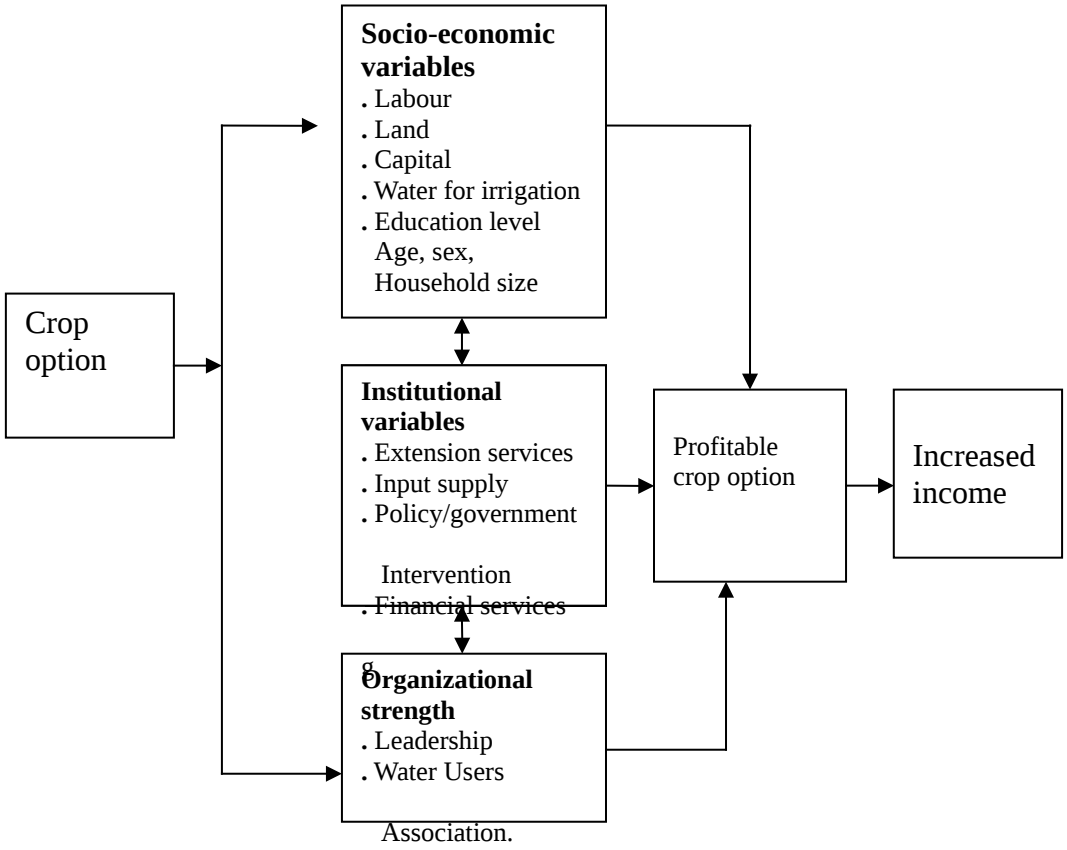

Figure 1: Conceptual framework of the study

3.2 Description of the Study Area

3.2.1 Location

The Bashay irrigation schemes lies in Mbulu District, Manyara Region. The district is bounded by Karatu District and Lake Eyasi in the northern part, and Babati, Hanang and Iramba districts in the East, South and West, respectively (Fig. 2). The district is located between latitude $3^0 – 4^0$ south and longitude $34^0 – 35$` east. Mbulu District lies in the altitude 1000 m to 2400 m above sea level. The district has total land mass of 4600 km² of which 90 000 ha is arable land whereby 2727 ha is potential for irrigation out of which only 41% is utilized for irrigation (Mbulu District profile, 2009).

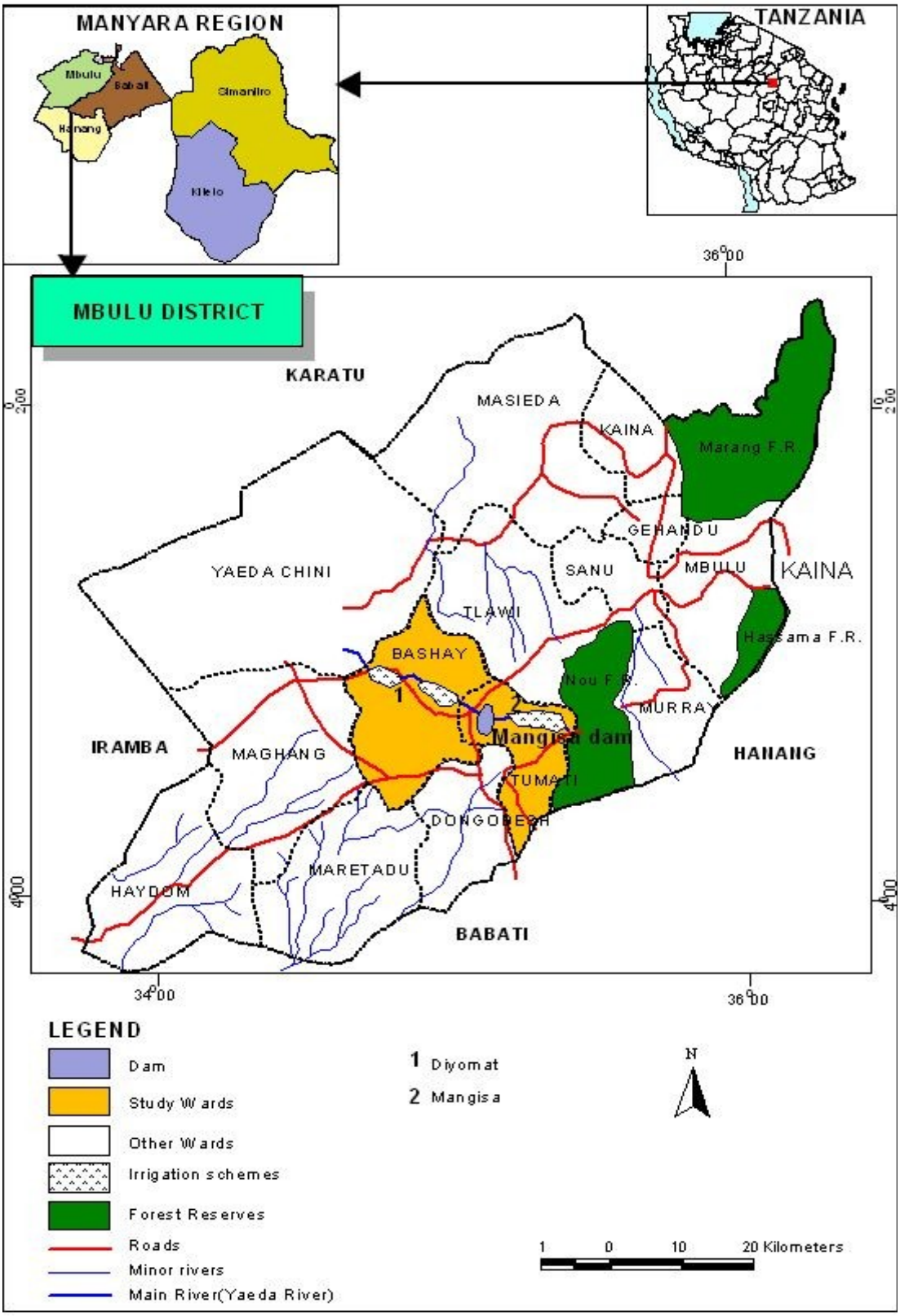

Figure 2: Map of Mbulu District showing the study area

3.2.2 Demographic

According to the national population census of 2002, the district had the population of 237 882 people, among them males are 120 535 and female 117 347. The district has about 38 729 households and the average population growth is 3.8% per annum which is higher than the national average of 2.8% per annum (NBS, 2003).

3.2.3 Climate

The climate varies from one area to another in the district. Rainfall distribution is bimodal, with two distinct seasons (short and long rain seasons). The short rains fall between November and February, and this less predictable rainfall season is called “VULI”, while the long rainy season (March and May) is locally termed “MASIKA”. The long and cold dry season extend from June to October. Rainfall ranges from less than 400 mm in western zone to over 1200 mm in the eastern zone. Almost half of the district receives an average of 600 mm which is generally considered limiting for reliable agriculture. The annual temperature is generally uniform with regard to time and place ranges from 15 ^{0}C – 24 ^{0}C.

3.3 Research Design

The study involved a cross-sectional single visit survey to collect qualitative and quantitative data. This design allowed collection of data at one point-in-time (Bailey 1998). Data collection was done from October 2010 to January 2011. According to the nature of the study, the design was feasible, economical and collected data can be used to determine relationship between different variables.

3.4 Sampling Procedure and the Sample Size

The target population for this study was small-scale irrigation farmers’ household from selected irrigation schemes. Two schemes namely Mangisa and Diyomat of Tumati and

Bashay Wards, respectively, were selected purposively; based on the criterion of the potential area for the main cash crop production. These schemes share the same source of water which is Mangisa Dam and Yaeda River. Mangisa is located at the upstream and Diyomat downstream. Table of random numbers was used in a complete randomized sampling technique to obtain 100 respondents, 55 from Diyomat and 45 from Mangisa villages. The study adopted such sample sizes as recommended by Bailey (1998) who contended that the minimum sample size should be at least 30 cases regardless of the population size. The samples were justified by limitation of time and financial resources; accuracy and a need to ensure sufficient number for meaningful analysis as compiled by Bailey (1998).

3.5 Data Sources and Methods of Collection

3.5.1 Secondary data collection

Secondary data were obtained from various publications, books, journals, electronic sources and other research works. These publications are found at Sokoine National Agriculture Library (SNAL), District Agricultural and Livestock Development Office (DALDO) and Mbulu District Council (MDC).

3.5.2 Primary data collection

Primary data collection was done through field survey, whereby structured questionnaire which was formulated, pre-tested, and edited were used. The questionnaire was translated into Kiswahili by experts who are conversant in the terminologies of the field of study. Then the Kiswahili version was pre-tested and edited ready for administration (Appendix 2). The questionnaire was then administered by the researcher and the data were collected from household farmers who participate in irrigation agriculture. It was necessary to gather the detailed information on household characteristics such as age, sex, education

and marital status. The detailed information also gathered was about the types of crops grown under irrigation, and acreages under cultivation. Output records were also probed, which were the volumes of harvest per acre. All costs and revenue estimates were done in Tanzanian shillings (TZS). Data on factors influencing productivity including farm size, land use and tenure, labour availability and use, water resource availability and management, agricultural inputs availability and uses, also data on extension service deliveries were also collected (Appendix 2).

3.6 Data Analysis

Data collected from primary source was coded and analyzed by using Statistical Package for Social Sciences (SPSS) and Linear Programming (LP) software. Three analytical tools used to test the stated hypothesis were GM Analysis, Linear Regression Analysis and Linear Programming.

3.6.1 Identify and characterize the production methods.

Descriptive statistics such as cross tabulation, compare mean, frequency distribution means and percentages were used to identify and characterise the production methods existing in Bashay irrigation schemes.

3.6.2 To determine profit levels for the selected crops

To analyse these objective the gross margin analysis was employed in order to establish relative profitability per ha for different crops including garlic, onion, potatoes, maize, common beans at different scenarios. The model has been chosen because it can be used to measure economic return per unit of inputs in crops production.

Mathematical specification of GM model

GMi = TRi – TVCi ……(i)

Where:

GMi = Average gross margin per ha for crop i

TRi = Average total revenue per ha for crop i

TVCi = Average total variable costs per ha for crop i

3.6.3 Key factors influencing crop profitability

The multiple regressions model was applied to trace the key factors that influence the crop profitability which is return per ha per crop (GM) as a dependent variable. Model predict that profitability can be influenced by land, labour, capital for input, education level, sex, extension service and credit.

Mathematical specification of multiple regressions model

$$Yi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \lambda_1 D_1 + \lambda_2 D_2 + \varepsilon_0 \ldots\ldots\ldots\ldots\ldots\ldots\text{(ii)}$$

Where;

Yi = GM per ha (profit) for crop i

β_0 = Constant coefficient

$\beta_1, \beta_2 \ldots . \beta_5$ = Are regression coefficients

X_1 = Area under cultivation (ha)

X_2 = Labour in mandays

X_3 = capital in Tsh used to purchase inputs for crop production.

X_4 = age in years

X_5 = Education level of the respondent

D_I = Access to extension services dummy (0= receive, 1= not access)

D_2 = Access to credit (0= receive, 1= not receive)

ε_0 = error term (difference between observed values X_i and the expected values of the random variables)

Dependent variable

Household income per ha was obtained by converting crop yield into money value by multiplying quantity harvested with prevailing unit market price, which is the gross margin of the household.

Independent variables

The independent variables expected to influence the farm profitability are explained below:

- Farm size**:** This is measured in hectares and it is postulated to influence increase in profitability. It is expected that increase in farm size will increase the quantity harvested and thus increase income per household.
- Labour in man-days**:** Labour is one of the factors that influence production. It is postulated to influence profitability positively.
- Capital in TZS**:** This carries the cost of inputs used per crop per ha. This includes cost of seed, fertilizers and chemicals. It is postulated to influence the profitability positively. Increase investment in fertilizer and seed will influence crop output and enhance increase in income per ha.
- Age**:** This is thought to influence attitudes towards information sources. These factors are related to decision making process. Increase age in years is related to farming knowledge and experience, thus expected to influence the profit positively.

- Education level**:** (Number of years spent in school): Education level of a respondent influence altitude change towards adoption of new agricultural innovation/ technology. It is expected to influence productivity positively.

- Dummy variables (access to credit and access to extension services)

  Agriculture credits solve for financial constraint faced by farmers, it provides incentives for farmers to adopt new technologies, on the other hand, extension services will make farmers access to appropriate technology to boost production. Therefore, farmers who access to credit facilities and extension service are in better position to increase farm productivity than those farmers do no access. This is expected to influence profitability positively.

3.6.4 Options for profitable crop production

To determine the most profitable crop production option LP model was used to explore the possibilities of maximizing the profit within the constraints of land, family labour, hired labour, seed, and fertilizers.

The LP model was developed as follows**:**

The objective function is to maximize profit.

$$MaxZ = \sum a_i \lambda_i \quad \text{……(iii)}$$

Subject to:

$$\sum l_i \lambda_i \leq lav \quad \text{……...(iv)}$$

$$\sum f_i \lambda_i \leq fav \quad \text{……...(v)}$$

$$\sum h_i \lambda_i \leq hav \text{ …….}$$

(vi)

$$\sum s_i \lambda_i \leq sav \text{ ……...(vii)}$$

$$\sum ft_i \lambda_i \leq ftav \text{ ……(viii)}$$

$\lambda_i \geq 0$ Non- negative

i = 1, 2, 3, 4, 5, 6

Where: a_i = Net profit (TZS) per ha for crop í.

l_i = Farm size for crop i per ha

f_i = Family labour in man days per ha for crop i

h_i = Cost of hired labour in TZS per ha for crop i

s_i = Cost of seed in TZS per ha for crop i

ft_i = Cost of fertilizer in TZS per ha for crop i

lav = Land in hectares

fav = Family labour in man days

hav = Cost of hired labour in TZS

sav = Cost of seed in TZS

$ftav$ = Cost of fertilizer in TZS

3.7 Limitation of the Study

In the course of conducting fieldwork during this study, some setbacks were encountered. The responses of the interview were based on their memory. However, most farmers do not keep the written records and hence were not in position to recall some necessary data like cost incurred in production, quantity harvested per unit area, and sales price. Furthermore, the respondents were not in position to estimate research parameters like farm size, thus, they were misinterpreting the units like acre and hectares, and convention

of local measurements like bags, tins and traditional basket to metric measures (kilograms or tons). Therefore, this study tried to minimize this problem by probing some questions more than once in different ways to get the correct information. In addition, this was done through observation as well as triangulation to minimize invalidity brought about by incorrect data. Therefore, in spite of these setbacks the study data and the findings thereof were correctly collected and confidently reliable, and adequately addressed pertaining to the objectives of the study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-Economic Characteristics of Household Heads

Socio-economic characteristics are important attributes of any society as they reflect its behaviour in decision making and its probable expected responses to many stimuli exposed to it. The characteristics of a given households have important social and economic implications on crops production (Ferris and Malcon, 2000). Household characteristics of respondents usually influence the decision of respondent to opt the type of crop to produce and volume of the agricultural output. Therefore, this section describes the characteristics of sampled respondents which include age, sex, marital status, education level, and family size. For this study the household is considered to be composed by people who eat and sleep in the same house.

4.1.1 Age of respondents in years

The study reveals that age of respondents range from18 to 82 years. By category most (41%) of the respondent belongs to age group of 40 to 50 with a mean of 45 years, this age indicate that most of respondent belong to productive age group. About 29% and 35% of respondent in the up and down stream belongs to the age group above 50 years, while 31% and 22% in the up and down stream respectively fall at age group between 20 to 40 and there is little involvement of young people below 20 years which is 1% (Table1). This implies that, there are a high proportion of adults in the community who mainly make up the community workforce. The occurrence of respondent above 50 years suggest high life expectance. Age affects education, wealth and decision making and hence can influence determination of crop production option.

Table 1: **Socio-Economic Characteristics of Household**

Variables	Upstream		Downstream	
	Frequency	Percent	Frequency	Percent
Age of respondent by category				
Below 20 years	NIL	NIL	1	1.8
Between 20- 40 years	14	31.1	12	21.8
Between 40-50	18	40.0	23	41.8
Above 50 years	13	28.9	19	34.5
Total	45	100.0	55	100.0
Sex of respondent				
Male	32	71.1	50	90.9
Female	13	28.9	5	9.1
Total	45	100.0	55	100.0
Marital status				
Never married	NIL	NIL	2	3.6
Married	42	93.3	52	94.5
Widow	1	2.2		
Divorce	2	4.4	1	1.8
Total	45	100.0	55	100.0
Level of education				
None	8	17.8	6	10.0
Primary	37	82.2	45	81.8
Secondary	NIL	NIL	4	7.3
Total	45	100.0	55	100.0
Household size in category				
Between 2-4 members	6	13.3	8	14.5
Between 5-7 members	31	68.9	35	63.7
Between 8-12 members	8	17.8	12	21.8
Total	45	100.0	55	100.0

4.1.2 Sex of respondents

The results in Table 1 show that female interviewees were 29% and 9% in the up and down stream respectively whereas the rest 71% and 91% were males. This observation is characteristic of most African cultures, which in most cases deny women from ownership and control of resources. Economic activities are thus mainly male dominated. In the research area, the tribal culture of the Iraq is equally suppressive in terms of female ownership of economic resources (Gilba, 2009). This is exacerbated by the fact that land is inherited only by sons and never by daughters. This implication has effect to decision making on crop production option, which is highly influenced by men. This situation can

be attributed to the fact that irrigated agriculture is the capital and energy intensive activity which is not influenced to majority of women.

4.1.3 Education level of the respondents

The farmer's levels of education are presented in Table1 which indicates majority (82 %) of respondents has completed primary education, 7.3% of the respondents in the up stream have attained secondary education, while about 10% of the respondents have no formal education. This result implies that more than 90% of respondent have formal education. This can be attributed by the deliberate efforts made by government in 1978 to expand primary education whereby it was compulsory for school age children to go to school (THDS, 1996). Education is one of the long term strategies that may be used to improve agriculture in developing countries like Tanzania. Amani *et al*. (1987) reported that education contributes agricultural improvement by 50%. A population comprise of low level of education tend to resists the new agricultural innovation (Mcfalls, 2003). This has resulted into low agricultural productivity and endemic poverty for rural people who majority are farmers.

4.1.4 Marital status of respondents

Table 1 shows that most (93% and 94%) of the respondents in the up and down stream respectively were married this shows that the society is stable. The divorce rate was low and fall to 4.4% and 1.8% respondent in up- and downstream, respectively, never married 3.6%, in the down stream and widow 2.2% in the up stream. A stable family can concentrate more on production than an unstable one, thus may influence the adoption of best production option.

4.1.5 Household size and composition

The results presented in Table 1 show that, household size of the respondents ranged between 2 and 12 members with the average household size of 6 members, this is above the national level average of 5 members per household (NBS, 2003). The majority of the households (69% and 64%) in the up- and downstream respectively, had medium family size of 5–7 members; while 17.8% and 21.9% of the households in the up- and downstream, respectively had large family size of 8 – 12 members and 13.3% and 14.5% of the respondents in the up and down stream had small family size of 2–4 members, respectively. Family size is important in determining the levels of production and consumption. Family size is reliable, available and immediate labour for farm work basing on the extent of contribution of each in farm work (Senkondo, 1992). Household composition is important indicator and can reflect labour available.

4.2 Crop Production Methods in Bashay Irrigation Scheme

4.2.1 Crop production priorities

Various crops are grown in Bashay irrigation schemes including maize, beans, round potatoes, sweet potatoes, garlic, onion, vegetable, banana, sugarcane, and chickpeas. Fig. 3 represent farmer's priorities on crops produced in order of importance basing on the criteria of return per ha, farm size available, labour requirement, input availability, food requirement, and favourable climate for crop production. The result give first priority to garlic 47.15%, maize as second 29%, beans as third 11.15%, potatoes as fourth 8.2% and onion as fifth 5.5%.

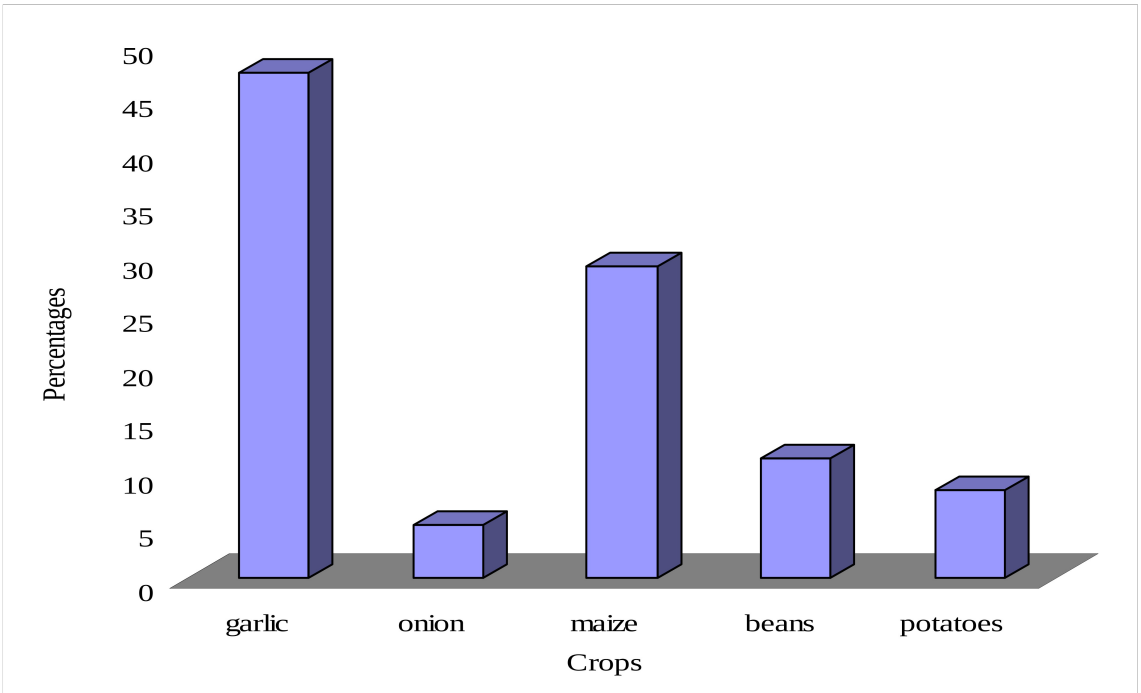

Figure 3: Distribution of respondent by crop priority

Garlic was given the first priority because it is the crop which is the most paying among others with high farm gate price and thus reassures farmers with cash income. Maize scored second, hence the crop is among the very important food crop which is the staple food for Bashay people. Thus almost all farmers produce maize to meet their primary objective of achieving food security. Beans are also among the very important and useful food crop almost consumed as daily diet by Bashay people. The crop is less capital, material, and labour intensive mostly intercropped with other crops and harvested as bonus in respect to others main crops grown. Potatoes were mentioned among the important crops grown in the schemes, as it serves both food and cash crops. Most farmers afford to cultivate this crop because it is the short term crop with less irrigation water demanding, less capital and material for production. Onion was also mentioned as among the important cash crop produced in the study area. The crop is competitive with garlic requiring high capital, high water requirement and is also labour intensive but less paying when compared to garlic.

4.2.2 Characteristics of respondents by farm size, crop types and husbandry Practices

Table 2 shows the farming system in the study area characterised by small-scale holders owning small plots of 0.1– 0.4 ha (60%, and 76.%) respondents in the up and down stream, respectively, 0.4- 0.44 ha owned by 33% respondents in the up-stream and 14% in the down-stream, less than 0.1 ha owned by 2.2% respondents in the up-stream and 7.2% in the down-stream, respondents who own land size greater than 1.2 ha were 4% up-stream and 2.2% in the down stream. The difference in holding the farm size is determined by water availability. From the data the numbers of farmers holding small farm size increases down the stream as compared to the respondents in the up stream. Land size holding under irrigation is at large determined by water availability. Stream flow decreases down stream this limits expansion of the potentials area for irrigation and still competition for water between upstream and downstream water users has been increasing. This in turn requires a good understanding of the value of irrigation water and the implications of water management (Johnson and Baltodano, 2004). In other words, decision makers and other stakeholders need to be precisely opt for production of the high values crops worthwhile to water resources available (Kadigi *et al.*, 2004; Temu, 2005).

Furthermore, Table 2 indicates the major crops grown in study area includes garlic 98% and 96% of respondent in the up and down stream respectively, onion by 28.8% up stream and 38% down stream, maize and beans are grown by all respondent 100% these crops are considered as the main staple food in study area. Potatoes are grown by 37.7% and 30.1% respondent in the up and down stream, respectively.

Table 2: Characteristics of respondents by farm size, crop types and husbandry practices in the study area

Variable	Descriptions	Up- stream (percent)	Down stream (percent)
Farm size (ha)	less than 0.1	2.22	7.20
	Between 0.1- 0.4	60.00	76.00
	Between 0.44-.1.2	33.33	14.50
	Above 1.2	4.44	2.20
Crops grown	Garlic	98.00	96.00
	Onion	28.80	38.10
	Maize	100.00	100.00
	Beans	100.00	100.00
	Potatoes	37.70	30.10
Cropping pattern	Garlic monocropping	87.00	76.00
	Onion monocropping	96.00	100.00
	Maize intercropping	100.00	100.00
	Beans intercropping	100.00	100.00
	Potatoes monocropping	98.00	95.00

Moreover, the results in Table 2 show that the common cropping patterns are both intercropping and/or mono cropping. Garlic is grown as pure stand by 87% and 76% in the up stream and down stream respectively, the remaining percentage intercropped garlic with beans, where by beans are planted at the ridges of seedbed. Maize and beans are intercropped in all fields (100%).This has the advantage of well utilization of resources used in production. Potatoes are grown as pure stand (98% and 95%) at up and down stream respectively, in few cases are cultivated in field with banana, sugarcane, and beans.

4.3 Crop Production in the Study Area

4.3.1 Farm size under crop production

Table 3 shows that 60% of respondents in the up stream cultivates garlic at the farm size of 0.1 to 0.4 ha , 33.3% respondents has allocated 0.45 to 1.2 ha for garlic production, 2.2% allocated 0.1 ha and 4.4% allocated 1.2 ha and above for garlic production. Also the study finds that the average land size owned by farmers at upper stream is 0.6 ha which is close related to the findings reported by Fischer (2006) that most of the household participates in irrigation hold an average land size of 0.4 hectare equivalent to 1 acre. He

commented that size of land under irrigation affects the yield of agricultural production which including garlic production.

In the down stream most (76%) respondents cultivates garlic at farm size of 0.1 to 0.4 ha followed by 14.5% who have allocated farm size of 0.45 to 1.2 ha, 7.2% allocated 0.1 ha for garlic cultivation, while only 2.2% have allocated 1.2 ha and above for garlic production. The average land size owned by farmers in the down stream is 0.36 ha. This area is less than that own by respondent at up- stream. Garlic is the most water demanding crop in the study area and since stream flow down the scheme decreases, the farm size under garlic production also decreases affecting yield and household income (Abu-Thallam, 2003).

Table 3: Farm size under crop production in study area (ha)

Scheme	Cops	< 0.1	0.1- 0.4	0.45- 1.2	>1.2
Upstream	Garlic	1(2.22)	27(60)	15(33.33)	2(4.40)
	Onion	1(7.70)	8(62.55)	4(30.76)	0(00)
	Maize	0(00)	34(75.6)	9(20)	2(4.40)
	Potatoes	0(00)	10(58.8)	4(23.50)	3(6.70)
	Beans	0(00)	34(75.6)	9(20)	2(4.40)
Down stream	Garlic	4(7.20)	48(76)	8(14.50)	1(2.20)
	Onion	6(28.60)	12(57.2)	3(14.30)	0(00)
	Maize	2(3.60)	35(63.6)	15(27.30)	3(5.50)
	Potatoes	3(17.60)	11(64.7)	3(17.60)	0(00)
	Beans	2(3.60)	35(63.6)	15(27.30)	3(5.50)

Note: Figures in parentheses are in percentages

Furthermore Table 3 shows that onion is cultivated in small scale farms where most (62.55%) of respondent at up stream cultivates onion in farm size of 0.1- 0.4 ha, 30.76% have allocated 0.45 to 1.2 ha, and 7.7 % allocated 0.1ha for onion production. While in the down stream 57.2% respondent cultivates onion in farm size of 0.1 to 0.4 ha, 28.6 % cultivates farm size less than 0. 1 and 14.3% cultivates farm size between 0.45 up to 1.2 ha for onion production. Data shows that percentages of respondents who own small farms at

down stream are greater as compared to up stream. Thus, the study assumes that there is water shortage in the down stream.

Furthermore Table 3 results indicate that in up stream, majority (75.6%) of respondents cultivate maize in farm size of 0.1 to 0.4 ha followed by 20 % respondents of maize growers allocated 0.45 to 1.2 ha for maize production and 4.4 % cultivate maize in area greater than 1.2 ha . In the down stream majority (63.6. %) cultivate maize at farm size of 0.1 to 0.4 ha, 27.3 % cultivate maize at farm size of 0.45 to 1.2 ha and 5.5% manage to cultivate maize at farm size above 1.2 ha. Percentage of land cultivated from o.4 ha to 1.2 ha and above, increases down the stream, this is because the crop is less water required, thus at down stream with less access to irrigation water the crop can performed well.

Moreover Table 3 result indicates that the land size allocated for potatoes cultivation in the up stream is between 0.1 up to 0.4 ha by 58.8% of respondents, 0.45 to 1.2 ha by 23.5 % and above 1.2 ha by 6.7% respondents in up stream. While in down stream 64.7% respondents cultivate potatoes at farm size of 0.1 to 0.4 ha, 17.6 % at farm size less than 0.1 ha and 17.6% of respondents at farm size of 0.45 to 1.2 ha. Data shows that farm size allocated for potatoes production has increased down the stream. The study assumes that potatoes are a short term crop maturity that can be produced by farmers less access to irrigation water in study area.

Common beans are produced by all respondents, and are intercropped with maize. In garlic and onion farms beans are grown at the edges of seed beds. It is also mixed in the farms of potatoes and plantains. All farmers can manage beans production due to its low capital demand. Common bean seeds are locally prepared, and share fertilizers and chemical applied to the main crops. The result in Table 6 revealed that in up stream,

majority (75.6%) of respondents cultivate common beans in farm size of 0.1 to 0.4 ha followed by 20 % who cultivates common bean in farm size of 0.45 to 1.2 ha while 4.4 % cultivate common beans in area greater than 1.2 ha. While in the down stream majority (63.6. %) of respondents cultivate common beans at farm size of 0.1 to 0.4 ha, 27.3 % at farm size of 0.45 to 1.2 ha and 5.5% manage to cultivate beans at farm size above 1.2 ha. Percentage of land cultivated from 0.4 ha to 1.2 and above, increases down the stream, this is because the crop is short term with early maturity that can be produced well in the down stream with less access to irrigation water.

4.3.2 Inputs used in crop production in study area

Table 4 results reveals that seed for garlic are locally prepared from the farmers stock (100%). The variety grown is silvery pinkish which is locally available in study area. The most common fertilizers used in study area are farm yard manure (FYM) (95.5% and 92.7%) in the up and down stream respectively. Farmers prefer this manure due to its availability, cheapness, easy application. Minjingu phosphate fertilizer has been used by 15.5 % in the up stream and not used in the down stream. This study assumed that the wealthier farmers are in the up stream who are able to purchase the Minjingu fertilizes. Moreover the study shows that only 4.4% of respondents used urea in the up stream and 5.4 % at down stream. The study also assumes that there is low adoption rate of utilizing industrial fertilizers due to low knowledge among garlic growers in the study area.

Furthermore Table 4 shows that onion growers in study area uses locally prepared onion seed (84.6% and 85.7%) in the up and down stream respectively. According to respondents the common variety grown is Red Bombay. Farmers in the study area found to apply different types of fertilizer for onion farm, about 79.9 % and 90.4% in up and down stream have applied farm yard manure, urea have been used by 61.5% and 52.4% of the

respondents in up and down stream respectively. Minjingu phosphates have been applied by 46.1% and 19% of respondents at up and down stream respectively. Booster has been used by 53.8% and 42% of the respondents in the up stream and down stream respectively. The study assumes that good output with onion production is influenced with fertilizer application. According to (Sani and Jaliya 2004), the amount of fertilizers for onion differ from location to location however the recommended fertilizer application is 65kg N/ha, 40kg P/ha and 45 kg K/ha.

Table 4: Inputs used in crop production in study area

Schemes	Description	Inputs	Garlic (%)	Onion (%)	Maize (%)	Potatoes (%)	Beans (%)
Up-stream	Seeds	Local	100.0	84.6	26.6	100.0	100.0
		Improved	0	15.4	73.3	0	0
	Fertilizers	FYM	95.5	79.9	4.4	53.8	0
		Minjingu Phosphate	15.5	46.1	0	0	0
		Urea	4.4	61.5	4.4	0	0
		Booster	55.5	53.8	0	0	0
	Agrochemicals	Pesticides	53.3	69.2	0	0	0
		Fungicide	62.2	46.1	0	0	0
Down stream	Seeds	Local	00.0	85.7	20.0	100.0	100.0
		Improved	0	14.2	80.0	0	0
	Fertilizers	FYM	92.7	90.4	5.5	46.0	0
		Minjingu phosphate	0	19.0	0	0	0
		Urea	5.4	52.4	0	0	0
		Booster	45.4	42.9	0	0	0
	Agrochemicals	Pesticides	29.0	47.6	0	0	0
		Fungicide	65.5	38.1	0	0	0

Further study reveals that agrochemicals such as pesticides and fungicides have been used by 69.2 % and 46.1% of respondents respectively in the up stream. At down stream the pesticide and fungicides have been applied by 47.6 % and 38.1% of respondents respectively (Table 4) The study assumes that due to warm climatic condition there is less

fungal infestation in the down stream (Sani and Jaliya, 2004) and thus little fungicide have used.

Moreover from Table 4 various inputs have used for maize production. The improved seed was used by 73.3% (up stream) and 80% (down stream). Little of farm yard manure has been used 4.4 % (up stream) and 5.5(down stream), no respondent has used Minjingu fertilizers and only 4.4% respondents have used urea. Booster, fungicide, and pesticide have not been used. The study found that there is good turn up in the uses of improved seed, this is due to government support in subsidizing agriculture inputs through vouchers system, although the package oblige the improved seed to be used with Minjingu phosphate and urea/CAN/DAP fertilizers, but farmer's area still reluctant in uses of industrial fertilizers in fear of their land for cultivation being ruined off. The adoption rate was also stimulated by PADEP projects were some farmers groups were supported with improved seed.

Furthermore Table 4 indicates that potatoes growers have used local seed by 100%, farm yard manure by 53.8% and 46% in the up and down stream respectively. Industrial fertilizers were not used for potatoes production in study area. The study assumes that potatoes can be produced with less capital inputs thus even less capital farmers can produce potatoes. Table 4 further shows the inputs used in the production of common beans where local seed by 100%, the crop share others inputs with the main intercropped crops. The study assumes that common beans can be produced with less capital inputs thus even less capital farmers can produce the crop.

4.3.3 Water requirement for crop production and crops yield in the study area

Table 5 result shows that in the up stream garlic mature after 5 months and has frequently irrigated at an average of 10.2 times among the required 12 times. In the down stream the garlic matures at an average of 4.7 months, and an average irrigation was 7.2 times among required 12. According to Gajete (2004), garlic need to be irrigated 8 -10 times with sandy loam soil, the frequent irrigation has effect on final yield. Moreover, the result in table 7 shows yield obtained from garlic, whereby 32% of respondents have fall to minimum yield of 2.8 t/ha while 14% respondents have achieved maximum yield of 10t/ha. The average yield was 3.8 t/ha achieved by 54% of respondents in the up stream.

Table 5: Water requirement for crop production and crops yield in the study area

Scheme	Description	Garlic	Onion	Maize	Potatoes	Beans
Upstream	Maturity (Months)	5.0	5.5	4.33	4.5	3.0
	Frequent irrigation	10.2	10.2	3.3	3	3.3
	Require irrigation	12.0	12.0	4.0	4.0	4.0
	Minimum yield (t/ha)	2.8(32)	7(34)	2.5(19)	2.5(21)	0.2(21)
	Maximum yield (t/ha)	10(14)	18.5(17)	5.5(31)	11(26)	0.75(16)
	Mean yield(t/ha)	3.8(54)	8.5(49)	3.5(48)	4.95(53)	0.5(63)
Down stream	Maturity (Months)	4.7	5.0	4.0	4.3	3.0
	Frequent irrigation	7.2	7.5	1.9	1.8	1.9
	Require irrigation	11.75	11.2	4.0	4.22	4.0
	Minimum yield (t/ha)	1.65(16)	5.5(32)	1(17)	2.75(41)	0.15(38)
	Maximum yield(t/ha)	6(23)	13(21)	4.5(32)	12.75(11)	0.5(11)
	Mean yield (t/ha)	2.25 (61)	7.75(47)	2.5(51)	6.(52)	0.25(51)

Note: Figures in parenthesis are percentages

In the downstream the minimum yield was 1.65 t/ha gained by 16% of the respondents, and the maximum yield was 6 t/ha gained by 23% respondents. The average yield was 2.25 t/ha gained by 61% of the respondents. This result indicates that the main line for garlic yield is water as the up stream achieved to irrigate garlic farms at average of 10.2 times and get yield of 10 t/ha while at downstream have irrigated garlic farms at average of 7.2 and fall to the maximum yield of 6 t/ha. The study conducted by Hickey (2006) in Australia revealed that the average yield range from 6-8 t/ha which is equivalent to yield obtained in the up stream but higher than the yield obtained in the downstream.

Moreover, Table 5 shows that the onions mature within 5 – 5.5 months in the study area. Through its maturity it requires frequent irrigation according to the soil type. Onion need about 11 up to 12 numbers of irrigation frequencies. In the upstream an average of 10.2 number of irrigation has been achieved while in the downstream 7.6 number of irrigation have achieved. Furthermore, the result presented in Table 5 shows that the minimum yield for onion was 7 t/ha which was attained by 34% of respondents, the maximum yield was 18.5 t/ha achieved by 17% of respondents, while the mean yield was 8.5 t/ha gained by 49% of the respondents in the upstream. In the downstream, the minimum yield was 5.5t/ha gained by 32% of respondents and the maximum was 13 t/ha achieved by 21% and the mean yield obtained was 7.75 t/ha obtained by 47% of respondents.

The study assumes that water is main determinant for onion yield. the opportunity of accessing at least 10.2 frequent irrigation in the up stream resulted in maximum yield of 18.5t/ha, while in the down stream have managed to irrigate onion farms at an average of 7.6 times and thus fall to maximum onion yield of 13 t/ha. FAO (2000) statistics show that the average yield of onion in the country is about 2.9 t/ha while the world’s average stands

at 17.7 t/ha. The study conducted by Peji *et al*. (2008) in Serbia revealed that under irrigation the maximum yield of onion was 34.99 t/ha.

Likewise, Table 5 indicates that the average maturity for maize is 4 months that could requires at least not less than four times irrigation. Upstream have achieved 3.3 times irrigating while at down stream only an average of 1.9 frequencies achieved. Moreover, Table 5 shows that the mean yield of maize was 3.5 t/ha. The minimum was 2.5 t/ha, and the maximum yield was 5.5 t/ha attained by 48%, 19%, and 31% of respondents respectively in the up stream. In the downstream the yield ranges from 1 t/ha to 4.5 t/ha, whiles the mean yield stand at 2.5 t/ha, these have attained by 17%, 32% and 51% of the respondents, respectively. The study revealed that high yield of maize obtained in the upstream is influenced by the water availability. According to Kaliba e*t al*. (1998), the average yield for maize obtained at central Tanzania range from 4.25 t/ha (composite varieties) to 6 – 8 t/ha high yielding hybrid (e.g. H 6302). This is higher than the yield obtained in the study area.

Result from Table 5 shows that potatoes mature between 4.5 up to 5 months and it requires at least four times numbers of irrigation to attain its maturity. In the up stream the average number of irrigation achieved was three times while at down stream was only 1.8. Furthermore, Table 5 shows that the minimum yield for potato in the up-stream was 2.5 t/ha attained by 21% respondents and the maximum yield was 11 t/ha achieved by 26% respondents, and the mean yield was 4.95 t/ha obtained by 53% of respondents.

On the other hand, at down stream the minimum yield was 2.75 t/ha and maximum yield was 12.75 t/ha, the average yield being 6 t/ha attained by 41%, 11%, and 52% respondents respectively. This implies that potatoes are less water required crop thus it has performed

well in the down stream compared to the yield obtained in the up stream. Yield of potato has been reported to vary with soil moisture available and management levels. According to Okoboi (2001), the yield of potatoes in Uganda varies from 4.78 t/ha at Kisora District to 15.85 t/ha in Kabale District which is higher than yield obtained in study area.

Table 5 result shows the common beans matures at three months. In the up stream it has been irrigated at an average of 3.3 frequencies and 1.9 in the down stream. The yield for beans varied from 0.2 t/ha to 0.75 t/ha with the mean yield of 0.5 t/ha, gained by 21%, 16% and 63% of respondents respectively. While in the down stream the average minimum yield was 0.15 t/ha obtained by 38% of respondents, and the maximum was 0.5t/ha achieved by 11% of respondents, while the mean yield obtained was 0.25t/ha which was obtained by 51% of respondents. The study assumes that the common bean is a crop which is very sensitive to the moisture and hence the limited irrigation has affected the yield in the down stream of the Bashay schemes.

4.4 Profit Levels for Major Crops under Different Scenario in Study Area

Farmers in Bashay irrigation schemes grow various food and cash crops. For the purpose of this study, five major crop enterprises; garlic, onion, maize, potatoes, and beans were selected. Tables 6 and 7 show the estimated costs of production, which included land clearance, ploughing, harrowing, seedbed making, seeds, planting, weeding, irrigation, fertilizers, agrochemicals, irrigation, harvesting and preservation for each crop. They also show total revenue obtained through multiplication of quantity of yield by the prevailing market price, and calculating GM by deducting the Total Variable Cost (TVC) from Total Revenue (TR). This GMA can be used by farmers as a guide in selecting profitable crops to be produced in study area.

4.4.1 Gross margin for major crops produced in the Up-stream

The results in Table 6 show that TVC incurred in garlic production was at TZS 2 335 315 per ha, TR was TZS 5 023 230 per ha, and the GM was TZS 2 687 915 per ha. The NSW-Agriculture farm enterprise budget found that the yield of garlic in Australia range from 6 to 10 tones per ha. The TVC was $ 20 030.87/ha and the GM was $ 3,169.14/ha but this GM is higher than that obtained in this study. Furthermore, the results depict that TVC incurred in onion production was at TZS 1 296 990 per ha, the TR was TZS 2 975 000 per ha, therefore, the GM was TZS 1 678 010 per ha. Likewise Table 6 result revealed that TVC incurred in maize production was TZS 383 890 per ha, the TR was TZS 740 127.5 per ha, therefore, the GM was TZS 356 237.5 per ha. In a similar study by Bagamba *et al.* (2008) maize GM in south Uganda was Ush 601 700 per hectare. This GM looks slightly higher than the present GM obtained in the upper stream of the Bashay irrigation scheme.

Moreover Table 6 result show that the TVC incurred in potato production was TZS 153 382.5/ha, the TR was TZS 536 695/ha, and the GM was TZS 383 312.5/ha. The study by Kabira (2002) in Kenya revealed that the Irish potatoes (Tigoni variety) yielded 1700 kg per hectare and gives GM KES 156 910 per hectare, which is relatively higher than the data obtained in this study. Moreover, the results show that the TVC incurred in beans production was TZS 115 527 per ha, the TR was TZS 411 237 per ha, and the GM was TZS 295 710 per ha.

Table 6: Gross margin for major selected crops produced in the Upstream / hectare

Activity	Garlic N=44	Onion N=13	Maize N=45	Potatoes N=17	Beans N=45
Land clearance	12000	1250	0	2277.5	0
Ploughing	75000	76175	30768	19022.5	0
Harrowing	62500	59625	0	7575	0
Ridges	95000	102500	0	595	0
Cost for seed	994750	143218	75000	51258	37500
Planting	93750	95545	51312	14950	45000
Weeding	380000	252352	100148	23737	0
Cost for irrigation	122185	13193	23615	10595	0
Cost of Minjingu fertilizer	5700	14332	0	0	0
Cost of Urea fertilizer	25250	68125	0	0	0
Cost of manure	204323	104200	8120	13985	0
Cost of pesticide	17287	81875	0	0	0
Cost of fungicide	40340	42500	0	0	0
Cost of booster	6525	4803	0	0	0
Cost of harvesting	98845	96050	51682	7030	19500
Cost of transportation	38425	10022	29627	2060	11250
Cost of preservation	0	0	9325	0	0
Cost of storage	11390	49550	4293	297.5	0
Trimming cost/shelling	52045	81675	0	0	2277
Total Variable Cost	2 335 315	1 296 990	383 890	153 382	115 527
Total Revenue	5 023 230	2 975 000	740 127	536 695	411 237
Gross Margin	2 687 915	1 678 010	356 237	383 313	295 710

From the results of this study, garlic attained the highest GM of 2 687 915 TZS per ha. This confirms garlic to be granted as the most profitable crop enterprise in the up-stream of the Bashay irrigation scheme. Other crops in the order of decreasing GM was onion> potatoes> Maize> beans (Table 8).

Fig. 4 presents in summary relationship between the TVC, TR, and GM. It revealed that garlic and onion has high TVC (TZS 2 335 315) and (TZS 1 296 990) respectively compared to others; maize, potatoes and beans. In other words, this implies that these crops are capital intensive and demand high investment cost particularly cost of input and labour (Table 6). The TR is higher compared to TVC, this make positive GM for all

studied crops. In other words irrigation agriculture is the profitable venture that can assure farmers with sustainable food security and income. In the similar way Fig. 4 shows that potatoes and beans are the least cost intensive having low TVC, thus even farmers with low capital can produce these crops. Similarly the TR for these crops is high and therefore gives positive GM but less profitable compared to Garlic and onion.

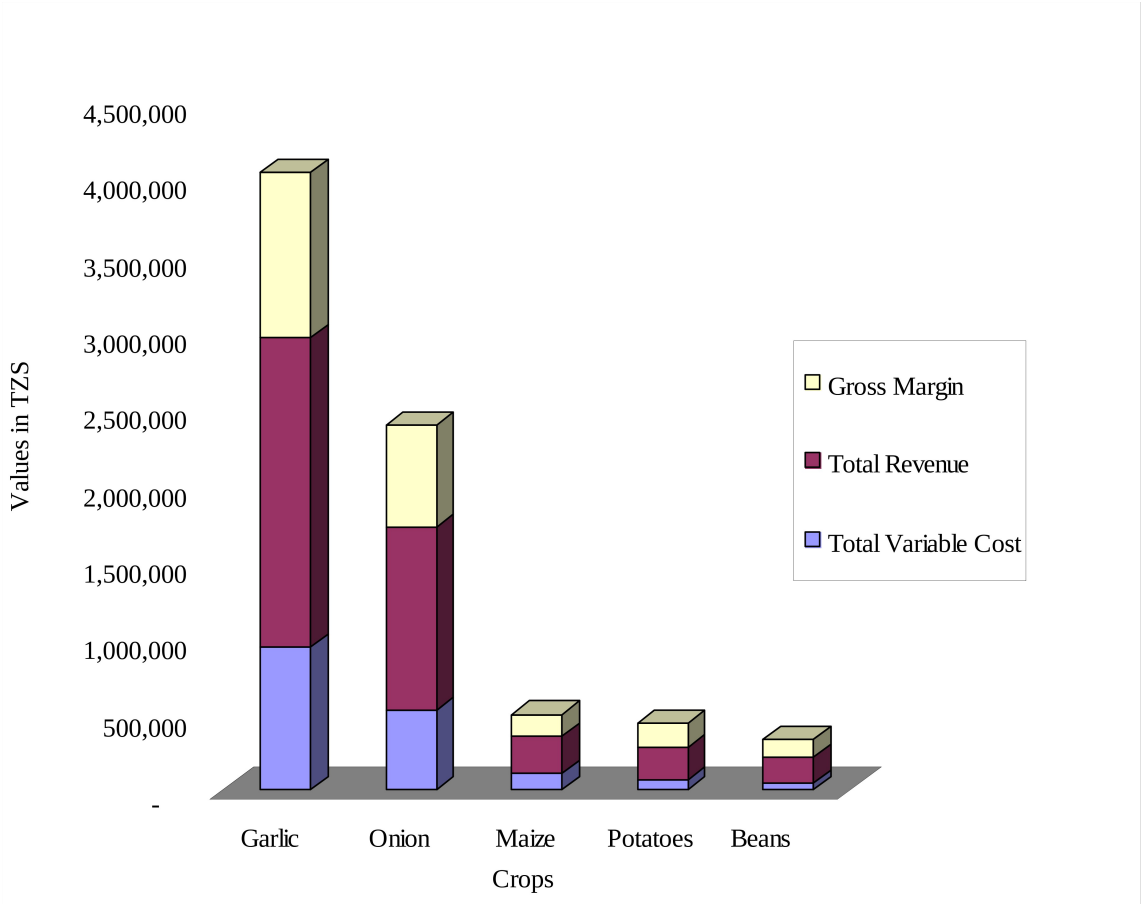

Figure 4: **Relationship between TVC, TR, and GM - Up stream**

4.4.2 Gross margin for major crops produced in Down-stream

Table 7 result indicates that in the down-stream the TVC incurred in garlic production was TZS 1 968 473/ha, the TR was TZS 4 243 473/ ha, and the GM was TZS 2 275 000 /ha. Furthermore from Table 7 the TVC incurred on onion production was TZS 474 875/ ha, TR was TZS 990 710/ha, and the GM was TZS 515 835/ha. Likewise, the TVC incurred

on maize production was TZS 240 362/ha, TR was TZS 526 220/ha, and the GM was TZS 282740/ha. These results confirm that, the GM for garlic, onion and maize in the down-stream was lower than the GM incurred in the up-stream of Bashay irrigation scheme.

Moreover the TVC incurred on potatoes production was TZS 219 760/ha, TR was TZS 502 500/ha, and the GM was TZS 282 740/ha. In addition, the TVC incurred on beans production was TZS 99 100/ha, TR was TZS 232 110/ha, and the GM was TZS 133 010/ha.

Table 7: **Gross margin for major selected crops produced in the Down-stream per hectare**

Activity	Garlic N=53	Onion N=17	Maize N=55	Potatoes N=18	Beans N=55
Land clearance	11250	14930	0	5000	0
Ploughing	69875	61262	45000	54375	0
Harrowing	57025	59618	0	0	0
Ridges	93217	44540	0	0	0
Cost for seed	867575	70105	56250	46175	38123
Planting	89435	28045	26050	48375	31250
Weeding	280995	57352	45147	43125	793
Cost for irrigation	72185	20693	8615	3125	0
Minjingu fertilizer	8750	14332	0	0	0
Urea fertilizer	30625	24085	0	0	0
Cost of manure	171821	12920	10500	10250	0
Cost of pesticide	34350	13228	0	0	0
Cost of fungicide	21250	6212	0	0	0
Cost of booster	6525	4803	0	0	0
Cost of harvesting	95625	14605	21875	6585	22125
Transportation	30925	10022	13000	2750	6138
Cost of preservation	0	0	13925	0	223
Cost of storage	0	9955	0	0	0
Trimming cost	27045	8168	0	0	448
Total Variable Cost	1 968 473	474 875	240 362	219 760	99 100
Total Revenue	4 243 473	990 710	526 220	502 500	232 110
Gross margin	2 275 000	515 835	285 858	282 740	133 010

The results in the down-stream of the irrigation scheme (Table 7) show that garlic production enterprise is more profitable than other enterprises because it yields positive GM of TZS 2 275 000/ha. The other crops after garlic were in the order onion> maize> potatoes> beans. These findings in the down-stream were more or less the same as the ones envisaged in the up-stream where garlic production was leading as a profitable enterprise and beans production being the last. In other words, the production levels of other crops investigated in this study were between garlic and beans production levels in terms of their GM (Tables 6 and 7).

Fig. 5 presents in summary relationship between the TVC, TR, and GM for the down stream. It revealed that garlic is the most capital intensive crop with high TVC followed by onion. High TVC means requisite for high capital investment to these crops. On the other hand maize, potatoes and beans have been produced with less capital. The TR were high for all crops compared to TVC thus gives the positive GM. Garlic is the leading profitable enterprises with beans the least of all studied crops in the down stream of the Bashay irrigation schemes.

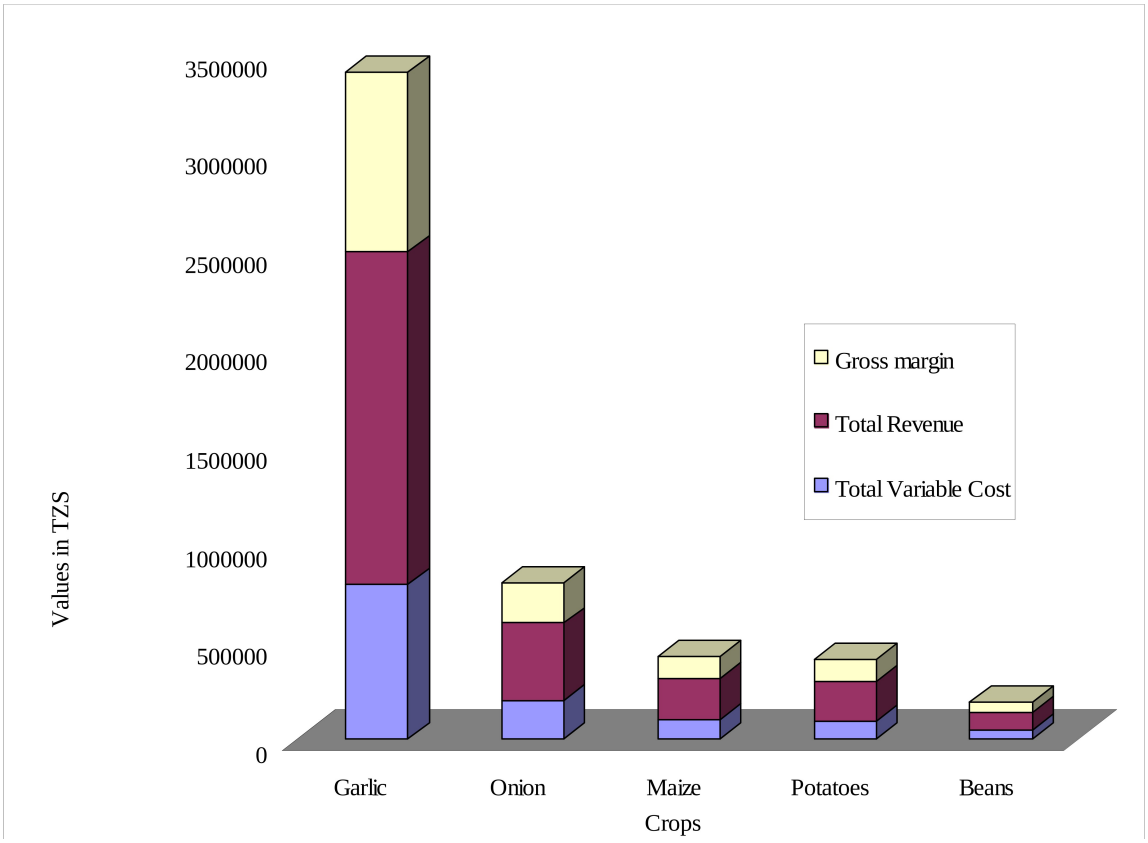

Figure 5: Relationship between TVC, TR, and GM - Down stream

4.5 Factors Influencing Crop Profitability

4.5.1 Output from the regression analysis

In assessing the relative importance of the factors reported to influence various crop production options in the Bashay irrigation scheme, an ordinary least square regression model was developed and estimated with net income per hectare being the dependent variable. The important determinants of net income in all estimations were: farm size, labour, input capital, education level of respondent, age of respondent, access to extension service (dummy) and access to credit (dummy). The model was estimated separately for the two sets of communities covering farmers in the up-stream and down-stream. These determinants are as discussed hereunder for each of the studied crops.

4.5.2 Factors influencing crop profitability in the Up- stream

A multiple linear regression model was used to estimate the factors hypothesized to influence crops profitability among small-scale irrigation farmers. Table 8 presents the results of the regression analysis.

Table 8: Factors influencing crops profitability per hectare in the Up stream of Bashay irrigation scheme

Explanatory Variables	Garlic		Onion		Maize		Potatoes	
	β –coeff.	Sig.	B –coeff.	Sig.	β –coeff.	Sig.	β –coeff.	Sig.
FZS	0.497	***	4.247	**	0.113	***	1.907	**
LBMD	0.285	*	2.973	**	0.402	*	0.417	*
CAPINP	0.325	***	2.717	*	0.445	***	0.683	**
AGE	0.029	NS	0.051	NS	0.032	NS	0.344	*
EDULEV	0.291	*	0.579	*	0.108	*	0.022	NS
EXT	0.011	NS	0.193	NS	0.043	NS	0.155	NS
CREDIT	0.342	*	0.253	*	0.63	NS	.046	NS
	R^2=.653		R^2=.968		R^2=.786		R^2=.645	
	Adj.R^2=.623		Adj.R^2=.774		Adj.R^2=.770		Adj.R^2=.537	

The *, **, *** significant at 10%, 5% and 1% probability levels, respectively.

Abbreviations for determinants: FSZ for the farm size, LBMD for the labour in man-days, CAPINP for capital for input purchases, AGE for age of respondent, EDULEV for education level of respondent, EXT for access to extension services and CREDIT for access to credit facilities.

From Table 8 the values of the coefficient of determination R^2 are 0.653, 0.968, 0.786 and 0.645 for the garlic, onion, maize and potatoes respectively. These show the existence of a high correlation between explanatory variables (independent variables) and net income per hectare (dependent variable). The means of the adjusted R^2 of 62.3%, 77.4%,77.0% and 53.7% for garlic, onion, maize and potatoes respectively show that the variation in income per hectare earned from aforementioned crops are due to fitted predictors and the remaining percentages are caused by predictors not included in the model. Furthermore

Table 8 results show that the proportion of income per hectare is positively influenced by farm size and significant ($p<0.001$) for garlic and maize, ($p<0.05$) for onion and potato. This indicates that farmers who derive high proportion of their income from irrigation put more effort on it to maximize the farm size. This also implies that there is strong association between land size and crops profitability in the up stream of Bashay irrigation schemes.

Moreover Table 8 results indicate the coefficients labour in man days was positively related with crops profitability and significant ($p<0.05$) for onion and ($p<0.10$) for garlic, maize, and potatoes. Crop production under irrigation is labour intensive as most activities are onerous and performed by hand. In study area the reliable source of labour is family labour, hence the household with greater number of labour forces is expected to increase crops output, hence increases household income from crops production.

Likewise, Table 8 result revealed that, the coefficients capital for inputs was positively related with crops profitability and significant at ($p<0.001$), for garlic and maize, ($p<0.05$) for potatoes and ($p<0.10$) for onion. The positive relationship between input capital and increase in income for crops could be attributed to the more resource invested in purchase of improved seeds, fertilizers, and agrochemicals. There is low adoption in uses of improved agricultural inputs in the study area, thus as more resources are invested in purchase of agricultural inputs, the more output is expected and hence increase in household income.

Table 8 further shows that, the coefficient age was positive, and significant at ($p<0.10$) for potatoes production while not significant for garlic, maize and onion. These results indicate that for every unit increase in age of a farmer the probability of investing resource

in potatoes production increases thus increase the household income from potatoes production. On the other hand, the variable education levels of irrigation farmers have positive relationship to crops profitability as postulated previously and statistically significant at ($p<0.10$) for garlic, onion, and maize. This suggests that literate farmers were more likely to adopt new innovation that may influence crops profitability. The plausible explanation for this is that education does influence information processing. The belief is that education gives a farmer the ability to perceive, interpret and respond to new information much faster; therefore, high level of education is expected to positively influence the decision making (Mcfalls, 2003).

Moreover, Table 8 result shows that the crops profitability in the up-stream of Bashay irrigation scheme is not influenced by extension services as hypothesized previously. Further, result shows that access to credit was statistically significant at ($p<0.10$) for garlic and onion. This indicates that as number of farmers' access to credit increases, the crops output is expected to increase since garlic and onion are capital intensive (Fig. 4).

4.5.3 Factors influencing crops profitability Down stream

The result presented in Table 9 revealed that the R^2 for garlic, onion, maize and potatoes were 0.75, 0.954, 0.815, and 0.928, respectively. This implies that there are high correlations between dependent and independent variables. The adjusted R^2 for garlic, onion, maize and potatoes were 72%, 92.1%, 78.8% and 90.6%, respectively. This implies that the variation in net income of crops profitability in the down stream has been explained by the farm size, labour in man-days, input capital, age of respondent, education level of respondent, access to extension service and access to credit.

Table 9: Factors influences crops profitability per hectare in the Down stream of Bashay irrigation schemes

Explanatory Variables	Garlic		Onion		Maize		Potatoes	
	β –coeff.	Sig.	B –coeff.	Sig.	β –coeff.	Sig.	β –coeff.	Sig.
FZS	0.675	***	1.044	***	.331	**	0.962	***
LBMD	0.571	**	1.014	**	.288	**	0.754	**
CAPINP	0.477	***	1.020	***	.439	***	0.641	*
AGE	0.018	NS	0.723	NS	.092	NS	0.120	NS
EDULEV	0.001	NS	0.066	NS	.024	NS	0.526	*
EXT	0.257	**	0.937	*	.076	NS	0.49	NS
CREDIT	0.202	*	0.047	NS	.205	**	0.029	NS
	R^2=.75		R^2=.954		R^2=.815		R^2=.928	
	Adj.R^2=.720		Adj.R^2=.921		Adj.R^2=.788		Adj.R^2=.906	

The *, **, *** significant at 10%, 5% and 1% probability levels, respectively.

The results in Table 9 show that the variable farm size was positive and highly significant at (P<0.001) for garlic, onion, potatoes, and at (P<0.05) for maize. This indicates that an increase in farm size was expected to increase crop output; therefore, as the size of the farm increases the household income is also expected to increase.

Furthermore, Table 9 results show that estimates for labour in man-days, have positive relation with crops profitability in the down stream and significant at (P<0.05). This indicates that increase in labour in man-days will influence an increase in crop output, thus, resulting in increased income per ha. Crops production under irrigation is labour intensive as such both family and hired labour is a limiting factor to achieve good and optimum yield.

The input capital was positive and significant, (P<0.001) for garlic, onion, maize and (P<0.10) for potatoes. This indicates that increased investment on inputs like improved seeds, fertilizers and agro-chemicals in crops production in the down stream will influence increased crop yield and, thus, improved household income. Similarly, age of a respondent

was positive but had no significant effect in increasing income earned by household from down stream farmers (Table 9).

The results for education level of farmers was positive and not significant for garlic, onion, and maize growers but statistically significant at (P<0.10) for potatoes growers in the down stream (Table 9). This implies that increase in the level of education to potatoes growers will increase household income gained from potatoes production. According to Carter (1984), education level has positive effects to agricultural profitability.

Furthermore Table 9 result shows that the variables, access to extension services was positive and significant at (P<0.05) for garlic and (P<0.10) for onion. The positive association with extension services implies that the increase in information dissemination will enhance increased quantity and quality of crops output that leads to high profit. The study conducted by Kiani *et al.* (2008) revealed that an extension service has positive and significant impact on crop production. Further regression output indicates that estimates credit was positive and significant (P<0.05) for maize and (P<0.10) for garlic. This could be attributed to credit facilities which enable farmers to have ability to acquire input and improve farm productivity.

4.6 Determination of Options for Profitable Crop Production in the Study Area

In determining the optimum option for profitable crop production in the study area, the Linear Programming Mathematical Model was employed using LPWYE software. All the crops studied which were garlic, onions, maize, round potatoes and beans were used. For the purpose of clarity, the developed LP Model Matrices were used.

4.6.1 Matrix for crop production options for Up-stream and Down-stream

The results for the matrices include: crop production options for Up-stream, Down-stream and combined streams from the surveyed study area. The results show that all the matrices had net profits per hectare incurred from garlic, onions, maize, round potatoes and common beans production (Table 10). The matrices also showed resource requirements and availability. These resources were land, family and hired labour, cost of seeds and fertilizer. The data for resource requirements were generated from survey data, while the data for resource availability were generated in a different technique. Land availability was calculated directly from the surveyed data as an average household land size in hectare allocated for irrigation cultivation, while computation of the availability of household family labour was based on the average household family size (six people) and the average number (57) of days required for farm operation per hectare, which finally were 345 man-days; but from the survey data the average hired labour was 172 man-days (Table 10). On the other hand, the available capital for seed and fertilizer was determined using estimated expenditure percentages from the household's net profit income from crop sales (Appendix 3).

Table 10: The linear programming matrix for crop production options for Up-stream and Down-streams of Bashay Irrigation Schemes

I. Up Stream LP Model	Crop Types						Available Resource	
	Garlic	Onions	Maize	R.Potatoes	Beans			
Net Profit (Tzs/ha)	2 687 915	1 678 010	356 237	383 313	295 710		Quantity	Unit
	Resource Requirements							
1. Land (ha)	0.4	0.4	0.4	0.4	0.4	≤	3.75	ha
2. Family Labour (mdays/ha)	225	60	97	40	40	≤	345	Mday
3. Hired Labour (mdays/ha)	102	127	55	22	25	≤	172	Mday
4. Seed Cost (Tzs/ha)	1 178 577	297 450	93 660	64 132	40 647	≤	450 000	TZS
5. Fertilizer Cost (Tzs/ha)	230 990	288 907	0	45 555	0	≤	241 250	TZS
II. Down stream LP Model								
Net Profit (Tzs per ha)	2 275 000	515 835	285 858	282 740	133 010		Quantity	Unit
	Resource Requirements							
1. Land (ha)	0.4	0.4	0.4	0.4	0.4	≤	2.25	ha
2. Family Labour (mdays/ha)	175	122	90	82	35	≤	345	Mday
3. Hired Labour (mdays/ha)	95	55	37	35	15	≤	172	Mday
4. Seed Cost (Tzs/ha)	1 241 822	218 750	61 545	104 857	39 636	≤	488 242	TZS
5. Fertilizer Cost (Tzs/ha)	187 880	175 482	71 510	48 182	0	≤	260 395	TZS

4.6.2 Optimum crop production options for the Up-stream

Taking into consideration of the limitation of land availability which was 3.75 hectares for up-stream, the optimum plan is to allocate 1.575 hectares for beans, 0.475 hectare for garlic and 1.7 hectares for onions and the plan gives net revenue of TZS 1 838 777.5 (Table 11).The sensitivity analysis results show that for beans production the net profit per hectare can change from TZS 282 932.5 to TZS 1 383 675 without affecting the optimum plan. Similarly, net profit per hectare for garlic and onions can change from TZS 2 465 712.5 to TZS 6 420 885 and TZS 1 057 507.5 to TZS 1 955 922.5, respectively. On the other hand, the optimum plans on seed, fertilizer and land are the scarce resources.

Furthermore, Table 11 results further show that for seed feasibility, availability of capital can range from TZS 275 410 to TZS 1 249 445. In addition, the feasibility for fertilizer and land ranges from TZS 78 967.5 to TZS 380 835 and 2.2 to 8.625 hectares respectively. Moreover, the sensitivity analysis shows that shadow prices for seed, fertilizer and land are TZS 3.45, TZS 8.9 and TZS 239 615, respectively. These results imply that an increase in capital by one TZS for seed will improve net income by TZS 3.45 Likewise, an increase in capital by one TZS for fertilizer will increase net revenue by TZS 8.9, and an increase of one ha for land will improve the net revenue by TZS 239 615.

Table 11: Optimum crop option for profitable crops – Up-stream

Crop	Optimum Land Allocation Plan (ha)	Lower Limit for Net Profit per ha	Present Limit for Net Profit per ha	Upper Limit for Net Profit per ha	
Beans	1.575	282 932.50	295710	1 383 675	
Garlic	0.475	2 465 712.50	2 687 915	6 420 885	
Onions	1.700	1057507.50	1 678 010	1 955 922	
Shadow prices					
Scarce Resources	Shadow Prices	Lower Limit for the Availability of Resource	Current Available Resource	Upper Limit for the Availability of Resource	Unit
Seed	3.45	275 410.00	450 000.00	1 249 445.00	TZS
Fertilizer	8.90	7 8967.50	241 250.00	380 835.00	TZS
Land	239 615.00	0.88	3.75	3.45	Ha

Net Revenue = TZS 1 838 777.5

4.6.3 Optimum crop production options for the Down stream

The crop production constraint in the down-stream based on the limitation of land availability which was 2.25 ha, and the optimum plan allocated 1.5 ha for maize and 0.75 ha for garlic; and the plan gives net revenue of TZS 1 096 045 (Table 12).

Table 12: Optimum crop option for profitable crops – Down stream

Crop	Optimum Land Allocation Plan (ha)	Lower Limit for Net Profit per ha	Present Limit for Net Profit per ha	Upper Limit for Net Profit per ha	
Maize	1.5	258 750	285 857	2 275 000	
Garlic	0.75	1 563 430	2 275 000	5 767 920	
Shadow prices					
Scarce Resources	Shadow Prices	Lower Limit for the Availability of Resource	Current Available Resource	Upper Limit for the Availability of Resource	Unit
Seed	4.2	92315	488 242.50	1 645 440	TZS
Land	182 135	0.975	2.25	8.1	TZS

Net Revenue =TZS 1 096 045

From Table 12 the results from sensitivity analysis show that for maize production net profit per ha can change from TZS 258 750 to TZS 2 275 000 without affecting the optimum plan. On the other hand, for garlic production, the net profit per hectare can change from TZS 1 563 430 to TZS 5 767 920. By examining the required resources, the results show that, the optimum plan for seed and land are the scarce resources. The results further show that, the seed feasibility for availability of capital can range from TZS 92315 to TZS 1 645 440, while for land the feasibility range is from 0.975 to 8.1 ha. Furthermore, sensitivity analysis shows that the shadow price for seed is TZS 4.2 and for land is TZS 182 135. These results imply that an increase in capital for seed by one TZS will improve net income by TZS 4.2; likewise, an increase of one hectare for land will improve the net revenue by TZS 182 135.

4.6.4 Optimum crop production options for the combined streams

In view of the limitation of land availability which averaged to 3 hectare for combined Up- and Down- streams, the optimum plan allocates 2.25 hectare for onion and 0.75 hectares for garlic production and gives net revenue of TZS 1 891 117.50 (Table 13).

Table 13: LP matrix for crop production options for the two streams combined

III. Overall LP Model	Crop Types	Available

	Garlic	Onions	Maize	Round potatoes	Beans		Resource	
Net Profit (Tzs/ha)	2 481 457	971 922	321 047	358025	195 610		Quantity	Unit
Resource Requirements								
1. Land (ha)	0.4	0.4	0.4	0.4	0.4	≤	3	ha
2. Family Labour (mdays/ha)	199.0	98.7	93.0	74.0	36.0	≤	345	Mday
3. Hired Labour (mdays/ha)	98.8	88.0	45.0	32.4	21.0	≤	172	Mday
4. Seed Cost (Tzs/ha)	1 212 782.0	248 262.0	75 636.0	91 282.0	40108.0	≤	649210	TZS
5. Fertilizer Cost (Tzs/ha)	207 638.0	218017.0	71 511.0	47 433.0	0.0	≤	346 245	TZS

From Table 14 the sensitivity analysis results show that for onion production a net profit per hectare can accrue from TZS 655 250 to TZS 2 481 458 without affecting the optimum plan. Analogously, net profit per ha for garlic can also change from TZS 971 923 to TZS 4 566 603. The results also show that for the optimum plan, seeds and land are the scarce resources; and seed feasibility range with availability of capital from TZS 372 392.50 to TZS 727 669, while land feasibility ranges from 1.35 to 4 hectares.

Table 14: Optimum crop option for profitable crops - overall

Crop	Optimum Land Allocation Plan (ha)	Lower Limit for Net Profit per ha	Present Limit for Net Profit per ha	Upper Limit for Net Profit per ha	
Onions	2.25	655 250	971 923	2 481 458	
Garlic	0.75	971 923	2481 457	4 566 603	
Shadow prices					
Scarce Resource	Shadow Prices	Lower Limit for the Availability of Resource	Current Available Resource	Upper Limit for the Availability of Resource	Unit
Seed	3.9	372 392.50	64 9210	1 819 173	TZS
Land	583 375	1.35	3	4	Ha

Net Revenue =TZS 1 891 117.5

The result presented in Table 14 shows that from the sensitivity analysis the shadow prices for seed and land are TZS 3.9 and TZS 583 375, respectively. This implies that for 1.0 TZS used in seed as capital will increase net income by TZS 3.9. Likewise, an increase of land by one hectare will increase the net revenue by TZS 583 375.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

This study was centred on determination of profitable crop production option using linear programming analysis. The empirical result is expected to guide the farmers and other stakeholders on optimizing crop production at Bashay irrigation scheme through efficient uses of scarce water resource and the limited land for cultivation.

5.1.1 Production options for major selected crops in the study area

Qualitative analysis on production options for the selected crops shows that the major crops cultivated in Bashay irrigation schemes include: garlic, maize, beans, onion and potatoes. According to farmers' preference, crop production priorities has ranked crops in the order garlic> maize> beans> potatoes> onion. The farming system is characterised by small-scale holders, whereby the majority (68%) own farms size ranging from 0.1 to 0.4 ha. The common cropping patterns are both intercropping and monocropping.

5.1.2 Profit levels for the selected crops under different scenario in the study area

It was hypothesized that Profit level for major crops produced under different scenario are the same in the study area. The result from GMA indicates that the GM of all the studied crops gives positives returns per hectare. In the upstream garlic give the highest GM of 2 687 915 TZS per ha. This shows garlic to be the most profitable crop enterprise. Other crops in the order of decreasing GM were onion> potatoes> Maize> beans with GM of 1 678 010, 383 313, 356 237, 295 710 respectively. In the downstream garlic attained positive GM of TZS 2 275 000 per ha. The other crops after garlic were in the order onion >maize> potatoes> beans with GM of 515 835, 285 858, 282 740, and 133 010

respectively. Hence the result confirmed for all the studied crops the GM at upstream is high than the GM at down stream. Hence the null hypothesis was rejected.

5.1.3 Factors influencing crop profitability per area in the study area

It was hypothesized that the key factors such as farm size, labour, cost of inputs, education level of respondent, access to credit and extension services has no influence on crops profitability. According to multiple regression analysis, the output result shows that: farm size, labour, and input capital are the major determinants of net income for all studied crops and are statistically significant at $P<0.05$. Hence reject null hypothesis. On the other hand, education level of farmers was found to influence profitability of onion and maize in up-stream and potatoes in the down-stream. Furthermore, access to credit influences profitability for onion, garlic, and maize in the up-stream and potatoes in the down-stream.

5.1.4 Collate options for profitable crop production to be adopted in the study area

The results from linear programming aiming at determining the profitable crop production option revealed that in the up-stream garlic, onion and beans fall in the final optimum plan with maximum value of net revenue of TZS 1 838 778.5 In the down-stream, maize and garlic fall in the final plan with maximum value of net revenue of TZS 1 096 045. Generally, for the Bashay irrigation scheme (combined up- and down- streams) the crops which fall in the final plan were garlic and onion with maximum value of net revenue of TZS 1 891 117.5 Garlic was confirmed the most profitable crop in all scenarios. However, the challenges in garlic production include: high water requirement, labour intensive, high input capital, and requirement for large farm size.

5.2 Recommendations

Based on the findings and conclusions drawn from the study, the following measures are recommended:

i. In order to maximize crop profitability in the Bashay irrigation schemes, garlic, onion, and beans are the best option crops to be adopted by the upstream farmers considering the constraints of land, labour, water and financial resources. On the other hand, garlic and maize are the best option crops on which farmers will maximize profitability on efficient use of available water for irrigation in the downstream. Nevertheless, generally, garlic and onion are the most profitable crops in the Bashay irrigation schemes, and takes the best option crops to be adopted, which will grant farmers with high profit.
ii. Round potatoes can also be adopted in the irrigation scheme because the crop requires less production resources, although it generates low profit.
iii. More efforts by government and other stakeholders should be vested in production of the most profitable crops as a way of reducing poverty and improve food security as a national strategy toward achieving Millennium Development Goals. Government should extend provision of subsidies to the most profitable crops not to maize crops only.
iv. The water users association (WUA) should be strengthened for sustainability of irrigation infrastructures and efficient irrigation water management which will suppress the cases of conflicts and corruption associate with irrigation water.
v. The approach of determining the most profitable crops is very useful and should be adopted by agriculture extension officers to make the irrigation water which is the scarce resources be of high value production.

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APPENDICES

Appendix 1: Mangisa Dam

Appendix 2: A household survey questionnaire

SECTION A.: BASIC INFORMATION.

Questionnaire No …….date of interview……Name of village…… ward ……District…….
Interviewer's name ……

SECTION B. HOUSEHOLD INFORMATION.

1. Name of respondent……
2. Age of respondent ……
3. Gender …….1= male,( ) 2= female ( )
4. Relation to head of household: 01= Head of household ( ), 02= wife/husband of head of household ( ), 03 = Son/daughter ( ), 04= others specified ( ).
5. Marital status: 01= Never married ( ), 02 =Married ( ), 03= Divorced ( ), 04 =Widowed ( ). 05= separates ( ).
6. Level of education: 01= none ( ), 02= Primary education ( ), 03 =Secondary education ( ), 04 = above secondary education ( ).
7. What is the size of the household……..
8. What is your main occupation?
   Farmer =01 ( ), officially employed=02 ( ), casual labor =03
   Business (specified) = 04, others (specified) = 05 ( )
9. What is your major source of income? : 01 Sales of food crop ( ), 02 Sales of cash crop ( ), 03 sales of livestock and its products ( ), 04 wage employment ( ), 05 off-farm income generating activities ( ), 06 others ( ) specified……

SECTION C. ECONOMIC ACTIVITY

7. What is your major source of income? 01= Sales of food crop ( ), 02 =Sales of cash crop ( ), 03 =sales of livestock and its products ( ), 04 wage employment ( ), 05=off-farm income generating activities ( ), 06 others ( ) specified……
8. What is your main occupation?

01=Farmer ( ), 02=officially employed ( ), 03= casual labour ( ), 04=Business ( ), 05= others (specified) ( ).

SECTION D: IDENTIFICATION OF CROPS GROWN IN THE SCHEMES

10. What are the main crops you grow last season? Rank by order of importance

Crops	Rank in order of importance	Area (ha)	Grown as	
			1st crop	2nd crop
01				
02				
03				
04				
05				

SECTION E.
KEY FACTORS INFLUENCE PRODUCTIVITY

(i)**Land availability, use**, **and tenure**

11. What is the total area under irrigation cultivated by the family last season?
    .....acres.
12. List down the total agricultural land under irrigation used per crop by family last season.

.

s/n	Name of land /plot	Crop grown	Total area(ha)	Total yield (kg)	Category of ownership
Total					

Key for ownership- 01 hired, 02 under customary law, 03 long time lease under land ordinance, 04 allocated by village government. 05 Bought, 06 others specify.

13. If the land is not owned by the family what is the cost of hiring? .....Tsh/acre.

(ii). Labour availability and use

14. What was the source of labour last season? 01= family labour ( ), 02= hired labour ( ), 03= both ( )
15. If family labour were used, give the number, age and sex of household members and who were available for the farm activity in last season.

Age group	Male	Female	Available household members for farm work	
			Part time	Full time
Below 15 years				
15-18 years				
19-50 years				
Above 50 years				

16. What was the total labour used in crops production last season

CROP	ACTIVITY	LABOUR AVAILABILITY			
		family labour (manday)		Hired labour (manday)	
		Female	Male	Female	Male

(iii) Water resource availability and management

17. What are the sources of water for irrigation? 01= River ( ), 02=charcoal dam, 03= others specify ( )

18. Is the water for irrigation available throughout the cropping season? 01= YES, 02=NO

19. How many times you irrigate your crop last season? Indicate per each crop

Type of crops	Crop maturity (months)	Achieved irrigation (Numbers)	Required irrigation (numbers)

20. Is there any schedule for irrigation? 01=YES, 02=NO
21. If yes who co-ordinate the schedule for irrigation is? 01 =Water Users Association, 02= scheme leadership, 03=traditional canals leadership ( ), political leader ( ), 04= others specify ( ) ……
22. Is there any charges paid for irrigation water? 01= YES, 02= NO
23. If yes how does water for irrigation is charged?..... TZS
24. Are there any problems with irrigation water in your scheme 01=YES, 02=NO
25. If yes mention them.

……
……

(iv) Agriculture inputs availability

26. Did you use any agricultural inputs in the last season? 01= yes ( ), 02= no ( )
27. If yes indicate type, amount and price of agricultural inputs you used in crop production last season in question 36
28. If no why didn't you use agriculture inputs in the last season?
    01. Expensive ( ), 02 not available ( ), 03 others ( ) specify……

(v) Extension service availability

29. Do you access extension service? 1= YES, 2=NO
30. If yes how many times do the extension officers visit you last season? 01= once ( ), 02 one to two times per month. ( ), 03= several times in the last season ( ), 04= never Visited ( ).
31. Please mention particularly what type of advice you get from extension officer lasts season.… ……...
32. If no why? 01= remote, 02=no research center in the area, 03= no transport, other specify ……

(vi)Accesses to credit

33. Did you access credit last season 01=YES 02= N0
34. If yes explain how did you used in farming last season?

……

SECTION F.CROP PRODUCTION COST AND YIELD

34. What is the cost of production for the main crops?

Activities	Types of crops grown per household											
	Crop 1……			Crop 2……			Crop 3…….			Crop 4…….		
Activities	**Quantity (Q)**	**Price per unit (Tsh)**	**Total cost (Tsh)**	**quantity**	**Price per unit(Tsh)**	**Total cost (Tsh)**	**Quantity (Q)**	**Price per unit (Tsh)**	**Total cost (Tsh**	**Quantity (Q)**	**Price per unit (Tsh)**	**Total cost (Tsh**
Acreage (Plot) ……												
Land clearance												
Plowing												
Harrowing/												
ridges making												
Seeds												
Planting												
Weeding 1st 2nd 3rd												
Cost of Irrigation												
FERTILIZERS ; Minjingu												
- UREA/CAN												
farm yard manure												
Pesticides												
fungicide												
Harvesting												
Transportation												
Preservation												
Storage												
Other cost-mention												
Other cost-mention												
Total variable cost (Tsh)												
Total yield in kg ……..												
Revenue												

SECTION G: FARM IMPLEMENT USED AND COST

36. What kind of farm machinery/tool/equipment did you used in cropping last season?

Implement	number	own	Hired	Borrowed	Acquisition	
					Original price	Years
Tractor						
Ox-plough						
Power tiller						
Knapsack sprayer						
Hand hoe						
Forked hoe						
Panga						
Ox- cart						
Bicycle						
Truck						
Others mention (1)						
(2)						
(3)						

Appendix 3: Output of LP analysis up stream

Evolution of the optimal plan for: Profitable Crop LP Project - Upper stream

****

Iteration number	Incoming variable	Outgoing variable	Pivot value	Net Revenue
1	GARLIC	SEED	%471431.00	0.00
2	ONIONS	FERTILZ	%92244.05	410515.81
3	BEANS	LAND	0.99	675895.39

- - Optimum solution found after 3 Iterations - -

- - Maximum value of Net Revenue = 735511.234 - -

The Plan : N.R. range for which each activity level stays constant

********** (with the incoming variable)

	Level	Lower limit N.R.	Present	Upper limit N.R.
Beans	Tzs	0.627	113173.516(maize)	118284.000
Garlic	Tzs	0.187	986285.560(maize)	%1075166.000
Onions	Tzs	0.685	423003.840(r.potato)	671204.000

			553470.250(fertilz)	
			%2568354.500(fertilz)	
			782369.940(maize)	

Activities not in optimal plan

****

		Present N.R.	N.R. needed before entry
Maize	Tzs	142495.000	147547.251
R.potato	Tzs	153325.000	196080.201

Binding constraints Resource supply range over which the M.V.P. is constant

********** (with the outgoing variable)

		M.V.P. $/unit	Lower limit	Present Level	Upper limit
SEED	TSHS	1.380	110164.883(GARLIC)	180000.000	499778.090(ONIONS)
FERTILZ	TSHS	3.558	31587.797(ONIONS)	96500.000	152334.969(HLABOUR)
LAND	ACRE	95846.311	0.878(BEANS)	1.500	3.448(HLABOUR)

Slack constraints

****

	Lower limit	Surplus	Upper limit	Surplus
FLABOUR	MDAY		138.000	94.810
HLABOUR	MDAY		69.000	19.991

Appendix 4: Output of LP analysis down stream

Evolution of the optimal plan for: PROFITABLE CROP LP MODEL - LOWER

****

Iteration number	Incoming variable	Outgoing variable	Pivot value	Net Revenue
1	GARLIC	SEED	%496729.24	0.00
2	MAIZE	LAND	0.95	357780.97

- - Optimum solution found after 2 Iterations - -

- - Maximum value of Net Revenue = 438418.434 - -

The Plan : N.R. range for which each activity level stays constant

********** (with the incoming variable)

	Level	Lower limit N.R.	Present	Upper limit
MAIZE	TZS 0.601035000.297	(RPOTATO)	114343.000910000.000	(SEED)
GARLIC	TZS 0.302625372.880	(RPOTATO	10000.000%2307168.800	(LAND)

Activities not in optimal plan

****

	Present N.R.	N.R. needed before entry
ONIONS	TZS 106334.000	220319.324
RPOTATO	TZS 133096.000	143540.817
BEANS	TZS 38204.000	99572.467

Binding constraints Resource supply range over which the M.V.P. is constant

********** (with the outgoing variable)

	M.V.P. $/unit	Lower limit	Present Level	Upper limit
SEED	TZS1.685	36926.766(GARLIC)	195297.000	658176.250(FERTILZ)
LAND	ACRE 72854.155	0.393(MAIZE)	0.900	3.243(FERTILZ)

Slack constraints

****

	Lower limit	Surplus	Upper limit	Surplus
FLABOUR	MDAY		138.000	72.341
HLABOUR	MDAY		69.000	38.702
FERTILZ	TSHS		104158.000	45637.019

Appendix 5: Output of LP analysis overall

Evolution of the optimal plan for: PROFITABLE CROP LP MODEL - OVERALL

****

Iteration number	Incoming variable	Outgoing variable	Pivot value	Net Revenue
1	GARLIC	SEED	%485112.79	0.00
2	ONIONS	LAND	0.80	531336.24

- - Optimum solution found after 2 Iterations - -

- - Maximum value of Net Revenue = 756447.834 - -

The Plan : N.R. range for which each activity level stays constant

********** (with the incoming variable)

		Level	Lower limit	Present N.R.	Upper limit
ONIONS	TZS	0.903	262100.062(RPOTATO)	388769.000	992583.310(SEED)
GARLIC	TZS	0.297	388769.000(SEED)	992583.310	%1827641.000(BEANS)

Activities not in optimal plan

****

		Present N.R.	N.R. needed before entry
MAIZE	TZS	128419.000	280700.431
RPOTATO	TZS	143210.500	290495.405
BEANS	TZS	78244.000	258458.982

Binding constraints Resource supply range over which the M.V.P. is constant

********** (with the outgoing variable)

		M.V.P. $/unit	Lower limit	Present Level	Upper limit
SEED	TZS	1.565	148957.375(GARLIC)	259684.000	727669.190(ONIONS)
LAND	ACRE	233350.366	0.535(ONIONS)	1.200	1.601(FERTILIZER)

Slack constraints

****

	Lower limit	Surplus	Upper limit	Surplus
FLABOUR MDAY			138.000	67.650
HLABOUR MDAY			69.000	15.045
FERTILZ TSHS			138498.000	8879.125

Appendix 6: Estimation of man days per acre

Household size	6
Operations	No of days
Land preparation	4
Planting	2
Weeding	4
Irrigation	10
Harvesting Transport	1
Processing+Storage	2
TOTAL	23

Average profit	Up stream	2,160,474.67
	down stream	1,301,977.00
	Overall	1,731,225.83

2. Estimation of capital for		Up stream	Down stream	overall
Sc hool fees	20.00%	432,095	260,395	346,245
Medical services	7.50%	162,036	97,648	129,842
Clothing	9.50%	205,245	123,688	164,466
Food supplem.	20.00%	432,095	260,395	346,245
Hired labour	10.00%	216,047	130,198	173,123
Seed	15.00%	324,071	195,297	259,684
Fertilizer	8.00%	172,838	104,158	138,498
Others	10.00%	216,047	130,198	173,123
Total	100.00%	2,160,475	1,301,977	1,731,226