ECONOMIC VIABILITY AND ECONOMIC IMPACT OF MKINDO IRRIGATION SCHEME IN MVOMERO DISTRICT, TANZANIA

LUGENDO PRUDENCE YAMINDINDA

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

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ABSTRACT

This study was about economics of small scale irrigation schemes funded by TASAF. The study was conducted at the Mkindo irrigation scheme in Mvomero District, Morogoro. The main objective of the study was to analyze the economic viability and determine the impact of the irrigation scheme on household income and food security. Specifically study: (i) analyzed the economic viability of the irrigation scheme; (ii) determined the impact of the irrigation scheme on household income and income distribution and (iii) determined the impact of the irrigation scheme on household food security. Data were collected using structured questionnaires administered to random samples of 80 households practicing irrigation at Mkindo and 80 households depending on rainfed agriculture at Dakawa. Cost Benefit analysis and with and without approaches were employed to determine economic viability and impact respectively. The calculated NPV, BCR and IRR values were TZS 2 396 687 745, 5.56 and 16.0% respectively. The average household income for irrigators was significantly ($p<0.005$) higher than that of non irrigators. The Gini coefficients for irrigators and non-irrigators were found to be 0.386 and 0.496 respectively. Amount of food consumed or stored from own produced food by irrigators was not significant ($p>0.005$), compared to non irrigators, the number of month which a household was able to feed themselves from own produced food was significantly ($p<0.005$) higher for irrigators than non irrigators and irrigators households were having significantly ($p<0.005$) more meals per day than non- irrigators. The regression results indicate that irrigation practice to be one of the factors significantly affects crop yield positively. These suggest that it is worthwhile for the government and development partners to support small scale irrigation schemes in the country. However the support should be accompanied by promoting use of fertilizers because they complement each other.

DECLARATION

I, Lugendo Prudence Yamindinda, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work and that to the best of my knowledge it has not been submitted to any other university for a degree award.

Lugendo Prudence Yamindinda | Date

(MSc. Candidate)

The above declaration is confirmed

Prof. N.S.Y. Mdoe | Date

(Supervisor)

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DEDICATION

This dissertation is dedicated to my father Mr. Barnabas Lugendo and my mother Mrs. Monica Yohana Lugendo, whom together laid the foundation of my education.

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LIST OF ABBREVIATIONS

AfDB	African Development Bank
AIDS	Almost Ideal Demand System
ASDP	Agricultural Sector Development Programme
ASDS	Agricultural Sector Development Strategy
BCR	Benefit Cost Ratio
BOT	Bank of Tanzania
CBA	Cost Benefit Analysis
CV	Contingent Valuation
CVM	Contingent Valuation Method
DFID	Department for International Development
DP	Development Partners
EAC	East African Community
FAO	Food and Agricultural Organization
FIVIMS	Food Insecurity and Vulnerability Information and Mapping Systems
IFAD	International Fund for Agricultural Development
IMT	Irrigation Management Transfer
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
LES	Linear Expenditure System
MKUKUTA	Mkakati wa Kukuza Uchumi na Kupunguza Umaskini
MOFEA	Ministry of Finance and Economic Affairs

NIMP	National Irrigation Master Plan
NPV	Net Present Value
NSGRP	National Strategy for Growth and reduction of poverty
PA	Performance Adequacy
PD	Performance Dependability
PE	Performance Equity
RDS	Rural Development Strategy
SAM	Social Accounting Matrix
SCGE	Simple Computational General Equilibrium Model
SCI	Structure Condition Index
SPSS	Statistical Package for Social Scientists
SWMRG	Soil Water Management Research Group
TASAF	Tanzania Social Action Fund
TFP	Total Factor Productivity
TZS	Tanzania Shillings
UNDP	United Nations Development Programme
USA	United States of America
WFP	World Food Programme
WTP	Willingness to Pay

CHAPTER ONE

INTRODUCTION

1.1 Background Information

The last century has seen unprecedented growth in irrigation projects on a global level, but much of this growth has been in the developing countries, including Tanzania. In Tanzania, the government has taken several measures to ensure the development of irrigation schemes. These measures include the formulation of the National Irrigation Policy of 2009 and National Irrigation Master Plan (NIMP) of 2002. The National Irrigation Policy of 2009 considers irrigation development in Tanzania to be critically important in ensuring that the nation attains a reliable and sustainable crop production and productivity as a move towards food security and poverty reduction.

These measures have been accompanied by government investments in irrigation projects through government budget and support from various development partners, including the World Bank, UNDP, FAO, JICA, IFAD, AfDB and others. These investments have contributed to the expansion of irrigated land which has increased from 0.264 million ha in 2006 to 0.370 million ha in 2010 (MOFEA, 2010). It is envisaged that the area under irrigation will increase from 0.370 million ha in 2010 to 1 million ha by 2015 (MOFEA, 2010). However, most of these irrigation schemes have been established without thorough analysis of their economic viability. There are costs associated with irrigation projects and expansion of irrigation which need to be weighed against the benefits. The benefits and costs of irrigation vary with the scale of the irrigation scheme and management of the resources that have accompanied its development.

This study is concerned with the analysis of economic viability and the impact of small-scale irrigation projects supported by the World Bank through the Tanzania Social Action

Fund (TASAF). TASAF was established by the government of Tanzania in 2000, with a funding facility that allows local and village governments to respond to community demands for interventions that will contribute to the attainment of specific Millennium Development Goals. Towards this endeavor, TASAF contributes to achieving the goals of Tanzania poverty reduction strategy (MKUKUTA I and II). TASAF has been implemented in phases. The first phase (TASAF-I) was implemented in 40 districts (local government authorities) in Tanzania Mainland as well as in Zanzibar since 2000 and ended in December 2004. It was financed by the World Bank, Tanzanian Government and community contributions. The second phase which commenced in 2005 covered all the districts (local government authorities) in Tanzania and ended in 2010. TASAF is now in the third phase (TASAF III) which started in 2011 and will end in 2015. This Phase is funded by the World Bank and other Development Partners (DP), including the Department for International Development (DFID) and World Food Program (WFP). Almost all the regions in the country have received some funds for irrigation schemes from TASAF. Mkindo irrigation scheme in Mvomero District is one of the small-scale irrigation schemes in Morogoro region which have been rehabilitated using funds from TASAF.

1.2 Statement of the Problem and Justification

As already pointed out, the importance of expanding irrigation cannot be overemphasized especially in areas where rainfall is increasingly becoming unreliable. Irrigation has the potential of allowing double cropping, decreasing the uncertainty of water supplied by rainfall, increasing the yields on the existing cropland and eventually, improving and ensuring food security and reliable income from agriculture. To justify investments in irrigation, the costs associated with irrigation need to be weighed against the benefits. The costs associated with irrigation will vary with the scale and management of the irrigation scheme. TASAF has supported investments in small-scale irrigation schemes in several parts of Tanzania on grounds of improving the welfare of rural people. However, there is scanty information on the economic viability and the impact of irrigation schemes on the welfare of smallholder farmers in Tanzania. Studies on economic viability include studies by Kabbiri *et al.* (2008); Denis (2008) and Germana (1993) who analyzed the economic viability of different technologies used by small farmers in farming activities in Tanzania. With regard to the impact of irrigation, Shitundu and Luvanga (1998); Cosmas and Tamilwai (2005); Mkavidanda and Kaswamila (2001) and Kadigi *et al.* (2003) have analyzed the impact of irrigation technology on food security and household income. Besides the scale of irrigation scheme, the economic viability and the impact of irrigation will likely vary from one location to another. Thus there is need for location specific studies on viability and the impact of irrigation on welfare of smallholder farmers. The study analyzed the economic viability and the impact of Mkindo irrigation smallholder scheme on household income and food security. The Mkindo smallholder irrigation scheme is found in the Mkindo Watershed in the Wami River Basin. The irrigation scheme was initiated by government of Tanzania in collaboration with JICA in 1984.

1.3 Objective of the Study

The general objective of the study was to analyze the economic viability and determine the impact of Mkindo irrigation scheme on household income and food security.

1.3.1 Specific objectives of the study

(i) To analyze the economic viability of Mkindo irrigation scheme in Mvomero district,

(ii) To determine the impact of irrigation on household income and income on distribution, and

(iii) To determine the impact of irrigation on household food security.

1.4 Research Hypotheses

(i) Investments in smallholder irrigation projects/schemes are not economically viable.

(ii) Investments in smallholder irrigation projects/schemes have no positive impact on household income and income distribution.

(iii) Investments in smallholder irrigation projects/schemes have no positive impact household food security.

1.5 Organization of Dissertation

This study is organized into five chapters including this chapter which presents the background information, problem statements, general objective, specific objectives and research hypotheses. The second chapter reviews literature relevant to the study while the third chapter presents the methodologies used to assess the extent to which the study hypotheses hold. Chapter four presents and discusses the findings of the study while the last chapter presents conclusions and recommendations based on the major findings of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Measuring Economic Viability of Investments/Projects

Various methods ranging from discounting to non-discounting methods are used to analyze the economic viability of investment projects. Discounting measures include cost-benefit ratio, net present value and internal rate of return, while non-discounting measures include payback period, rate of return, contingent valuation, Hedonic Pricing Method, Travel Cost Method, Production Factor Method and Averting Behavior Method (Hoevenagel, 1994).

Discounting measures of project's worthiness such as cost-benefit ratio, net present value and internal rate of return explicitly take into account the time value of money, based on the economic fact that money today is worth more than a promise of money in the future. Cost-benefit analysis (CBA) is a discounting measure of project worthiness which originated in the USA in 1936 and has become a world-wide tool to evaluate choices between alternative projects in decision making (Pearce *et al*., 1993). Traditionally, it is associated with government interventions and the evaluation of public policies and projects (Zerbe and Dively, 1994). It is an assessment method that quantifies the monetary value of all policy or project consequences for the society in which the program is being run (Boardman *et al.*, 2001). It is particularly useful when a choice has to be made out of several projects (selection), and when the project involves a stream of benefits and costs over time.

Despite being useful, erroneous cost-benefit analysis can result into wrong investment decisions. Arrow *et al.* (1996) points out the advantages and limitations of cost-benefit analysis. Cost-benefit analysis can be dangerous if taken literally on large issues, and on large timescales. This is because some of the largest items, such as water resources and their services are difficult to price. Cost-benefit analysis based on pricing of costs and pricing of benefits: each given a money value, and then costs and benefits are compared. If there is net loss, then one turns the project down. Otherwise one accepts it. The prices usually come from the markets but some of the most important environmental assets have no market prices (Chichilnisky, 1996b). The problem is serious because errors in prices can radically change the results: a project can turn from positive to negative, when the wrong prices are applied. When property rights are ill-defined, as they are for the most important environmental assets such as water and the atmosphere, prices can be highly inaccurate (Chichilnisky, 1994). Therefore, it is very important to make sure that, price are determined accurately in all cost-benefit analyses of projects involving some of the most important environmental resources known to humankind.

Another problem that emerges in doing cost-benefit analysis of projects across a long period of time is the issue of discount factor. Anything discounted at a rate of 3-6 per cent becomes meaningless after 50-100 years, i.e. the economic income of the entire planet shrinks down to the value of a car when so discounted (Chichilnisky, 1997). Yet some of the most important environmental problems-risks like nuclear power plants, global warming and biodiversity destruction-are only meaningful over such a timescale. Arrows *et al*. (1996) reported that, “Both economic efficiency and intergenerational equity require that benefits and costs experienced in future years be given less weight in decision-making than those experienced today”. This statement could be dangerous if taken literally; definitely it can be said to be plainly wrong. As an economist would wish to be eligible what is said here, and correct for the wrong inferences that can be drawn from this testimonial by thinking of cases where it holds true. Discounting the future is neither necessary nor sufficient for efficiency and intergenerational equity. All this could be taken into account when doing cost-benefit analysis. Therefore, policy-makers and researchers should take into account those uncertainties.

Cost- benefit method uses tools like net present value (NPV) and Internal Rate of Return (IRR) to evaluate the public project and policy. NPV of a time series of cash flows, both incoming and outgoing, is defined as the sum of the present values (PVs) of the project cash flows. NPV is a central tool in discounted cash flow analysis, and it is a standard method for using the time value of money to appraise long-term projects. Used for capital budgeting, and widely throughout economics, finance, and accounting, it measures the excess or shortfall of cash flows, in present value terms, once financing charges are met (Lin *et al.,* 2000).

The weaknesses of NPV are that, it is very sensitive to the discount rate: a small change in the discount rate causes a large change in the NPV. As the estimate of the suitable discount rate is doubtful, this makes NPV numbers much undecided. Also NPV often relies on uncertain forecasts of future cash flows. The magnitude of this problem obviously depends on how uncertain the forecasts are. One solution to both problems is to calculate a range of NPV numbers using different discount rates and forecasts, so that one can generate, for example, best, worst and median NPV numbers, or even a probability distribution for the NPV (Lin *et al.,* 2000).

The IRR is a rate of return used in capital budgeting to measure and compare the profitability of investments. In the context of savings and loans, the IRR is also called the effective interest rate. The term internal refers to the fact that its calculation does not incorporate environmental factors (e.g., the interest rate or inflation) (Bierman, 1986).

In many situations, the IRR procedure will lead to the same decision as the NPV procedure, but there are also times when the IRR may lead to different decisions from those obtained by using the net present value procedure. When the two methods lead to different decisions, the NPV method tends to give better decisions. It is sometimes possible to use the IRR method in such a way that it gives the same results as the NPV method. For this to occur, it is necessary that the rate of discount at which it is appropriate to discount future cash proceeds be the same for all future years. If the appropriate rate of interest varies from year to year, then the two procedures may not give identical answers. It is easy to use the NPV method correctly, but it is much more difficult to use the IRR method correctly (Bierman, 1986).

Despite the disadvantages, the method has been used in many development projects, especially in developing countries like Tanzania. Kabbiri *et al.* (2008); Denis (2008); Balkema *et al*. (2010); EAC (2010); Brenters and Henny (2002); Akyoo and Lazaro (2008) and Germana (1993) have used cost-benefit analysis methods to analyse the economic viability of different projects in Tanzania and Kenya. This shows that, the method is very powerful in appraisal of development projects despite its weakness.

Unlike the discounting measures, non-discounting measures of project worthiness do not explicitly consider the time value of money. In other words, each dollar earned in the future is assumed to have the same value as each dollar that was invested many years earlier. The payback period, accounting rate of return or return on investment are two examples of methods used in capital budgeting that do not involve discounting future cash amounts (Averkamp, 2011).

The Contingent Valuation Method (CVM) technique is a non-discounting hypothetical-direct valuation technique requiring the active involvement of respondents (Awad *et al.*, 2010). This method can be used to evaluate the policy option on the natural resource which can't be evaluated by pricing mechanism. The CVM develops a framework of a hypothetical market used to elicit valuations for environmental and/or public goods preference, expressed in terms of Willingness to Pay (WTP). It mainly asks people what they are willing to pay for a benefit. The technique has great flexibility that can allow valuation of a wider variety of non-market goods and services than all the indirect valuation techniques. In the meantime, the CV technique is the only approach available for estimating non-use values (Mitchell and Carson, 1989; and McConnell and Haab, 2003).

However, the method has some weaknesses. First, it does not produce valid measurements when it concerns the goods that people are not used to, and when people reject responsibility for the goods in question. If people are asked, for example, about their willingness to pay for clean soil, they may state that it is zero, because they feel the polluter should pay. Puttaswamaiah (2002); Hoevenagel (1994); Wierstra *et al.* (1996) indicate that CVM works best where it is least needed. It does not provide valid estimates when people are unfamiliar and inexperienced with the goods. Validity may be a problem, since it is very difficult to describe a natural good in such a way that all its attributes are accounted for. Puttaswamaiah (2002) observe that CVM works best for those goods resembling ordinary commodities which means that it is best suited for valuing consumption goods that people consume more as their income increases.

Also when goods are not easily commoditized, as in choices concerning entire ecosystems, CVM results are doubtful. Supporters of this argument believe that an environmental good has several properties and that compressing the values of these attributes into a single metric (such as willingness to pay) leads to an information loss. The same argument is, however, also relevant to private goods, but in that case, people seem to accept their prices as their true value. The idea behind this is that people have experience in valuing and making trade-offs for attributes of private goods, whereas they do not have any experience in valuing environmental goods. In fact, they may not even be aware of all the attributes. This situation makes people liable to construct their values heuristically on the basis of the information provided by the elicitation setting (Vatn and Bromley, 1994).

In spite of the criticisms, considerable research has established the CVM as a sound technique for estimating values for public policy decisions. Some examples of these studies are by Rendall *et al.* (1974); Bishop and Heberlein (1979); Bishop *et al.* (1983); Seller *et al.* (1986); Cameron and James, (1987); Bowker and Stoll (1988); Cameron, (1988); McConnel (1990); Balderas and Laarrnan (1990); Donaldson *et al.* (1997); Rollins (1997); Rayn (1997); Willis and Powe (1998); Hayes and Hayes (1999); Carlson and Johansson (2000); Shackley and Dixon (2000); Loomis *et al.* (2000) and Scarpa (2000); Anastasios (2006) and Bamidele *et al*. (2010). These researchers have used this method to analyse the economic viability of irrigation projects.

The choice between discounting and non-discounting measures of project worthiness depends on the nature of investment/project to be evaluated. For projects like irrigation, that take a long time period for the benefits to return the investments, discounting measures are used because of the time value of money. Therefore, based on this theory, the study used Cost-benefit approach. NPV, BCR and IRR were used to analyse the economic viability of Mkindo irrigation scheme.

2.2 Approaches and Methods for Measuring Impact of Investments/Projects

Economic impact analysis examines the effect of a policy, program, project, activity or event on the economy of a given area. Economic impact is usually measured in terms of changes in economic growth and associated changes in livelihoods improvement. The proper analysis of the impact requires a counterfactual or before and after situation of what those outcomes would have been in the absence of the intervention (World Bank, 2006). Haile (2008) argues that, “impact assessment of any development intervention is a methodologically difficult and complex task to undertake”. Ravallion (2005) and Baker, (2000) suggest that no single method should dominate the impact evaluation of any development project, but instead rigorous impact evaluations should be open-minded in the choice of methodology. According to Baker (2000) the most important thing in impact evaluations is to derive robust and meaningful close proxies or indicative estimates that are comparable between and within individuals or groups, based on the aims of a particular development intervention so that, they can examines it impact to the given area.

To achieve the process of deriving close and meaningful proxies or indicative estimates that can be compared between and within groups, two approaches namely, before and after or with and without experimental design are used (Ravallion 2005; Johnson *et al.*, 2003 and Baker 2000). In order to determine the counterfactual, it is necessary to net out the effect of the interventions from other factors. This is accomplished through the use of comparison or control groups; those who do not participate in a program or receive benefits, which are afterward compared to the treatment group or individuals who received the intervention. Control groups are selected randomly from the same population as the program participants, whereas the comparison group is more simply the group that does not receive the program under investigation. Both the comparison and control group should resemble the treatment group in every way, with the only difference between them being program participation (Baker, 2000).

Determining the counterfactual is at the core of evaluation design (Baker, 2000). This can be accomplished using several methodologies which fall into two broad categories, experimental designs (randomized), and quasi experimental designs (none randomized). According to Baker (2000), it is, however, quite tricky to net out the program impact from the counterfactual conditions which can be affected by history, selection bias, and contamination. Qualitative and participatory methods can also be used to assess the impact, with these techniques often providing critical insights into beneficiaries' perspectives, the value of programs to beneficiaries, the processes which may have affected outcomes, and a deeper interpretation of the results observed in quantitative analysis. The strengths and weaknesses of each of these methods are discussed in more detail below.

Experimental designs, also known as randomization, are generally considered the most robust of the evaluation methodologies (Baker, 2000). By randomly allocating the intervention among eligible beneficiaries, the assignment process itself creates comparable treatment and control groups that are statistically equivalent to one another, given appropriate sample sizes.

While experimental designs are considered the optimum approach to estimating the project impact, in practice there are several problems. First, randomization may be unethical due to the denial of benefits or services to otherwise eligible members of the population for the purposes of the study. An extreme example would be the denial of medical treatment which can turn out to be life-saving to some members of the population. Second, it can be politically difficult to provide an intervention to one group and not another. Third, the scope of the program may mean that there are no non-treatment groups such as with a project or policy change that is broad in scope. Examples include an adjustment loan, or programs administered at a national level. Fourth, individuals in control groups may change certain identifying characteristics during the experiment which could invalidate or contaminate the results. If, for example, people move in and out of a project area, they may move in and out of the treatment or control group. Alternatively people who were denied a program benefit may seek it through alternative sources, or those being offered a program may not take up the intervention. Fifth, it may be difficult to be assured that the assignment is truly random. An example of this might be administrators who exclude high risk applicants to achieve better results. And finally, experimental designs can be expensive and time-consuming in certain situations, particularly in the collection of new data (Baker, 2000).

Baker (2000) argues that, "with careful planning, some of these problems can be addressed in the implementation of experimental designs". One way is with the random selection of beneficiaries. This can be used to provide both a politically-transparent allocation mechanism and the basis of a sound evaluation design, as budget or information constraints often make it impossible to accurately identify and reach the most eligible beneficiaries. A second way is bringing control groups into the program at a later stage, once the evaluation has been designed and initiated. Using this technique, the random selection determines when the eligible beneficiary receives the program, not if they receive it. Finally, randomization can be applied within a sub-set of equally-eligible beneficiaries, while reaching all of the most eligible and denying benefits to the least eligible (Pradhan *et al.*, 1998). However, if this latter suggestion is implemented, one must keep in mind that the results produced from the evaluation will only be applicable to the group from which the randomly-generated sample was selected.

If it is not possible to construct treatment and comparison groups through experimental design, quasi-experimental (non-random) methods can be used to carry out an impact analysis. These techniques generate comparison groups which resemble the treatment group, at least in observed distinctiveness, through econometric methodologies which include: matching methods, double difference methods, instrumental variables methods, and reflexive comparisons. Using these techniques, the treatment and comparison groups are usually selected after the intervention using non-random methods. Therefore, statistical controls must be applied to address the differences between the treatment and comparison groups and/or sophisticated matching techniques must be used to construct a comparison group that is as similar as possible to the treatment group. In some cases, a comparison group is also chosen before the treatment though the selection is not randomized (Baker, 2000).

According to Baker (2000), the main benefit of quasi-experimental designs is that they can draw on the existing data sources and are thus often quicker and cheaper to implement, and can be performed after a program has been implemented, given sufficient existing data. The principal disadvantages of quasi-experimental techniques are as follows:

i) The reliability of the results is often reduced as the methodology is less robust statistically;

ii) The methods can be statistically complex; statistical complexity requires considerable expertise in the design of the evaluation, analysis and interpretation of the results.

iii) There is a problem of selection bias. When generating a comparison group rather than randomly assigning one, there are many factors which can affect the reliability of results (Greene, 1997).

Besides quantitative techniques, qualitative techniques are also used for carrying out impact evaluation with the target to find out impact by the reliance on something other than the counterfactual to make a causal inference (Mohr, 1995). The focus in qualitative techniques is on sympathetic processes, behaviors, and conditions as they are perceived by the individuals or groups being studied (Valadez and Bamberger, 1994). For example, qualitative methods and particularly participant observation can provide insight into the ways in which households and local communities perceive a project and how they are affected by it. Because measuring the counterfactual is at the core of impact analysis techniques, qualitative designs have generally been used in juxtaposition with other evaluation techniques. Qualitative data can also be quantified. Among the methodologies used in qualitative impact assessments are the techniques developed for rapid rural assessment which rely on participants knowledge of the conditions surrounding the project or program being evaluated, or participatory evaluations where stakeholders are involved in all stages of the evaluation, determining the objectives of the study, identifying and selecting indicators to be used, and participating in data collection and analysis (Baker, 2000).

Like any other technique, the qualitative techniques have their own advantages and disadvantages. The advantages of qualitative assessments are as follow, they are flexible, can be specifically modified to the needs of the evaluation using open-ended approaches, they can be carried out quickly using rapid techniques, and can greatly enhance the findings of an impact evaluation through providing a better understanding of the stakeholders' perceptions and priorities, and the conditions and processes which may have affected the program impact. On the other hand, the main drawbacks are the subjectivity involved in data collection, the lack of a comparison group, and the lack of statistical robustness given mainly small sample sizes making it difficult to generalize to a larger representative population (Baker, 2000).

The validity and reliability of qualitative data are very dependent on the methodological skills, sensitivity, and training of the evaluator. If field staffs are not sensitive to specific social and cultural norms and practices, and non-verbal messages, the data collected may be misinterpreted. And finally, without a comparison group, it is impracticable to determine the counterfactual and thus, causality of project impact (Baker, 2000; Mohr, 1995).

Considering the advantages and disadvantages of the various approaches and methods of impact assessment, this study adopted with and without intervention approach and used a combination of quantitative and qualitative methods to assess the impact of Mkindo irrigation scheme on household income and food security.

2.3 Impacts of Irrigation Project

Historically, irrigation originated as a method of increasing the productivity of available land and thereby expanding total agricultural production, especially in the arid and semi-arid regions of the world (Bhattarai *et al*., 2002). In addition to increasing crop production and farm and family incomes, improved irrigation access significantly contributes to rural poverty reduction through improved employment and livelihoods within a region. Indirect benefits, such as more stable rural employment as well as higher rural wage rates, help landless farm laborers obtain a significant share of the improved agricultural production.

In addition to yield improvement and intensive production practices, better irrigation infrastructure and reliable water supply also enhance uses of other inputs like fertilizers and high yielding varieties. Therefore, irrigation is important in rural poverty reduction strategy.

The irrigation induced benefits are not limited to farming households but also affect broader sectors of the economy, by providing increased opportunities to growing rural service sectors and other off-farm employment activities (Bhattarai *et al*., 2002; Lipton, 2007; Hussain, 2007). Hussain (2007) argues that, indirect irrigation benefits could be larger than direct benefits through the multiplier effect and distribution of irrigation benefits also varies widely by type of the benefit and the socio-economic status of the beneficiaries. The direct benefits generally accrue to landholders, while a significant part of the indirect benefits accrue to the landless and small farmers, positively contributing to their livelihoods. Further, the overall benefits of irrigation are large when irrigation improving interventions, investments in infrastructure, improvements in system management and service delivery to farmers, are implemented in an integrated manner. Examples of such benefits are additional employment creation for landless laborers in agro-industries, rural marketing and other off-farm activities like house construction and basic infra-structural building.

2.3.1 The impact of irrigation on household income

Improvement in access to irrigation water serves as a reliable tool to increase income, branch out livelihoods and reduce vulnerability, since irrigation water creates options for extended production across the year, increases yields and outputs, and creates employment opportunities (McCartney *et al*., 2010; Hussain *et al*., 2004; Berhanu and Peden, 2002). Nonetheless, irrigation benefits may accrue unevenly across socio-economic groups (Hussain *et al*., 2004). Therefore in analysis of irrigation impact to household income, the issue of income inequality should also be considered. These show how irrigation improves household income and distribution of the income to the society. In this study, the impact analysis framework, with and without, will be used to assess income impact and inequality between user and non-user of Mkindo irrigation scheme.

2.3.2 The impact of irrigation on food security

Food security is one of the positive impacts of irrigation. But achieving food security in its totality continues to be a challenge, not only for the developing nations, but also for the developed world (Mwaniki, 2006). The difference lies in the magnitude of the problem in terms of its severity and proportion of the population affected. But, it is well documented that irrigated land leads to increased agricultural productivity. Irrigated areas are 2.5 times more productive comparing to rain-fed agricultural areas (Stockle, 2001). Therefore irrigation has been found to be a central key part in curbing food scarcity and reducing the level of poverty, not only in Tanzania but also in many other developing countries (Mwakalila 2004; Cosmas and Tamilwai, 2005; Mkavidanda and Kaswamila, 2001; SWMRG, 2005; Shitundu and Luvanga, 1998).

The definition of food security, agreed upon at the 1996 World Food Summit is "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Food security is commonly conceptualized as resting on three pillars: availability, access, and utilization. These concepts are inherently hierarchical, with availability necessary but not sufficient to ensure access, which is in turn necessary but not sufficient for effective utilization. Availability reflects the supply side. Access reflects food demand, as mediated by cash availability, prices, and intrahousehold resource allocation. Utilization reflects whether individuals and households make good use of the food to which they have access, commonly focused on the intake of essential micronutrients. Some consider stability to be a fourth dimension of food insecurity capturing individuals' susceptibility to food insecurity due to interruptions in access, availability or utilization (Barrett *et al*., 2009).

The temporal aspect of stability links to the oft-made distinction between chronic and transitory food insecurity. Chronic food insecurity reflects a long-term lack of access to adequate food, and is typically associated with structural problems of availability, access or utilization, especially poor access due to chronic poverty. Most food insecurity is chronic (Barrett, 2002). Transitory food insecurity, by contrast, is associated with sudden and temporary disruptions. The most serious episodes of transitory food insecurity are commonly labeled "famine", typically caused by simultaneous or sequential availability, access, and humanitarian response failures.

Hence, based on the concept of food security, several approaches are employed to assess its state. The first approach is indicator-based, emphasizing the indicators focusing on food security dimensions such as food availability, food accessibility and variability, and those based on FIVIMS (Food Insecurity and Vulnerability Information and Mapping Systems). The second approach relies on the general equilibrium point of view, using the Social Accounting Matrix (SAM) and the Simple Computational General Equilibrium Model (SCGE) to make policy simulations. The third approach focuses on the econometric estimation of consumer demand by applying the Linear Expenditure System (LES) and the Almost Ideal Demand System (AIDS) to assess elasticities, nutrition related measures and welfare indicators (Jrad *et al.*, 2010).

Based on the concept of food security and the impact of irrigation on food security, this study employed the food security indicator-based approach, and these indicators are food availability and food accessibility.

2.4 Previous Irrigation Related Studies in Tanzania

Irrigation-related studies have been undertaken in different parts of the country. These include studies on management of irrigation schemes, technical and productivity efficiently, social economic impact and economic valuation of irrigation.

2.4.1 Studies on management of irrigation schemes

The issue of irrigation management has got its rules in making sure that these irrigation schemes are performing well. Some of the studies in Tanzania have addressed the issue of management and its role. Tarimo *et al.* (2010) conducted study on evaluation of water distribution systems at Igomelo irrigation scheme to assess the performance of the scheme after intervention of the Irrigation Management Transfer (IMT). Irrigation performance indicators, such as Dependability (PD), Equity (PE) and Adequacy (PA) of water supply, Conveyance efficiency and Structure Condition Index (SCI) were used to evaluate the system. It was found that all these were indicators of a system that was performing well (Magayane *et al*., 2003).

2.4.2 Studies on technical aspects of irrigation and productivity of irrigation schemes

Mahoo *et al*. (2007) conducted a study in the Ruaha River Sub-basin of the Rufiji basin to assess knowledge, attitudes and practices in measuring productivity among the stakeholders. They found that, “there is a lack of general understanding and a wide disparity in practices related to the concept of productivity of water”. The concept of productivity of water is poorly understood, with inconsistent and incomplete monitoring, reporting and auditing among the stakeholders. Policy makers, engineers and researchers define productivity in one way and smallholder farmers apply their own definitions and descriptions, to assess productivity. This results in a lack of realistic analyses of water requirements and water values in various water sectors for fostering and implementing strategies for improved water allocation. Also Magayane *et al*. (2003) conducted a study that explore how water use efficiency and productivity of irrigation systems practicing water reuse, could be related to the efficiency and productivity of individuals farms within the water reuse systems.

Two irrigation systems having a chain of three users (Top, Middle and End users) reusing the runoff from upstream farms were sampled for investigation in the Ruaha river sub-basin. It was observed that the system which consisted of farmers with lower individual efficiency and productivity resulted in lower water reuse efficiency (90%) and productivity (0.55kg/m^3). Alternatively, the system which consisted of individuals with relatively higher efficiency resulted in higher water reuse efficiency of about (93%) and productivity (0.72kg/m^3). Magayane *et al*. (2003) concluded that, “current methods of assessing irrigation efficiency and productivity of water reuse does not accurately assess key conditions inspired by the Usangu situation and which affect the irrigation efficiency and productivity of water reuse in the area”. Lastly it concluded that, “irrigation efficiency and productivity of individual farms in any water reuse system are the major contributors to high water reuse efficiency and productivity”.

2.4.3 Economic valuation of irrigation water

On the issue of economic valuation, Ngaga *et al.* (2005) conducted a study in Pangani River Basin to provide estimates of the value of water in different uses and reviewed various issues and economic tools pertaining to water resource allocation and financing mechanisms in the basin. They found that, “on the value of water in alternative uses indicated that for irrigated agriculture such as coffee, the estimated average value was about TZS. 700 – 6 000/m^3. Water was estimated to be worth TZS. 30–100/m^3 in large scale sugar production, TZS. 3 500–5 300/m^3 for greenhouse-based cut-flower production, TZS. 200–600/m^3 for small scale traditional furrow irrigation agriculture, and TZS. 600–1 400/m^3 for improved irrigation agriculture schemes and for domestic consumption were equivalent to TZS. 1500 and 1250 per m^3 in the highlands and lowlands respectively. Also Kadigi *et al.* (2003) also conducted a study on economic analysis of value of irrigated paddy in Usangu basin. They found that,” if farmer in Usangu stopped producing irrigated paddy about 576 Mm^3 of water that was currently used in irrigation or 345.6 Mm^3 traded inter-regionally as virtual water would be utilized in alternative ways, either as evaporation from seasonal swamps within the basin or made available for other uses. Also there would be shrinkage in annual paddy production of about 105 000 tonnes of paddy which is equivalent to 66 000 tonnes of rice which is equivalent to 14.4% of the total annual paddy production in Tanzania. The opportunity cost of about TZS 16.4 billion will be incurred annually and the country balance of payments will be affected by an average of US$ 15.9 million per annum.

2.4.4 Studies on socio-economic impact of irrigation schemes

Previous studies on social economic impact have addressed the issues of income and food security. Chiza (2005) argue that, “Irrigation has a multi-facetted role in contributing to food security, self-sufficiency, food production and exports. In order to achieve good returns to investment, effort must be made to change from subsistence to commercial farming. There is therefore need to expand land under irrigation while intensifying crop production. These efforts, coupled with good market arrangements, will result into increased profits from farm produce and thereby reducing poverty at both household and national levels. Mwakalila (2004) found that irrigated agriculture is, therefore, a poverty-reducing intervention in the irrigation schemes of Igurusi. Though paddy production in the area is asserted as utilizing too much of the available water resources, the same is also playing an important role in enhancing food security, income and livelihoods of the local people in the area. Cosmas and Tamilwai (2005) found that Ndiwa indigenous traditional irrigation system contributes to poverty alleviation as it enables upland farmers to produce products, especially vegetables during the dry season. This not only rescues farmers from unreliable rain-fed agriculture, but also generates higher incomes since farmers can grow high value crops more frequently. They also found that Ndiwa farmers were better off compared to non-Ndiwa farmers in their possession of material assets such as better houses, more livestock, fields, durable household items and farm implements. Other studies on social economic aspect are from Mwakalila (2004); Mkavidanda and Kaswamila (2001); Shitundu and Luvanga (1998) and Kissawike (2008).

2.4.5 Chapter summary

In summary the following can be drawn from the review of literature: Firstly, despite its weakness the BCR method has been widely used as a criterion for project worthiness in evaluation of many investment projects. For this reason, the method was adopted in the evaluation of Mkindo irrigation scheme. Secondly, the literature has shown the before and after approach to be the most appropriate approach for measuring impact of project interventions. However, this study adopted the with and without due to absence of baseline data. Lastly most of the literature has indicated that irrigation has significantly impact on agriculture productivity and hence improving household’s income and food security. But more research needs to be done especially on the viability, management and efficient use of irrigation schemes and its adverse impact on environment.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 The Study Area

The study was conducted at Mkindo farmer-managed irrigation scheme found in northern part of Mvomero District in Tanzania. It is located at latitude 6^0 16’ and 6^0 18’ South, longitude 37^0 32’and 37^0 36’east and its altitude ranges between 345 to 365 metres above sea level, about 85km from Morogoro. The average annual temperature is 24^0C with a minimum of 15.1^0C in July and a maximum of 32.1^0C in February. The mean relative humidity is 67.5% while the mean annual sunshine hours are 7.0 per day. The soils are sandy clay loam. Mvomero District is one of five districts in Morogoro region composed of 101 villages with a total population of 260 535 (Mboera *et al.,* 2007). Rainfall in the district is bimodal, with a long wet season from March to May and a short wet season from October to December. The northern area has a humid to sub-humid climate, and annual rainfall ranges from 1500 to 2000 mm (Lyimo *et al.,* 2004), while the southern part of the district is much drier, with annual rainfall between 600 mm and 1 200 mm (Karimuribo *et al.,* 2005).

The majority of the district’s population derive livelihood from crop production. Major crops grown include paddy and maize. Only the population in the southern part of the district depends primarily on pastoralist livestock keeping, raising goats and traditional zebu cattle. Apart from Mkindo scheme, there are other schemes in Mvomero District including Mhonda, Mgeta, Mlali, Mgongola, Patel, Mbigiri, Dakawa, Ndole, and Mtibwa Sugar Estate. Mkindo scheme has been selected because it is one of the schemes which have received funds from TASAF. Figure 1 below shows a map of Mkindo catchment which is found in the Wami basin, Tanzania. As indicated in the map, the Mkindo catchment in which Mkindo Irrigation Scheme is found has been labeled in black colour and the red colour shows the boundary of the area under Wami Basin.

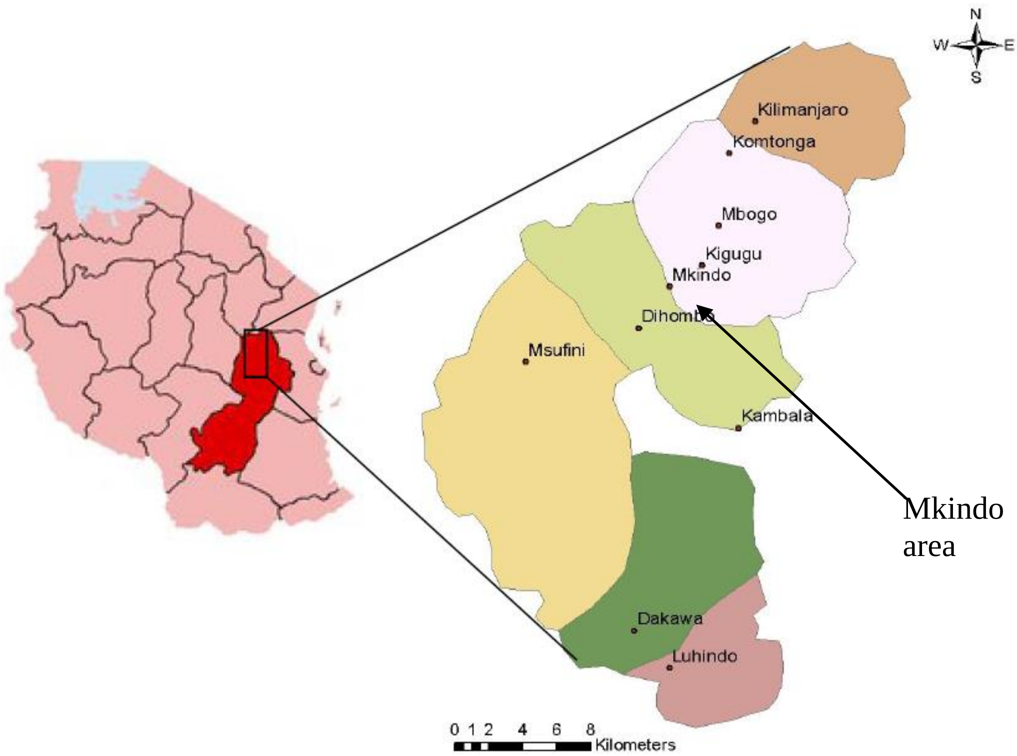

Figure 1: Map showing the Mkindo study area, Tanzania

3.3 Conceptual Framework

The purpose of investing in irrigation is to increase agricultural production and thereafter, improve the life standard of the people. However, before making decision on irrigation investment, economic viability of the project should be checked and identify whether it is economically viable. After successful investment in the irrigation project, impact assessment should be carried out in order to identify whether the project objective has been attained. This attainment can be justified by looking at variables like food security status, income distribution and household income.

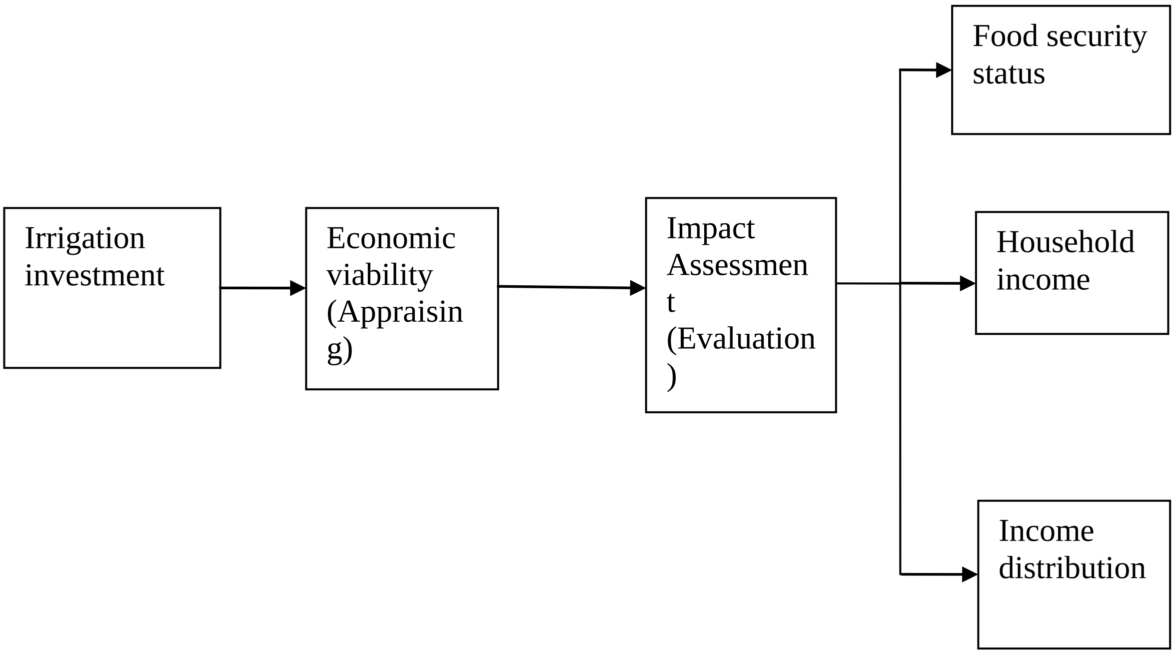

Figure 2: Conceptual framework for the study

3.4 Research Design

There are two approaches that can be used to assess the impact of adopting certain technologies like irrigation. These are before and after the introduction of the technology or with and without the use of the technology. This study employed the with and without design, which involved observations of a group of farmers practicing irrigation (with) and another group which was practicing rainfed agriculture (without), at one specific point in time. The before and after design is better compared to with and without design because it captures the spillover effects, but due to the unavailability of baseline data, with and without design was used in this study.

3.5 Data for the study

Data for the study were obtained from both secondary and primary sources as described below.

3.5.1 Secondary data

Secondary data were obtained from records kept by the former Chairman of Mkindo Farmer-Managed Irrigation Scheme, Mr. Moses Kimosa. These data include initial investment cost, number of farmers using the scheme, production costs, crop yields obtained by users of the scheme since it was in 2008/09 rehabilitated by TASAF.

3.5.2 Primary data

Primary data were collected using structured questionnaires administered to farmers selected from a list of farmers practicing irrigation at the Mkindo Irrigation Scheme and farmers practicing rainfed agriculture at Dakawa as described in the following sections.

3.5.3 Questionnaire design

Questionnaires presented as Appendices 1 and 2 were designed to obtain information required for answering the stated objectives. They were designed to capture both qualitative and quantitative data for farmers inside the scheme and those outside the scheme. They were divided into the following sections, as shown in Appendices 1 and 2.

i) Section A: General information about farmers household.

ii) Section B: Crop and livestock production activities.

iii) Section C: Irrigation practices, for irrigator questionnaire only.

iv) Section D: Resource use.

v) Section E: Impact of practicing and not practicing irrigation farming, to the lives of farmers.

3.5.4 Sampling and sample size

The target populations were farmers who were practicing irrigation farming at Mkindo Irrigation Scheme and farmers who were practicing rainfed farming at Dakawa. A sample of 80 farmers practicing irrigation was randomly selected from a sampling frame of 106 farmers practicing irrigation at the Mkindo Irrigation Scheme. The same sample size was selected from farmers practicing rainfed agriculture at Dakawa in order to make a comparison simple. The sample size of 80 farmers was determined by using the following formula:

$$N_0 = \frac{z^2 \ \delta^2}{e^2} \text{ or } N_0 = \frac{z^2 \ p(1-p)}{e^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where N_0 = sample size, Z = Z statistic for a level of confidence, at which the data are going to be tested. Z statistic (Z): For the level of confidence of 95%, which is conventional, Z value is 1.96. Investigators who want to be more confident (say 99%) about their estimates, the value of Z is set at 2.58 (Naing *et al.,* 2006). Therefore, the value of Z depends on the choice of investigator. P *or* σ = expected prevalence (proportion) or standard deviation. Expected proportion (P) is the proportion (prevalence) that, the investigators are going to estimate by the study and e = precision or error. It is suggested that 5%, e= 0.05 is the appropriate one because it gives the confidence interval of 95%, which is acceptable in social science research (Naing *et al.,* 2006**)**. However, if there is a resource limitation, investigators or researchers may use a larger e. In case of a preliminary study, investigators may use a larger e (e.g. >10%) (Naing *et al.,* 2006**)**. Using the above formula yields a sample size of 80 out of the sampling frame of 106 farmers who were practicing irrigation at the Mkindo Irrigation Scheme. The same sample size was adopted for farmers who were practicing rainfed agriculture at Dakawa, making a total sample of 160 farmers, who were interviewed for the whole study.

3.5.5 Recruitment and training of enumerators

Prior to administration of the questionnaire as described in Section 3.5.6, three enumerators with experience in data collection using questionnaires were recruited and trained. The training took one day and covered the following aspects (i) importance and objectives of the research, (ii) familiarizing the enumerators with the questionnaire to ensure common understanding of all the questions in the questionnaire, (iii) how to ask sensitive questions (iv) probing of options during the interviews, (v) how to record data and (vi) building rapport with the respondents.

3.5.6 Questionnaire administration

The questionnaires were administered by the researcher with the help of three enumerators who were already trained as indicated above. The administration of the questionnaires took 12 days, between 6 February and 17 February 2012. The questionnaires were administered using face-to-face interviews with the heads of households, and responses to the questions were recorded immediately. The questionnaire was in English but the interviews were conducted in Swahili. The enumerators were closely supervised during data collection to make sure that quality data were collected.

3.6 Data Analysis

The SPSS software version 16 was used to generate the descriptive statistics such as means, frequencies, cross tabulations, ratios, t-tests and chi squire analyses, to determine significance differences between irrigators and non-irrigators. Other analyses carried out to achieve the study objectives include discounting measures of project worthiness, Gini coefficient and regression analysis as described in the subsequent sections below.

3.6.1 Economic viability of Mkindo irrigation scheme

The budgeting technique was used to analyze the long-term economic viability of Mkindo Irrigation Scheme. The assumptions made in the analysis include: (i) Time horizon of 18 years was chosen, because irrigation projects are long-run in nature, therefore forecasting for the future years is necessary (ii) A discount rate of 12% was used according to Central Bank of Tanzania (BOT), as indicated in the "Economic Bulletin" for the quarter ending March, 2012. With these assumptions, the financial streams of revenues from crop sales and costs incurred were discounted to determine the NPV, BCR and IRR. The computation of NPV, BCR and IRR were done in Ms Excel software using built-in command. The mathematical equations underlying the computation of NPV, BCR and IRR and the criteria for accepting an investment project using each indicator worthiness are given in subsequent subsections.

3.6.1.1 Net present value

The NPV is calculated as the present value of the project's cash inflows minus the present value of the project's cash outflows. Cash inflows are the revenue obtained from selling crops obtained from the irrigation scheme and the cash outflow are the inputs cost for producing crops and initial investment cost. This relationship is expressed by the following formula:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} \qquad \text{.. (2)}$$

Whereby, NPV is the value of the net present value, B_t is the benefit at time t, C_t are costs incurred in production at time t, r is the interest rate and n is the time horizon. The project with higher positive number is the one which is selected.

3.6.1.2 Benefit-cost ratio

The benefit-cost ratio (BCR) is the ratio of all the discounted (yearly) incremental benefits and costs of a project. Thus, it expresses the benefit generated by the project per unit of cost of the project expressed in present values. The ratio was obtained by using the following formula:

$$\frac{B}{C} = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} \Big/ \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} \qquad \text{.. (3)}$$

The BCR expresses the benefit generated per unit of cost and it was interpreted as follows:

i) BCR > 1: present value of benefits exceeds the present value of costs.

ii) BCR = 1: present value of benefits equals present value of costs.

iii) BCR < 1 the present value of costs exceeds the present value of benefits.

Selection criterion: projects with a BCR of 1 or greater are economically acceptable when the costs and benefit streams were discounted at the opportunity cost of capital. The absolute value of the BCR varies depending on the discount rate chosen; the higher the discount rate, the smaller the BCR.

3.6.1.3 Net benefit per capita in the scheme

Net benefit per capita is the average benefit per person obtained within the irrigation scheme. Therefore, it involved only farmers at all farmers at the Mkindo irrigation scheme. It was calculated by taking the total sum of net benefits and dividing it by the number of farmers who were using the Mkindo Irrigation Scheme. It does not attempt to reflect the distribution of the income or wealth.

$$\boldsymbol{x} = \frac{\sum \boldsymbol{R}}{\boldsymbol{N}} \qquad \text{..} (4)$$

Where by R = Total net revenue, N= total numbers of irrigators farmers who interviewed and X= Net benefit per capita

3.6.1.4 Internal rate of return

The internal rate of return (IRR) is a rate of return used in capital budgeting to measure and compare the profitability of investments. The internal rate of return of an investment or project is the annualized effective compounded return rate or rate of return that makes the net present value of all cash flows (both positive and negative) from a particular investment equal to zero. In more specific terms, the IRR of an investment is the discount rate at which the net present value of costs (negative cash flows) of the investment equals the net present value of the benefits (positive cash flows) of the investment. The formula or IRR is as follow.

$$r_{n+1} = r_n - NPV_n\left(\frac{r_n - r_{n-1}}{NPV_n - NPV_{n-1}}\right) \qquad \text{...............................} (5)$$

Whereby, r_{n+1} = internal rate of return, r_n is considered the n^{th} approximation of the IRR.

Decision criterion

If the IRR is greater than the cost of capital, accept the project.

If the IRR is less than the cost of capital, reject the project

3.6.2 Impact of Mkindo irrigation scheme

This section is divided into four sub-sections. The first sub-section describes the method that was used to determine the impact of the irrigation scheme on income. The second sub-section describes the method used to analyze income distribution. The third sub-section describes how the impact of Mkindo Irrigation Scheme on food security was determined, while the last sub-section describes econometric analysis which captures the effect of practicing irrigation on crop yield.

3.6.2. 1 Analysis of impact of irrigation on household income

With and without design for impact analysis was used to measure the impact of irrigation on household income by comparing incomes of users of Mkindo Irrigation Scheme and non-users of the Scheme practicing rainfed agriculture at Wami Dakawa, who were not practicing irrigation farming. Their income from agriculture and other sources were compared by using t-test statistics. The unpaired, or "independent samples" t-test" method was used between the treatment group (farmers within the Mkindo Irrigation Scheme) and control group (farmers who were not practicing irrigation farming at Wami Dakawa).

$$t = \frac{x - y}{s_{xy}} \qquad \text{.. (6)}$$

The numerator equals the difference between two sample means, and the denominator, is called the standard error of difference, which equals the combined standard deviation of both samples.

3.6.2.2 Analysis of impact of irrigation on income distribution

The Gini coefficient was used to measure income distribution among the irrigators and non-irrigators in the study area. It is defined as a ratio with values between 0 and 1. The Gini coefficient is often used to measure income inequality. Here, 0 corresponds to perfect income equality (i.e. everyone has the same income) and 1 corresponds to perfect income inequality (i.e. one person has all the income, while everyone else has zero income). The Gini coefficient can also be used to measure wealth inequality. Therefore, the model was adapted to determine whether there was a difference in income distribution between irrigators at Mkindo and non-irrigators at Dakawa.

3.6.2.3 Analysis of the impact of Mkindo Irrigation Scheme on food security

The impact of irrigation on food security was determined by comparing food availability between the irrigators and non-irrigators. Food availability which reflects food supply, and the amount of own food consumed or stored and length of time able to feed themselves in the year were used as proxies for food availability. Also number of meals which household consume per day was also computed and then compared between irrigators and non irrigators respondents. T-test (amount of food and income used by household) and Chi-square (number of meals household consume per day and number of month whereby household are food secure) statistical test were carried out to determine if there is significant difference in food availability between irrigator and non irrigator respondents.

3.6.2.4 Econometric analysis of the factors influencing paddy yield

All the benefits that exist in farming were determined by the amount of the output produced. But the output produced is influenced by number of factors which need to examine their influence on the output. For this reason, the key independents variable like irrigator dummy, education dummy, labor force used and fertilizer were assessed in order to check their influence on dependent variable. Using the multiple linear regression models, the relationship between dependent variable and independent variables in the scheme was assessed. Multiple linear regression model applies to the data taken on a dependent variable *Y* and a set of *k* predictor or explanatory variables *X*1, *X*2, …, *Xk* with *i* sets of data. In matrix form, the formula was presented as follows:

$Y_i = \beta_i X_i + U$ ………………………………………………………….. (7)

Whereby Y_i represents the matrix of output and βi represents the matrix of the beta coefficients, which explain how, change in independent influence change in dependent variable. X_i is a matrix with i rows and k +1 column and u is the matrix of error term. Thus, the formula can be expanded to fit our prediction between independent and dependent variable as follows:

$Y = ß_0 + ß_1X_1 + ß_2X_2 + ß_3X_3 + ß_4X_4 + U$ …………………………….. (8)

Where Y = Production of main crop/Ha

$ß_0$ = Intercept

X_1 = Irrigation dummy variable taking the value of 1 for farmers practicing irrigation in the scheme and 0 for farmers practicing rainfed agriculture outside the scheme.

X_2 = Education dummy variable taking the value of 1 for those who received formal education and 0 for those who did not receive formal education.

X_3 = Labor force used in farming activities measured in number of people employed

X_4 = Amount of fertilizer used measured in kg.

U = Error term.

3.6.2.5 Explanation of variables and prior expectations

Irrigator dummy: Irrigator dummy variable was included in the model to show the difference on the influence of irrigation on dependent variable between users of the Mkindo scheme and non-users of Mkindo scheme. Irrigation has been found to have positive impact on crop production (Ozdogan, 2011). Thus the dummy coefficient for irrigation was hypothesized to be positive.

Education dummy: Respondents' exposure to education will increase the farmers' ability to obtain, process and utilize information relevant for improving his/her productivity in agriculture. Arrow (1973) suggests that, education adds to an individual's productivity and therefore increases the productivity of agriculture. The education variable was therefore, expected to have a positive influence on yield per acre.

Fertilizer use: The use of fertilizer has been found to increase yield per acre (Abdoulaye and Sanders, 2005; FAO, 2002). According to Fox and Rockstrom (2000) irrigation together with fertilizer use has positive impact on crop yield. Therefore the fertilizer use variable was included in the model to capture the effect of using fertilizer in the irrigation scheme and the coefficient of the variable was expected to be positive.

Labor (Number of people employed): Increase in the number of people employed is assumed to increase production. This is because an increase in number of people employed increase labor force. Labor force determines the size of land to be cultivated and timeliness of farm operation like planting and weeding and consequently improvement in farm output and productivity (Steven *et al*, 2012). Therefore, the coefficient of the variable labor was expected to have a positive effect.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter is organized into four sections. The first section presents the socio-economic characteristics of respondents; the second section presents results on crop and livestock activities in study area; the third section presents results on irrigation practices; and the fourth section presents results on economic impact and viability of irrigation scheme. Fourth section is divided into four sub-sections which are impact on household income and income distribution, impact on food security and econometric analysis which has been employed to capture the effect of using irrigation on crop yield.

4.2 Socio-economic characteristics of households heads

Table 1 presents the distribution of the household's heads according to age. The age of the household's heads has an influence on food production and consumption. As it is shown in Table 1, most (37.7%) of the household's heads were in the age group of 36-50 years. Very few household's heads were above 60 years old. This suggests that, most of the household heads were in the active age group that can participate effectively in production activities.

Table 1: Distribution of household heads by age

Age of households head	Farmer Category		%Total (n=160)
	%Irrigators (n=80)	%Non-irrigators(n=80)	
18-35 years old	10.7	22.0	32.7
36-50 years old	19.5	18.2	37.7
51-60 years old	5.0	5.0	10.1
Above 60 years old	15.4	4.1	19.5

Table 2 presents findings on other socio-economic characteristics of the household's heads. The distribution of household's heads by gender in the study area reveals that most (59.4%) of the household heads were male. However, it should be noted that women usually do not choose to become heads of household but it is the absence of a man able to play this role that leads them to perform these duties. As such, the female heads category consisted of widows, the divorced and those who were not yet married.

As it can be seen from Table 2, most (73.1%) of the household heads were married; with non-irrigators having a larger proportion of married heads than irrigators. The findings are similar to the findings reported by Mnyenyelwa (2008) in the study of traditional irrigation systems and livelihoods of small holders farmers conducted in Same district, Tanzania.

The findings in Table 2 show that most (85.6%) of household heads attained primary school education. The education level attained by these heads is sufficient for them to learn and adopt new farming technologies. These findings also support the findings by Mnyenyelwa, (2008) in the study of traditional irrigation systems and livelihoods of small holders farmers conducted in Same district, Tanzania.

Lastly, Table 2 indicates that most (98.8%) of the households head reported agriculture to be their main occupation. This suggests that agriculture is the major economic activity in the study area. Only a few heads depend on business as their main occupation. In the case of secondary occupation most (26.9%) of the household heads participate in petty business as their other economic activity apart from agriculture. Other secondary occupations reported by the interviewed household heads were wage employment and livestock keeping.

Table 2: Distribution of household heads by Socio-economic characteristics

	Farmer Category		%Total (n=160)
	%Irrigators(n=80)	%Non-irrigators(n=80)	
Gender of respondent:			
Male	30	29.4	59.4
Female	20	20.6	40.6
Marital status			
Married	35.2	38.4	73.6
Single	9.4	7.5	17
Widowed	5.7	3.8	9.4
Education level:			
Primary	46.3	39.4	85.6
Secondary	1.3	7.5	8.8
College	0.6	1.3	1.9
No formal education	1.9	1.9	3.8
Primary Occupation			
Agriculture	50	48.8	98.8
Business	0	1.2	1.2
Secondary Occupation:			
Business	6.3	22.6	26.9
Livestock keeper	0	1.9	1.9
Employee	0	3.8	3.8

4.3 Land owned by sampled farmers

Table 3 presents results on the amount of land owned by households. On average the non-irrigators own significantly larger land area per household than irrigators. This is because the land for irrigation at Mkindo Scheme is limited and subdivided into small plots among the farmers while at Dakawa there is a plenty of land for rain-fed farming and thus, enable people to cultivate larger areas.

Table 3: Land owned (Acres) by sampled households

Statistical measure	Irrigators	Non irrigators
Mean	2.7	5.2
Minimum	1	1
Maximum	9	24
Std. deviation	1.6	3.9

T-test = 5.291 significant at 95% level of confidence

4.3 Crop production

Maize and paddy were the main crops grown in the study area as shown in Table 4, which compares proportion of irrigators and non-irrigators who grow these crops. Most (87.5%) of all respondents grew paddy during the 2010/11 cropping season, while 43.1% of all respondents grew maize during the same cropping season. Irrigators grew maize in the dry land while non irrigators grew their paddy and maize in the dry land.

Apart from the two main crops, farmers in the study area grow other minor crops such as cassava, vegetables (tomatoes, onions, egg plant, okra and cabbages) and sunflower. As shown in Table 4, only one irrigator reported to grow cassava, while two non irrigators reported to grow vegetables and sunflower each, during the 2010/11 cropping season.

Table 4: Main crops grown in the study area in 2010/2011 cropping season

Main crop	Farmer Category		%Total(n=160)
	%Irrigators(n=80)	%Non-irrigators(n=80)	
Paddy	50	37.5	87.5
Maize	17.5	25.6	43.1
Other crops			
Cassava	0.6	0	0.6
Vegetable	0	0.6	0.6
Sunflower	0	0.6	0.6

Chi square = 22.857 significant at 95% level of confidence

4.3.2 Crop yield per acre (kg/acre) in the 2010/11 cropping season

Table 5 presents findings on yield per acre (kg/acre) for maize and paddy. As shown in Table 5 below the mean yield per acre for irrigators was significant higher than that of non irrigators. This implies that, irrigator farmers obtain more yields per acre compared to non irrigator farmers. This suggests that, irrigation farming increases crop yield compared to rainfed farming. The findings of this study support the findings by Droogers and Kite (2001), Evenson *et al.* (1999) and FAO (1996) who found that productivity, was higher in the irrigated area compared to the area where non-irrigated crops were cultivated. Therefore, there is indisputable evidence that irrigating land leads to increased productivity. One acre of irrigated cropland is worth multiple acres of rainfed cropland. Irrigation allows farmers to apply water at the most beneficial times for the crop, instead of being subject to the erratic timing of rainfall.

However, the mean yield per acre for maize was not significant as it is shown in Table 5. This implies that, their productivity was more or less the same between irrigators and non irrigators. This is due to the fact that, irrigators grew maize in the dry land areas which is the same as non irrigators who grew maize and paddy in the dry land. The mean yields of other crops cultivated in the study area were not computed because only one respondent grew cassava, sunflowers and vegetable each.

Table 5: Major crops yield per acres (kg/acre) mean comparison

Crop	**Statistical measure**	**Irrigators**	**Non irrigators**	**T- ratio**	**Sig**
Paddy	Mean(kg/acre)	2 664.40	1 126.83	12.12	.000
	Min(kg/acre)	1 040.00	.00		
	Max(kg/acre)	4 080.00	2 400.00		
	Std. Deviation	630.97	618.28		
Maize	Mean(kg/acre)	745.70	767.13	-0.12	0.901
	Min(kg/acre)	120.00	0.00		
	Max(kg/acre)	1 440.00	3 000.00		
	Std. Deviation	340.63	733.15		

4.4 Livestock production in the study area

Cattle, goats, chickens and ducks were the major livestock types kept in the study area as shown in Table 6. The table shows that most (66.3%) of the respondents in the study area kept chicken. The chi square value implies that, there was significant difference in the number of livestock kept between the irrigators and non-irrigators with irrigators raising significantly more livestock than non-irrigators.

Table 6: Types of livestock kept by sampled households

Types of livestock	Farmer Category		%Total(n=160)
	%Irrigators(n=80)	%Non-irrigators(n=80)	
Chicken	43.1	23.1	66.3
Cattle	0	1.3	1.3
Ducks	0.6	0.6	1.3
Goats	0.6	2.5	3.1
Pigs	0	0.6	0.6

Chi square = 29.824 significant at 95% level of confidence

4.5 Type of irrigation practiced in the study area

Farmers at Mkindo irrigation scheme practiced furrow irrigation. Furrow irrigation involves creating small parallel channels along the field length in the direction of main slope. Water is applied to the top end of each furrow and flows down the field under the influence of gravity. The speed of water movement is determined by many factors such as slope, surface roughness and furrow shape, but most notably by the inflow rate and soil infiltration rate.

4.6 Labor use in the study area

Table 7 presents the type of labor used in the study area during the 2010/2011 cropping season. The table reveals that most farmers used hired labor compared to family labor. Hired labor was used for both major and minor crops. The difference in hired and family labor use, between irrigators and non-irrigators was not significant at 95% level of confidence.

Table 7: Labor type in the study area

Crop type	Labor type	%Irrigators (n=80)	%Non irrigators (n=80)	%Total (n=160)
Paddy	Hired	53.8	41.3	95.1
	Family	1.4	3.5	4.9
Maize and other crop	Hired	65.9	29.5	95.5
	Family	4.5	0	4.5

Chi- square = 2.118 not significant at 95% level of confidence

Table 8 presents finding on the labor cost incurred per acre during the 2010/2011 cropping season. As shown in the table the average labor cost per acre for irrigators who grow irrigated paddy was significantly higher compared to non irrigators who grow dry land paddy. This implies that irrigators incur more labor cost per acre than non irrigators in the case of paddy. For the case of maize and other crops the difference of labor cost per acre was not statistically significant at 95% level of confidence.

Table 8: Labor cost per acre (TZS/acre)

Labor	Statistical measure	Irrigators	Non irrigators	T-test	Sig
Labor cost for the paddy	Mean(TZS/acre)	36 6178.1	1 596 431.2	7.49	.000
	Std. deviation	103 320.8	1 464 261.9		
Labor cost for maize and other crop	Mean(TZS/acre)	924 426.1	1 018 625.0	0.62	.533
	Std. deviation	738 801.6	653 178.5		

4.7 Fertilizer use in the study area

Table 9 compares the proportion of irrigators and non-irrigators who applied fertilizer on their farms during the 2010/11 cropping season. Most (67.5%) of respondents used fertilizer during 2010/11 cropping season with irrigators accounting for significantly a larger proportion of the farmers who used fertilizer in their farms. This finding suggests that, there is complementarity between irrigation and fertilizer use. These results also indicate that non irrigators' are rational because they know the risk of using fertilizer on rainfed agriculture. Using fertilizer in rainfed farming is risky resulting due to the likelihood of incurring loss if it fails to rain.

The complementarities relationship between fertilizer use and irrigation from this study support previous findings from different studies like those of Abdoulaye and Sanders (2005); FAO (2002); Fox and Rockstrom (2000); Morris *et al.* (2007); Shah and Singh (2001); Smith (2004); Wichelns (2003) and Yao and Shively (2007). These studies suggest strong complementarity between irrigation and fertilizer and argue that, fertilizer and water are issues that need to be handled simultaneously. This is because when water is a limiting factor, fertilizer may have no positive effect or may indeed have an adverse effect.

Table 9: Distribution of households by fertilizer use

	Farmer Category		%Total
	%Irrigators (n=80)	%Non-irrigators (n=80)	(n=160)
Users of fertilizer	48.8	18.8	67.5
Non users of fertilizer	1.3	31.3	32.5

Chi square = 65.641 significant at 95% level of confidence

Analysis on the amount of fertilizer used by respondents is presented in Table 10. The findings indicate that the average amount of the fertilizer used per acre by irrigators was significantly higher than average amount used by non irrigators. The minimum quantity was 0 kg for both irrigators and non irrigators while the maximum quantity of fertilizer used per acre was 100 kg for both irrigators and non irrigators as indicated in Table 10.

Table 10: Comparison of amount of fertilizer used

Statistical measure	**Irrigators**	**Non irrigators**	**T-ratio**	**Sig**
Mean (kg)	29.44	10.61	6.25	.000
Min (kg)	.00	.00		
Max (kg)	100.00	100.00		
Std. deviation	18.73	19.38		

4.8 Cost of inputs used in production

In the study area, farmers incur various costs including fertilizer, irrigation fees, and cost of buying sacks, pesticides and herbicides. Table 11 presents mean values of the cost (TZS) of the inputs used by the households in production during the 2010/11 cropping season. The t- ratio for fertilizer cost, and cost for buying storage sacks were significant for non irrigators at 95% level of confidence but the cost of spraying pesticides and herbicides were not significant.

Table 11: Cost of the inputs used in 2010/11 cropping season in TZS per acre

Cost (TZS)	Irrigators (mean)	Non irrigators (mean)	T-ratio	Sig	Mean difference
Fertilizer cost	64 215.2	161 483.3	-3.7	.000	-97 268.1
Cost of spraying	9 884.6	19 125.0	-2.3	.029	-9 240.3
Fees of water	5 000.0	.0			
Sacks cost	10 634.2	30 948.6	-5.3	.000	-20 314.4

Note: No t-statistic for water fees because only irrigators were paying that fee.

4.9 Long-term economic viability of the Mkindo irrigation scheme

Table 12 presents findings on the values of the indicators used for assessing economic viability of the Mkindo Irrigation Scheme. As can be seen from the table, the NPV of the project was positive, indicating that it was economically viable. The BCR was also positive and according to decision criteria, projects with BCR which are positive and greater than one are economically viable because the discounted benefits are higher than the discounted costs. The IRR was greater than the discount rate used to compute NPV and BCR, and as we know, a project with an IRR higher than the discount rate is deemed to be acceptable. The net benefit per unit capital invested was TZS 1 224 867.9.

These results support the findings by Vorgelegt (2001) who found that, NPV was a positive number, BCR was positive number greater than one and IRR was greater than the discount rate used in their study of costs and benefits of adopting runoff irrigation systems which was conducted in Kakuma, northern Kenya. However, the results are contrary to the finding by Hotes (1984), who argues that, the benefit/cost ratio of many irrigation projects, especially in developing countries, is unfavorable because the primary benefits are less than expected and primary costs. Kortenhorst (1983) supports Hote’s statements by indicating that many projects were initiated on political grounds, with little attention given to farmer’s needs or motivations. However, the findings and suggestion of Hotes and Kortenhorst should be considered with great attention because the study which was done by Inocencio *et al*, (2007) in assessing the costs and performance of irrigation projects, by comparing Sub-Saharan Africa (SSA) and other developing regions, suggest that, the popular view that SSA irrigation projects are expensive and not economically viable has to be understood in its proper context. Using simple regional averages, the unit costs in SSA appear to be higher than those for other regions. However, a careful look at the details reveals that under certain conditions, unit costs of irrigation projects in sub-Saharan Africa are not statistically different from those in non-SSA regions. Therefore, this finding by Inocencio *et al*, (2007), suggests that projects should reflect specific characteristics consistent with lower unit investment costs. Despite the argument of Hotes (1984), Kortenhorst (1983) and Inocencio *et al* (2007) still, irrigation projects in Sub Saharan Africa are viable and the missing requirements are to improve market infrastructure and credit facilities for purchasing agricultural inputs.

4.9.1 Sensitivity analysis

The problem of uncertainty in cost-benefit analysis may be addressed, to some extent, through sensitivity analysis. This type of analysis shows the variation in the measure of the project worthiness, for example NPV, IRR and BCR, as changes are made to the values of particular variables. Sensitivity analysis was carried out in this study to determine the effects on the above-mentioned measures of project worthiness by varying the different variables at different levels. As shown in Table 12, levels of 25%, 50% and 75% for variable cost, increase in yield and decrease in price were used to compute NPV, BCR and IRR. The values of NPV and BCR were positive, and value of IRR was greater than discount rate indicating that variation of variable cost, price and yield at those levels will not affect the viability of the project.

Table 12: Economic viability of Mkindo irrigation scheme

Item	Current Status	25	50	75
%Increase in paddy yield:				
Sum of discounted revenues(TZS)	2 921 697 008	2 995 859 681	3 595 031 617	4 194 203 554
Sum of discounted costs (TZS)	525 009 263	656 261 579	787 513 895	918 766 211
NPV (TZS)	2 396 687 745	2 305 818 102	2 773 737 722	3 241 657 342
BCR	5.56	4.56	4.56	4.56
IRR (%)	16.1	195	262	294
Net benefit per capita(TZS)	353 748	1 531 084	1 837 301	2 143 518
% Increase in cost:				
Sum of discounted revenues(TZS)	2 921 697 008	2 921 697 008	2 921 697 008	2 921 697 008
Sum of discounted costs (TZS)	525 009 263	656 261 579	787 513 895	918 766 211
NPV (TZS)	2 396 687 745	2 339 598 101	2 208 345 786	2 077 093 470
BCR	5.56	4.56	3.80	3.26
IRR (%)	16.1	149	152	132
Net benefit per capita(TZS)	353 748	1 531 084	1 837 301	2 143 518
% Decrease in price of paddy				
Sum of discounted revenues(TZS)	2 921 697 008	6 371 336 538	4 247 557 692	2 123 778 846
Sum of discounted costs (TZS)	525 009 263	525 009 263	525 009 263	525 009 263
NPV (TZS)	2 396 687 745	5 846 327 275	3 722 548 429	1 598 769 583
BCR	5.56	12.13	8.09	4.04
IRR (%)	16.1	183	117	52
Net benefit per capita(TZS)	353 748	1 531 084	1 837 301	2 143 518

4.10 The economic impact of irrigation in the study area

4.10.1 The impact of irrigation on household income

Table 13 presents the mean incomes in TZS, obtained from crops sales, livestock sales, wages and salaries, pensions and other sources of income. The table shows that the mean income from crops for irrigators was significantly higher than the mean income from crops of non-irrigators. However, there is no significant difference between irrigators and non irrigators for income from livestock, petty business, wages, pension and other sources. The high crop incomes obtained by irrigators are associated with high crop yields per acre for irrigated crops. This suggests that irrigation has had positive impact on household income because crop income account for the largest proportion of the total household income. This finding supports the findings by Lipton (2007) in the study of farm water and rural poverty in developing countries; Hussain (2005) in the study of pro-poor intervention strategies in irrigated agriculture in Asia; Mwakalila (2004) and Cosmas and Tamilwai (2005) in their studies done in Tanzania, who found that, the presence of irrigation increased crop productivity and hence rural household income.

Table 13: Mean household income in 2010/11 cropping season

Income source	Irrigators (mean TZS)	Non irrigators (mean TZS)	T-ratio	Sig	Min	Max
Total income	1 891 700.0	2 582 100.0	-1.9	.053	.00	13 640 000.0
Crops	714 857.1	347 135.9	-5.7	.000	.00	13 040 000.0
Livestock	61 637.5	341 662.5	-2.5	.012	.00	5 452 000.0
Petty business	90 893.7	197 850.0	-1.9	.058	.00	3 000 000.0
Wages	125.0	35 250.0	-2.6	.009	.00	800 000.0
Pension	.0	2 187.5	-	-	.00	110 000.0
Other sources	7 812.5	1 875.0	1.0	.283	.00	400 000.0

Note: t-statistic was not computed for pension income because none of the irrigators reported pension income

4.10.2 The impact of irrigation on income distribution

Table 14 presents finding on the income share regression-based inequality decomposition by predicted income sources. It shows that the respondents in the study area depend heavily on income from crops which they cultivate and that income contributes about 83.5% to the total income. Income share to total income from livestock and small business activities were about 9% and 6.5% respectively. This means that the crop sub sector was the main source of household income in the study area. Therefore, more investment priority should be given to crop production projects in order to improve the welfare of the people in the study area.

Table 14: Income share regression-based inequality decomposition by predicted income sources

Sources	Income	Absolute	Relative
Constant	0	0	0
Income from crops	0.834752	0.384342	0.824822
Income from livestock	0.090146	0.047531	0.102005
Income petty business	0.06454	0.027562	0.05915
Wages	0.007907	0.005434	0.011661
Pension	0.000489	0.000079	0.000169
Other income source	0.002165	0.001022	0.002193
Residual	0	0	0
Total	1	0.465969	1

Table 15 presents finding on the income distribution between irrigators and non-irrigators in the study area. Gini coefficient was used to measure income distribution. Non-irrigators had higher Gini coefficient compared to irrigators. Their values were 49.6% and 38.6% for non-irrigators and irrigators respectively. This implies that income inequality among non-irrigators was higher than income inequality among irrigators. This suggests that irrigation schemes decreases the level of income inequality among famers and therefore improve income distribution.

These findings were similar to the findings reported by various authors including Thakur *et al.* (2000) in their study on rural income distribution and poverty in Bihar; Janaiah *et al.* (2000) in their study on poverty and income distribution in rainfed and irrigated ecosystems in Chhattisgarh; Isvilanonda *et al.* (2000) in their study on recent changes in Thailand's rural economy; Ut *et al.* (2000) in their study on impact of modern farm technology and infrastructure on income distribution and poverty in Vietnam and Bhattarai *et al*. (2002) in their study of irrigation impacts on income inequality and poverty alleviation. In general these studies found that, on average, income inequality in irrigated agriculture was much less than in rain-fed agriculture. However, income inequality in the irrigated area compared to the unirrigated area could deteriorate or improve depending upon several underlying structural and institutional factors in the society, such as landholding skewness and economic structures. Some of these factors may not be associated with productivity improvement. Access to irrigation may actually decrease income inequality mainly through increased rural employment and trickle-down effects of the growth process (Chambers, 1988; Mellor, 1999).

Table 15: Gini index for total household income

Variable	Estimate	STE	Lower boundary	Upper boundary
Irrigators	0.386981	0.029423	0.328416	0.445546
Non irrigators	0.496163	0.033982	0.428496	0.563830

4.10.3 Impact of irrigation on household food security

Table 16 presents findings on the status of food security between irrigators and non-irrigators in the study area. The amount of crops produced by the households which were consumed and stored and the number of months in the year which households were able to feed themselves were used as proxies for measuring household food availability. The difference in the amount of food consumed or stored was not significant as indicated in

Table 16. However, the number of months in which households were able to feed themselves was significant at 95% level of confidence as indicated in Table 16, implying that irrigators were having significantly more months which they can feed themselves from own produced food compared to non-irrigators. Based on food availability, these findings imply that irrigators are more food secure than non-irrigators. Furthermore these finding support the findings of previous studies by Lipton (2007) in his study on farm water and rural poverty in developing countries; Hussain (2005) in his study on pro-poor intervention strategies in irrigated agriculture in Asia; Mwakalila (2004) and Cosmas and Tamilwai (2005) in their studies done in Tanzania; Ninno and Dorosh (2005) in their study on food aid and food security in the short and long run in Asia and Sub-Saharan Africa; Jean *et al.* (2005) in their study of food security and agricultural development in Sub-Saharan Africa and Lipton *et al*. (2003) in their study of effects of irrigation on poverty. Lipton *et al.* (2003) found that irrigation development improves the status of food security because through irrigation farmers can improve production and can produce twice a year.

Table 16: Status of food security in the study area

Food status	**Irrigators (mean)**	**Non-irrigators (mean)**	**T-ratio**	**Sig**
Crops consumed and stored(bags)	9.775	9.337	0.323	0.747
Months feed from own produce(months)	10.690	9.340	-5.399	0.000

Table 17 shows the number of meals households consumed per day. Most (73.6%) of the households consumed three meals per day, with irrigators and non-irrigators accounting for 47.2% and 26.4% of the households that, consumed three meals per day respectively. The difference in the percentage of the number of meals households consume per day was significant implying that irrigator’s households had more meals per day than non-irrigators.

Table 17: Number of meals the households consumed per day

Number of meals	Farmer Category		%Total
	%Irrigators (n=80)	%Non-irrigators (n=80)	(n=160)
Three	47.2	26.4	73.6
Two	2.5	22.0	24.5
One	0	1.9	1.9

Chi square = 36.944 significant at 95% level of confidence

4.11 Asset ownership

Table 18 presents finding on values of assets owned by respondents. On average irrigators owned assets with a value of TZS 1 857 862.5 while non-irrigators owned assets with a value of TZS 2 392 262.5 but, the difference in the value of assets owned by the two categories of farmers was not significant. The distribution of the asset values was measured by using Gini index and the finding suggest that, distribution of assets among irrigators was fair compared to non-irrigators as indicated by Gini coefficients of 67.2% and 69.4% for irrigators and non-irrigators respectively. These finding supports the finding by Tong *et al*. (2011) who suggest that irrigation, was unlikely to have a positive impact on the amount of durable assets. Nevertheless the finding was contrary to the finding by Dillon (2011) and Hussain and Hanjra (2004) who found that irrigation development has positive effects on assets holding. Also Hagos and Holden (2003), indicate that physical assets endowment, were reported to have a positive significant effect on improving household welfare and food security status. Cheryl *et al.* (2009) states that, “Ownership and control over assets such as land and housing provide multiple benefits to individuals and households, including secured livelihoods, protection during emergencies and collateral”.

Table 18: Values of assets owned by household

Statistical Measure	Irrigators	Non-irrigators	T- ratios	Sig
Mean(TZS)	1 857 862.5	2 392 262.5	0.748	0.456
Min	0.0	0.0		
Max	29 215 000.0	42 250 000.0		
Std. deviation	3 775 905.5	5 160 245.7		
Gini index	0.6	0.7		

4.12 Results of regression analysis

Table 19 presents findings of regression analysis. The model shows that only 72.7% of the variation in paddy yields is explained by the variables included in the model. Only two of the variables included in the regression model were influencing paddy yield significantly at 95% level of confidence. These variables are irrigation dummy and amount of fertilizer used. The coefficients of education and labor were found to be insignificant. The irrigation dummy variable was included in the model to capture the effect of practicing irrigation farming versus not practicing irrigation farming. The value of coefficient was 580.454 and was statistically significant at 95% confidence interval which indicates that increasing the volume of irrigation water by 1% would increase paddy yield by about 580 kg. This finding supports studies done by Lipton (2007); Hussain (2005); Mwakalila (2004) and Cosmas and Tamilwai (2005) who found that, the use of irrigation increases crop productivity.

The amount of fertilizer per acre was another variable which significantly affect paddy productivity. As shown in Table 19, there is a significant positive relationship between amount of fertilizer used per acre and paddy yield per acre. Increasing fertilizer by 1kg/acre would increase paddy yield by 71.3 kg/acre. But this finding should be interpreted carefully because there are necessary conditions for using fertilizer in order to improve crop productivity as indicated by Abdoulaye and Sanders (2005); FAO (2002);

Fox and Rockstrom (2000); Morris *et al.* (2007); Shah and Singh (2001); Smith (2004); Wichelns (2003); Yao and Shively (2007) who conducted studies on the efficient use, productive efficiency, technical change and adverse impact of the fertilizers use in different areas.

Table 19: Summary of regression results

	Unstandardized Coefficients				Collinearity Statistics	
Model variables	B	Std. Error	t	Sig.	Tolerance	VIF
Constant	488.85	199.92	2.44	0.016		
Irrigators dummy	580.45	101.82	5.70	0.000	0.475	2.106
Education dummy	65.42	188.05	0.34	0.728	0.964	1.037
Amount of fertilizer in kg	0.71	0.41	1.72	0.000	0.720	1.388
Labor(number of people employed)	-0.87	4.50	-0.19	0.846	0.858	1.166

F= 34.541significant at 95% level of confidence; R= 0.727; R^2 = 0.529

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

This study was concerned with the economics of small-scale irrigation in Tanzania. The study was conducted at Mkindo Farmer Managed Irrigation Scheme in Mvomero District, Morogoro Region. The main objective of the study was to analyze the economic viability and determine the impact of the irrigation scheme on household income and food security. The specific objectives of the study were (i) To analyse the economic viability of the irrigation scheme; (ii) To determine the impact of the irrigation scheme on household income and income distribution; and (iii) To determine the impact of the irrigation scheme on household food security. This chapter presents the conclusions and recommendations emerging from the major findings of the study.

5.1 Conclusions

5.1.1 Economic viability of the Mkindo scheme

An investment project is said to be economically viable if the magnitudes of the net present value (NPV), benefit cost ratio (BCR) and internal rate of returns (IRR) are positive, greater than one and greater than the used discount rate respectively. Since the calculated NPV, BCR and IRR values of the Mkindo irrigation scheme were positive, greater than one and greater than the discount rate respectively, it can be concluded that Mkindo the irrigation scheme is economically viable.

5.1.2 Impact of irrigation on household income

The findings of the study indicate that crop production contributes more to the total household income compared to other income sources, implying that many farmers in the study area depend on crop production as their main source of income. Furthermore irrigators were found to obtain significantly higher income from crops compared to non-irrigators leading into significantly higher total household incomes among irrigators than non-irrigators. Therefore it can be concluded that irrigation has had positive impact on household income.

5.1.3 Impact of irrigation on income distribution

Gini index results indicate that Gini coefficient for irrigators was significantly lower than that of non-irrigator, which implies that irrigation is inequality reducing leading into fair income distribution among farmers practicing irrigation. Therefore it can be concluded that irrigation had the positive impact on income distribution.

5.1.4 Impact of irrigation on household food security

The findings of the study show that irrigators were able to feed themselves from own produced food for many months of the year compared to non-irrigators. Also the proportion of irrigators who consumed three meals per day was significantly higher than the proportion of non-irrigators who consumed three meals per day. Therefore, based on food availability indicator, it can be concluded that, irrigation has positive impact on household food security.

5.2 Recommendations

The following are recommendations based on the major findings of the study.

5.2.1 Promoting and up scaling small scale farmer managed irrigation schemes

The findings of the study indicate that Mkindo irrigation scheme was economically viable and had positive impact on household income, income distribution and food security. This suggests that it is worth investing in small scale irrigation schemes in the country. It is therefore recommended that the government and development partners should promote and upscale small scale irrigation in the country through increased resource allocation to irrigation projects. Irrigation development will bring about increased agricultural production and consequently improve the well-being of the rural population. However, ex-ante economic viability analysis should be carried for each potential irrigation scheme before making investments.

5.2.2 Promoting fertilizer use

The results of the regression analysis indicated the coefficient of fertilizer use to have a significant positive effect on productivity of irrigated crops. This suggests that, promotion of smallholder irrigation schemes should be accompanied by creating awareness on benefits of using fertilizer to boost productivity of irrigated crops among smallholder farmers. But also, creation of awareness should be accompanied by strategies to ensure timely availability of fertilizers in rural areas at affordable price.

REFERENCE

Anastasios, M. (2006). Impact Analysis of Irrigation Projects: an Application of Contingent Valuation Method. *The American Journal of Agricultural and Biological Sciences* 1(1): 17 – 21.

Abdoulaye, T. and Sanders, J. H. (2005). Stages and determinants of fertilizer use in semiarid African agriculture: The Niger experience. *Agricultural Economics* 32(2): 167–179.

Akyoo, A. and Lazaro, L. A. (2008). An Accounting Method-Based Cost-Benefit Analysis of Conformity to Certified Organic Standards for Species in Tanzania. DIIS Working Paper No. 30. Copenhagen, Denmark, 2008. 76pp.

Arrow K. J. (1973). Higher Education as a Filter. *Journal of Public Economics* 2 (3): 193 – 216.

Arrow, K.J., Cropper, M.L., Eads, G.C., Hahn, R.W., Lave, L.B., Noll, R.G., Portney, P.R., Russell, M., Schmalensee, R., Smith, V.K. and Stavins, R.N. (1996). Is there a role for benefit-cost analysis in environment, health, and safety regulation? *The Science* 272: 221 – 222.

Averkamp, H. (2011). Evaluating Business Investments. [http://blog.Accounting coach.com/payback-non discounted-capital-budgeting/] site visited on 11/10/2011.

Baker, J. L. (2000). *Evaluating the Impact of Development Projects on Poverty*. A Handbook for Practitioners. The World Bank, USA. 217pp.

Balkema, A., Karoli, N. N., Henny, R. and Ralph, R. (2010). Socio-economic analysis of constructed wetlands systems for hygienic sanitation in Tanzania. *The Water Practice and Technology* 5(1): 6 – 8.

Bamidele, F., Ogunlade, I., Ayinde, O. and Olabode, P. (2010). Factors Affecting Farmers' Ability to Pay for Irrigation Facilities in Nigeria: The Case of Oshin Irrigation Scheme in Kwara State. *The Journal of Sustainable Development in Africa* 12(1): 339 – 340.

Barrett, C.B. (2002). "*Food Security and Food Assistance.*" *In Handbook of Agricultural Economics.* Agricultural and Food Policy**.** Elsevier Ltd, Amsterdam. 628pp.

Barrett, C., Bell, R., Lentz, E., & Maxwell, D. (2009). Market Information and Food Insecurity Response Analysis. *Food Security* (1): 151-168.

Berhanu, G. and Peden, D. (2002). Policies and Institutions to Enhance the Impact of Irrigation Development in Mixed Crop–Livestock Systems. International Livestock Research Institute Addis Ababa, Ethiopia. 260pp.

Bhattarai, M., Sakthivadivel, R. and Hussain, I. (2002). Irrigation Impacts on Income Inequality and Poverty Alleviation: Policy issues and options for improved management of irrigation systems. International Water Management Institute. Working Paper No. 39. Colombo, Sri Lanka. 15pp.

Bierman, H. J. (1986). Implementation of Capital Budgeting Techniques. *Financial Management Survey and Synthesis Series* 22 (3): 1- 24.

Bishop, R. C. and Heberlei, T.A. (1979). Measuring value of extramarket goods. *The American Journal of Agricultural Economics* 61: 926 – 930.

Bishop, R. C., Heberlei, T. A. and Kealy, M. (1983). Contingent valuation of environmental assets: comparisons with a simulated market. *The Natural Resource Journal* 23: 619 – 633.

Boardman, D. H., Greenberg, A.R. and Vining, D.L. (2001). *Cost–Benefit Analysis:* Collins College Publishers, New York. 526pp.

Bowker, J.M. and Stoll, J.R. (1988). Use of dichotomous choice nonmarket methods to value of whooping crane resource. *American Journal of Agricultural Economics* 70: 372 – 381.

Brenters, J. and Henny, R. (2002). A Sub-Sector Approach to Cost Benefit Analysis: Small-Scale Sisal Processing In Tanzania. Working Paper No. 4. Eindhoven Centre for Innovation Studies, Netherlands. 22pp.

Bruce J. Feibel. (2003). *Investment Performance Measurement*. New York: Wiley, 2003

Cameron, T. A. and James, M.D. (1987). Efficient estimation methods for use with c1osed-ended contingent valuation survey data. *Review of Economic Statistics* 69: 269 – 276.

Cameron, T. A. (1988). A new paradigm for valuation nonmarket goods using referendum data: maximum likelihood estimation by censored logistic regression. *Journal of Environmental Economics and Management* 13: 355 – 379.

Carlsso, F. and Johansson, S. O. (2000). Willingness to pay for air quality in Sweden. *Applied Economics* 32: 661 – 669.

Chambers, R. (1988). *Managing Canal Irrigation:* Practical analysis from South Asia. IBH Publishing Co. Pvt. Ltd., New Delhi, India. 281pp.

Cheryl, D., Caren, G. and Carmen, D. D. (2009). Collecting individual level asset data for gender analysis of poverty and rural employment. *Paper Presented at the FAO-IFAD-ILO Workshop on Gaps.* Rome, Italy, 31 March - 2 April 2009. 16pp.

Chiza, C. (2005): The Role of Irrigation in Agriculture, Food Security and Poverty Reduction. *Proceeding of the Discourse on Engineering Contribution in Poverty Reduction.* 18 - 19 March 2005, Dar es salaam, Tanzania. 28pp.

Chichilnisky, G. (1996b). The economic value of the earth's resources. *Trends in Ecology and Evolution* 11: 135 – 139.

Chichilnisky, G. (1994). North-South trade and the global environment. *American Economic Review* 84: 851 – 874.

Chichilnisky, G. (1997). The cost and benefit of benefit-cost analysis. *Environment and Development Economics* 2: 202 – 206.

Cosmas, H. S. and Tamilwai, C. S. (2005). Changes in the Upland Irrigation System and Implications for Rural Poverty Alleviation: A Case of the Ndiwa Irrigation System, West Usambara Mountains Research Report No. 5. Mkuki Na Nyota Publishers Ltd., Dar es Salaam, Tanzania. 55pp.

Denis, G. M. (2008). Adaptive Adoption of Rainwater Storage Systems by Farmers: A Case of Makunga Ward in Same District. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania.

Dillon, A. (2011). The Effect of Irrigation on Poverty Reduction: Asset Accumulation, and Informal Insurance: Evidence from Northern Mali. *The World Development* 39 (12): 2165 – 2175.

Donaldson, C., Thomas, R. and Torgerso, D. (1997). Validity of open-ended and payment scale approaches to eliciting willingness to pay. *Applied Economics* 29: 79 – 84.

Droogers, P. and Kite, G. (2001). Estimating productivity of water at different spatial scales using simulation modeling. Research Report No. 53. International Water Management Institute, Colombo, Sri Lanka. 16pp.

EAC (2010). Feasibility Study for a Natural Gas Pipeline from Dar es Salaam to Tanga (Tanzania) and Mombasa (Kenya). Methodology for Financial and Economic Analysis report. 28pp.

Evenson, R. E., Pray, C.E. and Rosegrant, M.W. (1999). Agricultural Research and Productivity Growth in India. IFPRI Research Report No. 109. International Food Policy Research Institute, Washington, USA. 103pp.

FAO (2002). Water and Fertilizer Use in Selected Countries. Discussion Paper. United Nations, Rome, Italy. 91pp.

FAO (2009). Rome Declaration on World Food Security. World Food Summit, 13- 17 November 1996 Rome, Italy. 2pp.

FAO (2002). The report on world food day. A FAO report, 14 November 2002, Bangkok, Thailand. 28pp.

FAO (1996). Agriculture and Food Security. World Food Summit, 15- 17 November 1996, United Nations, Rome, Italy. 15pp.

Fox, P. and Rockstrom, J. (2000). Water-harvesting for supplementary irrigation of cereal crops to overcome intra-seasonal dry-spells in the Sahel. Physics and chemistry of the earth. *Hydrology Oceans and Atmosphere* 25(3): 289 – 296.

Germana, C. L. (1993). A Socio- Economic Analysis of Modern Irrigation Projects under Small Scale Farming: A Case of the Lower Moshi Irrigation Project in Kilimanjaro Region. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 117pp.

Greene, W. H., (1997). *Econometric Analysis,* New Jersey, Prentice Hall Press, 1997.

Hagos, F. Holden, S. (2003). Rural Household Poverty Dynamics in Northern Ethiopia 1997- 2000. Paper for CPRC Conference, Manchester, UK. 35pp.

Haile, T. H. (2008). Impact of Irrigation Development on Poverty Reduction in Northern Ethiopia. Thesis for Award of PhD Degree at National University of Ireland, Cork, 289pp.

Hayes, C. and Hayes, A. (1999). Willingness to pay versus willingness to travel: Assessing the recreational benefits from Dartmoor National Park. *Journal of Agricultural Economics* 50(1): 124 – 139.

Hoevenagel R. (1994). An assessment of the contingent valuation method. In *Valuing the Environment: Methodological and Measurement Issues*, Pethig, R. (Ed.). Kluwer Publisher, Dordrecht. 372pp.

Hotes F.L. (1984). World Bank Irrigation Experience. Network paper 9d. Overseas Development institute. ODI, London. 14pp.

Hussain, I. (2007). Direct and indirect benefits and potential Disbenefits of irrigation: Evidence and lessons. *Irrigation and Drainage* 56: 179–194.

Hussain, I. and Hanjra, M. (2004). Irrigation and poverty alleviation: Review of the empirical evidence. *Irrigation and Drainage* 53(1): 1 – 15.

Hussain, I., Mark, G. and Munir A. H. (2004). Agricultural Water and Poverty Linkages: Case Studies on Large and Small Systems. International Water Management Institute, Colombo, Sri Lanka. 108pp.

Hussain, I. (2005). Pro-poor Intervention Strategies in Irrigated Agriculture in Asia. Poverty in Irrigated Agriculture: Issues, Lessons, Options and Guidelines, Final Synthesis Report: International Water Management Institute (IWMI), Colombo, Sri Lanka. 73pp.

Inocencio, A., Kikuchi, M.; Tonosaki, M.; Maruyama, A.; Merrey, D.; Sally, H.; de Jong, I. (2007). Costs and performance of irrigation projects: A comparison of sub-Saharan Africa and other developing regions. IWMI Research Report 109 Colombo, Sri Lanka: International Water Management Institute. 81pp.

Isvilanonda S., Ahmad A. and Hossain, M. (2000). Recent changes in Thailand's rural economy: Evidence from six villages. *Economic and Political Weekly, December* 30 : 4644 – 4649.

Janaiah, A., Bose, M.L. and Agrawal, A.G. (2000). Poverty and income distribution in rainfed and irrigated ecosystems: Village studies in Chhattisgarh. *Economic and Political Weekly* 30: 4664 – 4669.

Jean-Marc, B., Benoit, D., Françoise, G. and Tancrède, V. (2005). Food Security and Agricultural Development in Sub-Saharan Africa: Building for More Support. CIRAD Final Report, for FAO, Rome, Italy. 113pp.

Jrad S., Bashar N. and Hajar B. (2010). Food Security Models. National Agricultural Policy Centre. Policy Brief No 33. Damascus, Syria. 32pp.

Johnson, N. L., Lilja, N. and Ashby, J. A. (2003). Measuring the impact of user participation in agricultural and natural resource management research. *Agricultural Systems 78*(2): 287 – 306.

Kadigi, M.J.K., Kashagili, J.J. and Mdoe, N.S.Y. (2003). The Economics of irrigated paddy in Usangu basin in Tanzania: water utilization, productivity, income and livelihood implications. Fourth WaterNets/Warfsa Symposium: water, science technology and policy convergence and action by all, 15-17 October 2003, Morogoro, Tanzania. 6pp.

Karimuribo, E.D., Kusiluka, L.J., Mdegela, R.H., Kapaga, A.M., Sindato, C., Kambarage, D.M. (2005). Studies on mastitis, milk quality and health risks associated with consumption of milk from pastoral herds in Dodoma and Morogoro regions, Tanzania. *Journal of Veterinary Science* 6: 213-221.

Kabbiri R., Senkondo, E.M.M., Aboud, A.A., Israel, S.H., Mbaga, S., Msaky, J.J.T. and Mkomwa, S.A. (2008). Profitability of Draught Power in Semi Arid Tanzania: A case study of Hai, Kongwa and Siha districts. *Food and energy crises* 8 (271): 107-114.

Kissawike, K. (2008). Irrigation-based Livelihood Challenges and Opportunities. A gendered technography of the Lower Moshi irrigation scheme in Tanzania. PhD thesis submitted at Wegeningen University, Netherland. 235pp.

Kortenhorst L.F. (1983). Summary report on a workshop on small-scale irrigation in Kenya. Proceedings of international Institute for Land Reclamation and Improvement workshop, Nairobi, Kenya, 14 – 18 February, 1983. 55pp.

Lin, Grier C. I.; Nagalingam, Sev V. (2000). CIM justification and optimization. London: Taylor & Francis. 36pp.

Lipton, M. (2007). Farm water and rural poverty reduction in developing Asia. *Irrigation and Drainage* 56: 127–146.

Lipton, M., Litchfield, J. and Faurès, J.M. (2003). The Effects of Irrigation on Poverty: A Framework for Analysis. *Water Policy* 5: 413 – 427.

Loomis, J., Pierce, C. and Manfredo, M. (2000). Using the demand for hunting licenses to evaluate contingent valuation estimates of willingness to pay. *Applied Economics Letter* 7: 435 – 438.

Lyimo, N. L., Mtenga, H., Kimambo, L. A., Hvelplund, A. E., Laswai, T. and Weisbjerg, G.H. (2004). A survey on calf feeding systems, problems and improvement options available for the smallholder dairy farmers of Turiani in Tanzania. Livestock Research for Rural Development. An article, [http://www.cipav.org.co/lrrd/lrrd16/4/lyim16023] Visited on 15th March 2012.

Mahoo, H. F.; Mkoga, Z. J.; Kasele, S. S.; Igbadun, H. E.; Hatibu, N.; Rao, K. P. C.; Lankford, B. (2007). Productivity of water in agriculture: Farmers' perceptions and practices. Comprehensive Assessment of Water Management in Agriculture Discussion Paper 5 Colombo, Sri Lanka: International Water Management Institute. 37pp.

Magayane, M. D., Lankford, B. and Mahoo, H. F. (2003). Real or Imagined Water Competition? The case of rice irrigation in the Usangu basin and Mtera/Kidatu hydropower, Tanzania. 10pp.

Mboera, L.E.G., Mlozi, M.R.S., Senkoro, K.P., Rumisha, S.F., Mayala, B.K., Shayo, E.H., Senkondo E., Mwingira, V.S. and Maerere A. (2007). Malaria and Agriculture in Tanzania: Impact of Land Use and Agricultural Practices on Malaria Burden in Mvomero district. National Institute for Medical Research, Tanzania. 134pp.

McConnell, K.E. (1990). Models for referendum data: The Structure of discrete choice models for contingent valuation. *Journal of Environmental Economics and Management* 18: 19-24.

McConnell, K. and Haab, T. (2003). Valuing Environmental and Natural Resources. The Econometrics of Non-Market. Edward Elgar Publishing Limited, Northampton, USA. 326pp.

McCartney, M., Rebelo, L.M., Senaratna S. and de Silva, S.S. (2010). Wetlands, agriculture and poverty reduction**.** IWMI Research Report 137.Colombo, Sri Lanka. 39pp.

Mellor, J. W. (1999). Faster more equitable growth: The relationship between growth in agriculture and poverty reduction. A conference paper presented at Harvard Institute for International Development. Cambridge, USA. September 1999. 33pp.

.

Mitchell R. and R. Carson (1989). Using Surveys to Value Public Goods: The Contingent Valuation Method, Resources for the Future. Resources for the Future Washington DC. 488pp.

Mkavidanda, T.A.J. and Kaswamila, A.L. (2001). The Role of Traditional Irrigation Systems (Vinyungu) In Alleviating Poverty in Iringa Rural District, Tanzania. Repoa Research Report No. 01.2. Mkuki na Nyota Publishers, Dar es Salaam, Tanzania. 45pp.

Mlozi, M.R.S, Shayo, E.H., Senkoro, K.P., Mayala, B.K., Rumisha, S.F., Mutayoba, B., Senkondo, E., Maerere, A. and Mboera, L.E.G. (2006). Participatory involvement of farming communities and public sectors in determining malaria control strategies in Mvomero District, Tanzania. Tanzania Hlth Res Bull. 8: 134pp.

Mnyenyelwa M.A. (2008). Traditional irrigation systems and livelihoods of small holder farmers in Same district, Kilimanjaro Tanzania. A dissertation submitted in partial fulfillment of the requirements for the degree of masters of Science in agricultural economics of SUA. 94pp.

MOFEA (2010): National Strategy for Growth and Reduction of Poverty II. Government document. 186pp.

Mohr, L. B. (1995). The Qualitative Method of Impact Analysis. Evaluation Review. *The American Journal of Evaluation* 20 (1): 69-84.

Morris M, Kelly V.A., Kopicki R.J., Byerlee D. (2007). Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines. The International Bank for Reconstruction and Development / World Bank, Washington D.C. 144pp.

Mwakalila S. (2004). Socio-Economic Aspects of Irrigated Agriculture in Mbarali District of Tanzania. Research report. Department of Geography, University of Dar es Salaam, Tanzania. 19pp.

Mwaniki, A. (2006). Achieving food security in Africa: Challenges and issues. Issue brief. The United Nations. [http://www.un.org/africa/osaa/reports/Achieving Food Security in Africa Challenges and Issues.pdf.] Site visited on 10/10/2011.

Ngaga, Y.M., Turpie J.K., and Karanja F.K. (2005). Preliminary economic assessment of water resources of the Pangani River Basin, Tanzania: economic values and incentives. East African Integrated River Basin Management Conference, Morogoro, Tanzania. 9pp.

Naing, L., Winn, T. Rusli, B.N. (2006). Practical issues in calculating the sample size for prevalence studies. *Archives of Orofacial Sciences* 1: 9 – 14.

Ninno, C. and Dorosh, P. A. (2005). Food Aid and Food Security in the Short and Long Run: Country Experience from Asia and sub-Saharan Africa Food Aid and Food Security in the Short- and Long Run. SP discussions paper no 0538. 122pp.

Ozdogan, M. (2011). Exploring the potential contribution of irrigation to global agricultural primary productivity. *Global Biogeochem. Cycles*, Vol 25, 3016 – 3720.

Pradhan, M., Laura R. and Geert R. (1998). The Bolivian Social Investment Fund: An Analysis of Baseline Data for Impact Evaluation. *World Bank Economic Review*, 12(3). 457- 82.

Pearce D., Marglin, S. and Sen, A.K. (1993). Guidelines for project evaluation. UNIDO, New York, 1972. 383pp.

Puttaswamaiah K., (2002). On assessing the State of the art of the Contingent Valuation Method for Valuing Environmental Changes. Cost-Benefit Analysis: *Environmental and Ecological Perspectives*. Transaction Publishers. 430pp.

Ravallion, M. (2005). Assessing the Poverty Impact of Assigned Program In; The Impact of Economic Policies on Poverty and Income Distribution: Evaluation Techniques and Tools. (Edited by Bourguignon, F., Luiz A. and Da silva P.), Co publication of the World Bank and Oxford University Press, New York: 103 – 122.

Rendall, A., B.C. Lyes and C. Eastman. (1974). Bidding games for valuation of aesthetic environmental improvement. *Journal of Environmental Economics and Management* 1: 132 – 149.

Rollins, K (1997). Wilderness canoeing in Ontario: Using cumulative results to update dichotomous choice contingent valuation offer amounts. *Ca: nmJian Joumal of Agricultural Economics* 45: 1-16.

Ryan, M. (1997). Should government fund Assisted Reproductive Techniques? A study using willing to pay. *Applied Economics* 29: 841 – 849.

Scarpa R. (2000). Contingent valuation versus choice experiments: estimating the benefits of environmentally sensitive areas in Scotland. *Joumal of Agricultural Economics* 51(1): 122-128.

Seller, C., J.P. Chavas and J.R. Stoll. (1986). Specification of the logic model. The case of valuation of nonmarket goods. *Journal of Environmental Economics and Management* 13: 382-390.

Shackley, P. and S. Dixon. (2000). Using contingent valuation to elicit public preferences for water fluoridation. *Applied Economics* 32: 777-787.

Shah, T. and Singh, O. P. (2001). Can Irrigation Eradicate Rural Poverty in Gujarat? Water Policy Research Highlight No.10. 8 p.

Shitundu, J. and Luvanga, N. (1998). The Use of Labour-Intensive Irrigation Technologies in Alleviating Poverty in Majengo. Mbeya Rural. Research reports no 93.3 Research on Poverty Alleviation, Dar es salaam, Tanzania. 49pp.

Smith L.E.D. (2004). Assessment of the contribution of irrigation to poverty reduction and sustainable livelihoods. *International journal of water resources development*. 20(2): 243-257.

Steven Z., Tom H., Peter D. and Maureen R. (2012). The Potential Impact of Changes in Immigration Policy on U.S. Agriculture and the Market for Hired Farm Labor: A Simulation Analysis. Economic Research Report Number 135. USDA, USA. 42pp.

Stockle C. O. (2001). Environmental impacts of irrigation: A review paper. State of Washington Water Research Center. 15pp.

SWMRG (2005). Experiences with Micro Agricultural Water Management Technologies: Tanzania. Research report. The International Water Management Institute (IWMI), Southern Africa Sub-regional Office, Pretoria, South Africa. 28pp.

Tarimo, A.K.P.R, Amy Mchelle, R. and Nganga, I. (2010). Evaluation of water distribution systems at Igomelo Farmer-Managed Irrigation Scheme in Tanzania. Second RUFORUM Biennial Meeting 20 - 24 September 2010, Entebbe, Uganda, 3pp.

Thakur, J., Bose, M.L., Hossain, M. and Jinaiah, A. (2000). Rural income distribution and poverty in Bihar: Insights from village studies. *Economic and Political Weekly* 30: 4657- 4663.

Tong K. Hem S. Paulo S. (2011). The Impact of Irrigation on Household Assets. CDRI Working Paper Series No. 57 (10): 25pp.

Ut T.T, Hossain, M. and Janaiah, A. (2000). Modern farm technology and infrastructure in Vietnam: Impact on income distribution and poverty. *The Economic and Political Weekly* 30: 4638-4643.

Valadez, J. and Bamberger, M. (1994). Monitoring and evaluating social programmes in developing Countries: A handbook for policymakers, managers and researchers: The World Bank, 1818 H Street, N.W., Washington, DC, USA. 407pp.

Vatn, A. and Bromley D.W. (1994). Choices without prices without apologies. *The Journal of Environmental Economics and Management* 26 (2): 129-148.

Vorgelegt C. B. (2001). Costs and Benefits of Adopting Runoff Irrigation Systems. A case study from Kakuma, northern Kenya.79pp.

Willis, K. and Powe, N.A. (1998). Contingent valuation and real economic commitments: A private good experiment. *The Journal of Environmental Planning and Management* 45(5): 611- 619.

Wierstra, E., van der Veen en A. and Geurts P. (1996), “Monetaire waardering van milieuverandering: de Contingent Valuation methode”. *Maandschrift Economie* 60: 155 – 176.

Wichelns D. (2003). Policy Recommendations to Enhance Farm-Level Use of Fertilizer and Irrigation Water in Sub-Saharan Africa. *The Journal Sustainable Agriculture* 23(2): 53-77.

World Bank (2006). Outline of Principles of Impact Evaluation: International Workshop on Impact Evaluation for Development, 15 November 2006 - World Bank and the DAC Evaluation, Network, USA. 9pp.

World Bank (1980). Economic and Social Analysis of Projects and of Price Policy: The World Bank Staff Working Paper No. 369. 65pp.

Yao R.T, Shively G.E. (2007). Technical Change and Productive Efficiency: Irrigated Rice in the Philippines. *The Asian Econ. J.* 21(2): 155-168.

Zerbe R. and Dively D. (1994). Calculations of Costs and Benefits in Partial Equilibrium. Benefit–Cost Analysis: In Theory and Practice. Harper Collins, 1994.

APPENDICES

Appendix 1: Questionnaire on Economic Viability and Economic Impact of Mkindo Irrigation Scheme in Mvomero District, Tanzania

SECTION A. GENERAL INFROMATION

1. Questionnaire number: ……………………….……………….……………….
2. Name of interviewer ……………………………………………………………….
3. Date of interview ……………………………………………..…..………………..
4. Location of farm (Village)……………………………… …………………… (Ward)…………………………………………………………………………….
5. Name of respondent ……………………………………………………………
6. Gender of respondent: male( ) Female( )
7. What is your tribe? …………………………………………………
8. How old are you? ……………………………………………….
9. What is your marital status? Married ( ) Single ( ) Widowed ( ) Others. Please specify? ………………………………………………………..……………
10. How long have you lived in this place? ……………………………………………
11. Are you a native of this area? Yes ( ) No ( ) if no; where did you migrate……………………. And when ……………
12. What is the education level of household head? Primary ( ) Secondary ( ) College ( ) None ( ) Otherwise ( )
13. Household composition by age category.

	Below 10	10-18	19-35	36-50	Above 50
Men					
Women					

14. Occupation of respondent i) Primary occupation……………………………………ii) Secondary occupation…………………………………………………………………

SECTION B: CROP AND LIVESTOCK PRODUCTION ACTIVITIES.

15. What types of crops did you cultivate during the last cropping season (fill in the table below).

Name of crop	**Area (Ha)**	**Irrigated=1 Rainfed=2**	**Total output (Kg)**	**Amount sold (Kg)**	**Price per unit (Tsh / kg)**	**Amount consumed (Kg)**	**Amount given away(kg)**	**Amount of crop stored**

16. What types of livestock are you keeping?

Type of livestock	Number at the beginning of 2011	Number sold in 2011	Price per unit	Number remaining at the end of 2011

17. Please fill the table below for 2011.

Type of livestock	Product produced	Amount of product sold	Per unit price (Tsh) of the product	Amount given away	Amount consumed

IRRIGATION PRACTICES

18. Please fill the table below:

Total land owned by household	Amount of land that can be irrigated	Amount of land that was irrigated last season

19. What irrigation method do you use? Center-Pivot ( ); Drip ( ); Flood ( ); Furrow ( ); Gravity ( ); Rotation ( ); Sprinkler ( ); Sub irrigation ( ); Traveling Gun ( ); Supplemental ( ); Surface ( ) or otherwise; Explain …….................
20. Water for irrigation is readily available? Yes ( ) or No ( ) if no, what mechanism is used to ensure fairy distribution of water for irrigation to farmers? ………

21. What crops do you grow in irrigated land? ....

Is there any crop that you grow and harvest twice a year? Yes (   ) or No (   ) if yes what crop(s)? Please fill the table below:

Irrigated crop	Acreage	Output (specify units)
First crop		
Second crop		
Third crop		

SECTION C: ECONOMIC IMPACT OF THE IRRIGATION SCHEME

22. How much money did your household earn from the following non-farm income sources in 2010/2011 cropping season?

Source of income	**Monthly income in TSH.**
Petty business	
Wages and salaries (employment)	
Retirement pensions	

23. Has your agricultural income increased (   ), remained the same, (   ) or declined (   ) after the commencement of the irrigation scheme?
24. For either a answer, provide above give an explanation……………………………………………………………………… ……………………………………………………………………………………… ………………………………………………………………………………………
25.
26. How reliable is income obtained from agriculture now compared to the period before irrigation? (i) Very reliable (   ) (ii) .Reliable (   ) (iii) Less reliable (   ) (iv) Not reliable at all (   ).

27. Would you say you spend more time now in the field compared to years before commencement of the irrigation scheme? ( )Yes or( ) No
28. If you spend more time on the field now, what are the reasons for that? ……….…………………………………………………………………………… ………………………………………………………………………………………
29. How much time do you spend in the field per day?.......................................

30. Please fill the table below.

Activity	**Number of persons**	**Number of days used**	**Type of labor (family, exchange or hired labor)**	**Indicate if fulltime, partime or both**
Ploughing				
Planting				
Cultivating				
Weeding				
Fertilization				
Spraying				
Irrigating				
Harvesting				

31. How do you pay them?

Type of payment	**Per hours**	**Per day**	**Per week**	**Per month**
Amounts in (Tsh)				

32. Please provide information on variable costs of inputs (including hired labour) used during last (2010/2011) season.

Crop/Livestock enterprises	Inputs used, amounts and costs			
	Type of input	Amount (specify e.g.(Bags/kg/litre)	Cost per unit e.g. Tsh/Bag	Total cost
1.				
2.				
3.				
4.				

33. Has the number of people employed in your farm
    - increased (   )
    - remained the same (   )
    - Or declined (   ) compared to the years before irrigation.
34. If the number of employees has either increased or decreased, please explain the reason(s) for that.
    ……………………………….……....………………………………
    ……………………………………………..……….………………………………………
    ……………………………………………..……….………………………………………

FOOD SECURITY

35. Comparing the period before and after your involvement in irrigation, is your household? (a) More food secure (   ) (b) no change (   ) (c) less food secure (   ).
36. Do your household members sometimes go hungry? (   )Yes or (   )No
37. Are you able to feed yourself from own produced food throughout the year until the next harvest? Yes (   ) or No (   ).

38. If No, how many months in a year is your household able to adequately feed itself from own produced food? Tick on the mentioned months.

Months	Put tick on the mentioned months
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

39. How many meals does your household consume per day? a) three ( )b) two( ) c) one( ) d) sometimes no meal at all( ) e) other ( )*(state)*………
40. How much money does your household spend on food per month? TSH…………..…………………………………………………………………………..
41. Please rank the sources of food in your household in 2010/11 in order of importance (Most important =1)

Source of food	Rank
Own farm production	
Purchase	
Given by neighbours/friends/relatives	
Government food relief	

42. If you purchase food, how do you compare the amount of food purchase with the amount you used to purchase before being involved in irrigation? (i) Increased ( ) (ii) Remained the same ( ) (iii) Decreased ( ).

43. Please fill the table below.

Total Income earned	Income for food	Income for health service	Income for children education	Others activity

44. Please indicate household assets (and their value) which were purchased since you started irrigated agriculture?

Type of assets	**Number**	**Value**
Physical e.g. land, livestock, new house construction or rehabilitation of old house etc		
Land		
New house constructed (Indicate stage of new house)		
Rehabilitation of old house		
Livestock purchase		
Equipment and tools acquired e.g. ox-carts, TV, radio, mobile phone, plough, hand hoe etc		
Other (specify)		

Appendix 2: Questionnaire for Non Irrigator Farmers. Questionnaire on Economic Viability and Economic Impact of Mkindo Irrigation Scheme In Mvomero District, Tanzania

SECTION A. GENERAL INFROMATION

1. Questionnaire number: ……………………….……………………………….
2. Name of interviewer …………………………………………………………….
3. Date of interview ……………………………………………………………..
4. Location of farm (Village)……………………………… ……………………… (Ward)……………………………………………………….
5. Name of respondent ………………………………………………………………
6. Gender of respondent: male( ) Female( )
7. What is your tribe? …………………………………………………
8. How old are you? …………………………………………………
9. What is your marital status? Married ( ) Single ( ) Widowed ( ) Others. Please specify? …………………………………………………………………………
10. How long have you lived in this place? …………………………………………….
11. Are you a native of this area? Yes ( ) No ( ) if no; where did you migrate……………………. And when ……………
12. What is the education level of household head? Primary ( ) Secondary ( ) College ( ) None ( ) Otherwise ( )
13. Household composition by age category.

	Below 10	10-18	19-35	36-50	Above 50
Men					
Women					

14. Occupation of respondent i) Primary occupation……………………………………ii) Secondary occupation…………………………………………………………………

SECTION B: CROP AND LIVESTOCK PRODUCTION ACTIVITIES.

15. What types of crops did you cultivate during the last cropping season (fill in the table below).

Name of crop	**Area (Ha)**	**Irrigated=1 Rainfed=2**	**Total output (Kg)**	**Amount sold (Kg)**	**Price per unit (Tsh / kg)**	**Amount consumed (Kg)**	**Amount given away(kg)**	**Amount of crop stored**

16. What types of livestock are you keeping?

Type of livestock	Number at the beginning of 2011	Number sold in 2011	Price per unit	Number remaining at the end of 2011

17. Please fill the table below for 2011.

Type of livestock	Product produced	Amount of product sold	Per unit price (Tsh) of the product	Amount given away	Amount consumed

SECTION C: ECONOMIC IMPACT OF THE IRRIGATION SCHEME

18. How much money did your household earn from the following non-farm/farm income sources in 2010/2011 cropping season?

Source of income	**Monthly income in TSH.**
Petty business	
Wages and salaries (employment)	
Retirement pensions	

19. How reliable is income obtained from agriculture now compared to other activities? (i) Very reliable (   ) (ii) .Reliable (   ) (iii) Less reliable (   ) (iv) Not reliable at all (   ).

20. For either a answer, provide above give an explanation…………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………

21. How much time do you spend in the field? ……………………………………
22. Please fill the table below.

Activity	**Number of persons**	**Number of days used**	**Type of labor (family, exchange or hired labor)**	**Indicate if fulltime, partime or both**
Ploughing				
Planting				
Cultivating				
Weeding				
Fertilization				
Spraying				
Irrigating				
Harvesting				

23. How do you pay them?

Type of payment	**Per hours**	**Per day**	**Per week**	**Per month**
Amounts in (Tsh)				

24. Please provide information on variable costs of inputs (including hired labour) used during last (2010/2011) season.

Crop/Livestock enterprises	Inputs used, amounts and costs			
	Type of input	Amount (specify e.g.(Bags/kg/litre)	Cost per unit e.g. Tsh/Bag	Total cost
1.				
2.				
3.				
4.				

25. Do you employ people during the farming season? Yes (   ) No (   )
26. If Yes how many people? (   )

FOOD SECURITY

27. Do your household members sometimes go hungry? (   )Yes (   )No
28. Are you able to feed yourself from own produced food throughout the year until the next harvest? Yes (   ) No (   ).
29. If No, how many months in a year is your household able to adequately feed itself from own produced food? Tick on the mentioned months.

Months	Put tick on the mentioned months
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

30. How many meals does your household consume per day? a) thrice (   ) b) twice(   ) c) once(   ) d) sometimes no meal at all(   ) e) other ;explain………………………….
…………………………………………………………………………………………
…………………………………………………………………………………………
31. How much money does your household spend on food per month? TSH………...……………………………………………………………………
32. Please rank the sources of food in your household in 2010/11 in order of importance (Most important =1)

Source of food	Rank
Own farm production	
Purchase	
Given by neighbours/friends/relatives	
Government food relief	

33. Please fill the table below.

Total Income earned	Income for food	Income for health service	Income for children education	Others activity

34. Please indicate household assets (and their value) which were purchased since 2009?

Type of assets	**Number**	**Value**
Physical e.g. land, livestock, new house construction or rehabilitation of old house etc		
Land		
New house constructed (Indicate stage of new house)		
Rehabilitation of old house		
Livestock purchase		
Equipment and tools acquired e.g. ox-carts, TV, radio, mobile phone, plough, hand hoe etc		
Other (specify)		

Appendix 3: Discounted Cost and Benefit

Forecasted Cost	Forecasted Revenue	Net Revenue	Year	Discounted net Revenue
47935150	84725000	36789850	1	32848080.36
47385750	205820000	158434250	2	126302814.1
94771500	224607500	129836000	3	92414700.26
80926780.64	450422920.6	369496140	4	234821476.9
77907470.41	488239270.2	410331799.8	5	232833283
77282094.76	511367824.6	434085729.8	6	219921340
77152563.63	525571870	448419306.4	7	202842121.4
77125734.45	534373334.9	457247600.4	8	184674636.9
77120177.45	539886670.1	462766492.7	9	166878236.5
77119026.45	543379286.9	466260260.4	10	150123325.1
77118788.05	545617011.9	468498223.9	11	134682044.2
77118738.67	547063284.7	469944546	12	120623060
77118728.44	548006063.1	470887334.7	13	107915223.6
77118726.32	548623459.7	471504733.4	14	96479210.19
77118725.88	549031117.5	471912391.6	15	86216629.59
77171123.25	549300822.1	472129698.9	16	77014581.08
77129578.62	549479543.6	472349965	17	68795099.35
78191024.33	549600403.7	471409379.4	18	61301882.47