THE ECONOMIC EFFICIENCY AND EFFECTIVENESS OF DOMESTIC WATER ALLOCATION IN MOSHI RURAL DISTRICT: THE CASE OF KIRUA-KAHE

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ABSTRACT

Water is one of the scarce resources very important for the development for humankind hence efficient allocation is needed. Economically, efficient allocation of water is desirable to maximize the welfare of the society that obtains from available sources. The rural population water supply services have been left behind which increase with domestic water demand. There are some initiatives in Moshi Rural District to establish some water projects so as to solve the problem of water scarcity. There was a need to know the efficiency of domestic water allocation for the case of Kirua-Kahe because relatively little is known about the service and satisfaction of customers.

There are three specific objectives in this study which are to evaluate the domestic water allocation of Kirua-Kahe Water Project in Moshi Rural District, to determine the domestic water allocation efficiency in Kirua-Kahe Water Project and to examine the effectiveness of Kirua-Kahe domestic water allocation in Moshi Rural District. Cross section or survey design was used with both quantitative supplemented with qualitative approach to present results. Methods for data collection involved primary and secondary sources through interviews, questionnaires and direct observations.

Findings show that Kirua-Kahe uses Gravity and Pumping systems for supplying water. Gravity water supply system has 8 working intakes, 2 boreholes while Pumping water Supply system consists of 15 small pumping schemes being pumped from boreholes and 1 spring. Until January 2015, Kirua-Kahe Gravity had a total of 5 403 customer connections and 401 customer connections for Kirua-Kahe Pumping. Customers are Public, Homes, Social Institutions and Commercial connection through pricing system. The economic efficiency was carried out based on analysis of usage and collection efficiency and all constraints and optimality conditions were satisfied. Further research and more water projects is needed, to design service delivery models, technological innovations and education.

DECLARATION

I, PETER ONESMO META, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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The above declaration is confirmed;

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DEDICATION

This dissertation is dedicated to my Parents Mr Onesmo Meta and Mrs Fuyamen Meta for their tireless efforts in nurturing my academic endeavors. Whenever I needed their help and support they have been the most concerned to me. Secondly, the work is dedicated to all my brothers James, Michael, David, Calvin, Xavier and my sister Lilian with their families for their encouragement and prayers during my studies.

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LIST OF ABBREVIATIONS AND ACRONYMS

CBNRM	Community Based Natural Resource Management
DWE	District Water Engineer
EEA	European Environment Agency
H	hour
Km	Kilometer
Kw	Kilo watt
LP WYE	Linear programming from Wye college
M SC (ENAREC)	Masters of Science in Environmental and Natural Resource Economics
m^3	Cubic Meter
MDSP	Moshi District Socio-Economic Profile
MS EXCEL	Microsoft Excel
MS WORD	Microsoft Word
OECD	Organization for Economic Cooperation and Development
PRO	Public Relation Officer
PRT	Pressure Reducing Tank
PS	Personal Secretary
S	second
UN	United Nations
URT	United Republic of Tanzania
UWUA	Uchira Water Users Association
WHO	World Health Organization
Z	Objective function

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Water is one of the scarce resources which requires effective and efficient allocation due to economic characteristics it holds (Bradlow and Salman, 2006). It is essential resource for both life and all economic activities, including agriculture, energy and industrial outputs (EEA, 2012). Therefore water is necessary to be reliable, clean and sufficient not only for human health and well being but also essential for freshwater ecosystems and many services that they provide.

Globally, the problem of water allocation is considered as severe and countries are working towards effective water management system which requires a strategic approach involving both equitable and sustainable management (Hemson *et al.*, 2008). Tanzanian projections show that water availability will reach 1500m^3/capita/year by the year 2025 (URT, 2008). By 2025 Tanzania rural population is estimated to reach 60% of the total population and Moshi Rural Dostricts' population is growing at 1.9 % rate annually and one of the constraints is linked to water infrastructures (URT, 2002 cited by Meena and Shariff, 2008). Besides, Moshi Rural District population was 466 737 in the 2012 census and this growth will have a negative impact on water demand if appropriate measures are not taken into consideration whereby coverage of water supply in rural areas is below 50% indicating scarcity (URT, 2005).

Economic efficiency of water allocation is desirable to the extent that it maximizes the welfare of the society that obtains from available water sources. It requires both technical and cost efficiency for production of goods and services (Mann, 2008; URT, 2011).

Based on scarcity, economics defines the conditions required to secure the most efficient allocation of scarce resources in a variety of contexts. According to United Nations, water scarcity is denoted by 1000m^3/capita/year. Below the level of 1700m^3/capita/year is denoting water stress. Resource efficiency under this study normally refers to the ratio of resource inputs on one hand to economic outputs and social benefits on the other (EEA, 2012).

However, decisions concerning water allocation are guided not only by concerns of economic efficiency but also considerations of effectiveness through equity, environmental protection, social and political measures to ensure sustainability, guided by various theories, development plans, policies, legislations and regulations through water institutions (Bradlow and Salman, 2006; Brouwer *et al.*, 2003).

1.2 Problem statement and justification of the study

1.2.1 Problem statement

There has been an increase of human activities and one of the most affected areas are water sources and infrastructures which has resulted to many environmental problems one of it being water shortage. The rural population water supply services have been left behind which has resulted to increase in the demand for domestic water. Moshi Rural District is among the rural areas with various economic activities which have raised the demand for domestic water as time goes and there are problems which indicate that there is scarcity while the demand is still increasing both quantitatively and qualitatively. According to MDSP (2011) the major water sources originate from Mount Kilimanjaro and 98% of all sources have been destroyed. Currently there are initiatives that are being taken to restore the situation through undertaking various measures through establishment of well operating water projects and institutional set up. Kirua–Kahe is one of the areas where these initiatives have been done and results of these initiatives show a success but its level is not known while the effectiveness of domestic water supply seems to be threatened by destruction of water sources, infrastructures and population increase.

There are water committees and boards that have been established in Moshi Rural District for the purpose of ensuring enough, safe and potable water supply (Braathen, 2004). There was a need to know the efficiency of domestic water allocation in Moshi Rural District for the case of Kirua-Kahe to measure the success. Inspite of the importance of providing safe and reliable domestic water for poverty reduction and social development, also relatively little is known about user's satisfaction with the services.

1.2.2 Justification of the study

Since water is a very important and scarce resource for domestic consumption and Kirua-Kahe Water Supply Project is among the leading initiatives made in Moshi Rural District, its allocation seems to show success but there was no enough information on its efficiency. There are very few studies regarding the efficiency and effectiveness of domestic water allocation at ward or village levels whereby most information is generalized at national level. The research findings will be beneficial to various groups of people through providing necessary information as a benchmark for ongoing measures of domestic water supply for the whole of Moshi Rural District and elsewhere as well as addressing effective ways of its allocation that will help to overcome the threat of water shortage and to ensure sustainability.

The efforts and measures that are taken to achieve the objectives or goals, can either be quantified or show indications of their failures and successes that need to be addressed. Therefore there was a need to conduct a research towards efficiency of domestic water allocation under Kirua-Kahe in Moshi Rural District and assess the effectiveness of supply services in terms of satisfaction with the supply services for the sustainability of the service.

1.3 Objectives of the study

1.3.1 Main objective

The general objective of this study was to investigate the economic efficiency and effectiveness of domestic water allocation in Moshi Rural District the case of Kirua-Kahe Water Supply.

1.3.2 Specific objectives

The specific objectives of this study were to:

i. evaluate the process of domestic water allocation of Kirua-Kahe Water Supply in Moshi Rural District.
ii. determine the domestic water allocation efficiency in Kirua-Kahe Water Supply.
iii. examine the effectiveness of Kirua-Kahe domestic water allocation in Moshi Rural District.

1.4 Research questions

This study aimed to answer the following questions:

i. How efficient is domestic water allocation under Kirua-Kahe Water Supply in Moshi Rural District?
ii. What are the factors affecting efficiency of Kirua-Kahe domestic water allocation?
iii. To what extent is Kirua-Kahe domestic water services effective?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Water resource and its allocation

Water is key resource for human and economic development as well as supporting the ecosystem. Basically, there are two major sources of fresh water which are surface water in form of rivers, streams, lakes and ponds which are being supplied through gravity and ground water in the form of reservoirs that are accumulated below the earth's surface (Dhriti *et al.*, 2014). According to UN (2000), water allocation refers to the combination of actions that will make water users to receive water for their own benefits using a well recognized system of rights and priorities. Water resources have been allocated from earliest times due to global and local challenges that threaten the availability of water where ecosystems are suffering and conflicts between water users are increasing (Clements, 2015; Gurria, 2009; Le Quesne, 2007). There are ways to address these challenges one being water allocation and water rights. In many countries water policies and laws have been formulated as the major solutions and efficiency tends to be a perfect goal for the allocation of water (Gurria, 2009; Hodgson, 2006).

The notion of efficiency for water sources has two main interpretations which are technical and allocation efficiency. Water distribution systems efficiency is measured by comparing the water that is delivered to final users with the water that is treated or lost in the distribution system. Therefore, the allocation system is through granting water entitlements through a variety of administrative and geographical levels. In water use, technical efficiency has recently been interpreted in the sense of increasing output which is production of water and there are no limits to conservation, productivity or income generation (Le Quesne *et al.,* 2013). Equity, environmental protection while balancing supply and demand promote the efficient use of water.

One of the Dublin Principles state that water as an economic good (Gurria, 2009). It is regarded as a resource that is generally non-substitutable and renewable but still reduced as a resource with time. There is an increasing overall demand for water, water use is intensifying, and there are limits to its use (Lewis and Tietenberg, 2012). According to UN Environmental Program (2002), about 90% of readily available fresh water is the ground water but only 2.5% of the ground water is available for renewable process. The rest is non renewable and depletable resource.

In the URT (2002) the policy direction insists the allocation of water for basic human needs with adequate quantity and acceptable quality will receive highest priority, while other uses will be subject to social and economic criteria. Therefore, efficient use of scarce clean and safe water resources would be secured if those who are willing and able to pay the cost for water gained access to it, assuming that these would be able to secure the highest returns (Hemson *et al.*, 2008).

The meaning of domestic water according to WHO is water used for all usual domestic purposes including consumption, bathing and food preparation (Bartman and Howard, 2003). According to Savenije and van Der Zaag (2006), the primary uses of water have a special characteristic such that the elasticity becomes inelastic when the needs approach to the more essential needs of the user (Figure 1). Water is regarded as a "white gold" since people need water whatever the price or cost, the most essential use of water is for domestic use mostly for human consumption. For sectors such as industry, commerce and agriculture demand for water is generally more elastic. Water allocation is charged according to the economic sector including domestic, commercial or social services as from this study. Also, to some extent higher efficiencies are achieved through introducing water saving production technologies, shifting to less water demanding products or crops.

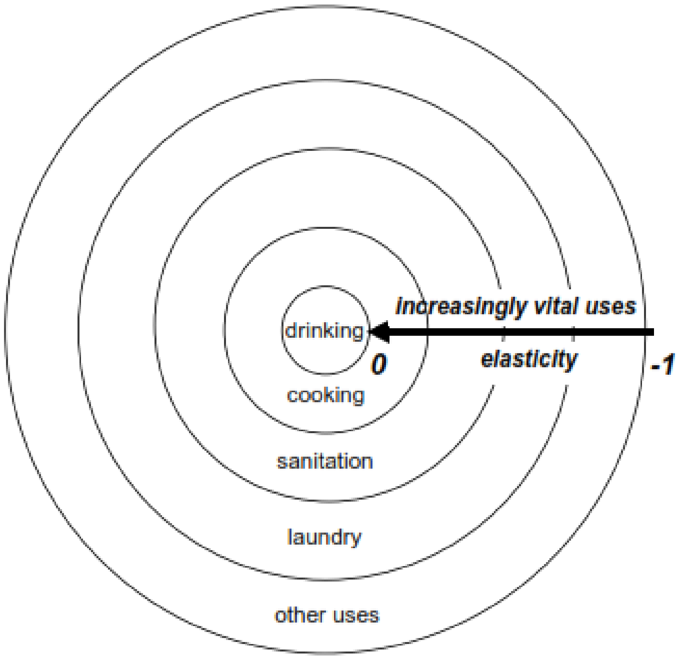

Figure 1:Different uses of water with different elasticities of demand

Source: Savenije and van Der Zaag (2006).

2.2 Economic Efficiency and Effectiveness of water allocation

Economic efficiency of water allocation exists when the marginal benefit from the use of this resource is equal across all sectors which maximize the social welfare (Braggins *et al.*, 2001). This is achieved through the allocation of water to uses that are of high value to society away from uses with low value (Hodgson, 2006; Kadigi *et al.*, 2002). Water uses differ from various areas of the country particularly between urban and rural areas and also individuals do not have the same utility functions.

An allocation of water resources describes what quantity and quality is produced, which combination of resource inputs used and how the output is distributed between people. Dinar *et al*. (1997) cited by Braggins *et al.* (2001) suggests a list of necessary criteria for achieving optimal resource allocation. These are flexibility in the allocation of supply, security of tenure for established users, real opportunity cost of providing the resource is paid for by the user, predictability of the outcome of the allocation process, equity of the allocation process and public acceptability of the allocation process.

According to Ombrados *et al.* (2012) there are ways at local and technological level that have been developed to address the problem of unsafe water in areas where piped water is being supplied. There are also water treatment methods including locally produced ceramic filters, dilute chlorine, solar disinfection, combined flocculation disinfection systems and the practice of boiling that are intended to make water microbiologically safe to drink.

Water quality is guided by several parameters such as physical parameters, chemical parameters and biological parameters which are very important for various purposes since there is a need for ensuring high quality of water (Dhriti *et al.*, 2014; Hickey, 2008). Water quality is very important to be considered in order to overcome the problem of waterborne diseases such as diarrhea, cholera and typhoid. The demand for water supplied has its own driving components mainly is consumer consumption either daily or monthly per capita or household determined for various purposes. Therefore, the average daily consumption can be determined by looking on the demand and uses for water.

Tanzania is one of the African countries which is endowed with water resources through rivers, lakes, wetlands and aquifers. In rural population, the water supply service is not left behind and the coverage increased from 48.5% in 2000 to 53% in 2003. The major water uses in Tanzania are irrigation accounting for about 89% domestic use covers about 9% and industrial water demand 2% (URT, 2008). Therefore, water is the basic resource due to its social-economic potential for human activities (URT, 2002). Domestic water is the most important use and major concern of this study. Access to water is a function of financial power and managerial efficiency (Hemson *et al.*, 2008).

2.3 Water policy and legislative study

Water is a key and pre-requisite for human being and other living things. Poor governance and inadequate investment as well as failure to manage water resources effectively has caused the population pressure not to have access while others suffers unsatisfactory services. Therefore additional financial resources are necessary but not sufficient condition for achieving international standards without the economic backbone of water policies (Gurria, 2009). As population increases, it is estimated that by 2015, with the rates reported in 2002, water services will need to be provided to approximately 32 million Tanzanian rural inhabitants. The water sector targets that were set to be achieved by 2010/11 was to increase proportion of rural population that has access to clean and safe water from 53% in the year 2003 to 65% by the year 2010/11 within 30 minutes of time spent on collection of water (URT, 2008).

The vital importance of water has also posed some challenges to law makers (Hodgson, 2006). Many traditional approaches to water rights have moved to modern water rights. According to Gurria (2009), there are some of modern water legislations in countries such as South Australia Water Resources Act of 1997 there is provision of licence which can be passed to another division which deals with the trading of licence or there is a passing of property. In Chilean law, water is considered as a public good where individuals can purchase rights of use by receiving grants from the state by prescription or by purchasing water rights.

The Local Government Act of 1982 for both District and Urban Authorities gives the respective Authorities, and Township Authorities, powers to establish, maintain, operate and control public water supplies drainage and sewerage work. Also the Tanzanian policy goal is to develop detailed criteria for water allocation, taking into account all social, economic and environmental criteria and raise awareness on the water allocation mechanisms and procedures (URT, 2002).This Water Act has been made similar to many of international laws from other countries as mentioned by Bradlow and Salman (2006)

2.4 Water valuation theory

The first step in deriving appropriate monetary measures of the utility change associated with changes in the quality or quantity of environmental goods is the assumption that the quality and quantity of environmental goods can be treated as an argument in a well behaved utility function (Common *et al.*, 2011). One of the most discussed and debated issues related to economic efficiency of water allocation is establishing the economic value of water. This valuation is the application of various techniques that will assist in the process of establishing a price or economic value of water.

This is a well established concept in the theory of resource economics which seeks to define the conditions in which a scarce resource such as water may be allocated producing the maximum welfare for society, such allocation is indicated as efficient (Arena *et al.,* 2009). The evaluation of efficient water resources allocation scenarios is very valuable as it allows a straightforward assessment of the actual value of resource.

Effective measuring of water values and demand skills as well as application of various tools such as data collection, statistical analysis, optimization models and research reporting. Water is valued in consumptive or withdrawal uses and in stream or amenity within the environmental value (Braggins *et al.*, 2001). If water can be freely traded then any allocation for a particular use can be transferred to another use and the initial benefits will be lost. One way is to make the rights tradable with a submarket which relates to a particular product. In fact, the right will have to be restricted in terms of what it can be used for. The restriction is not only because of the divergence between social benefits and private benefits from a particular use. However, the divergence may not persist over time and therefore it is necessary to change the mechanism for the permitted use if the initial use is no longer socially efficient.

2.5 Methods for economic valuation

Economists have long used a variety of valuation approaches to understand and estimate the value of natural resources. The principle economic valuation methods can be grouped into different categories based on different criteria on whether the behaviour is within real markets or hypothetical response. The other criteria is whether monetary values derived are observed technically in markets or merely inferred from behaviour and preferences (Aylward *et al.*, 2010).

The values of water as other natural resources can be categorized using various criteria. One of the mostly used is human values and non-human values. Human values are those which various groups of people consider to be the values of water resources for either use or non use. Under the use value can either be direct use value, indirect use value (ecological values) and quasi-option values while under non-use value can be rated for existence value, quasi-option values and vicarious values or bequest value (Bennett, 1998;

Price, pers.comm. 12.06.2009; Bateman *et al.,* 2003; Gowdy and Erickson, 2005; Gasparatos *et al.,* 2008 Pearce and Özdemiroglu, 2002; Edwards and Abivardi, 1998; Barrow, 1999 cited by Lusambo, 2009).

2.6 Approaches of domestic water allocation

A variety of institutional arrangement can be done to make sure that there is efficient allocation of resources such as dictatorship, central planning or free markets. Any of these could in principle achieve an efficient allocation of water resources (Common *et al.*, 2011). Also there are two aspects to consider in outlining the supply of water to final users who may be either wholesale supply, retail supply or both (Counsell, 2003).

2.6.1 State centred water management

According to Lein and Tagseth (2009) state centred approach requires planning tasks to be carried out by special water management authorities, having superior knowledge and overview of available resources, possible ways of using water and also ideas and tools to decide on the optimal way of allocating resources, a level like the ministry of water in Tanzania. Water is treated as a public good and large scale water development is generally too expensive for the private sector. State centred approach alone has been challenged within what has been termed classical, top-down approach to rural development and environmental management and difficult to manage.

2.6.2 Community-based water management

Community-based Natural Resource Management (CBNRM) has become a standard part of the international support due to the observed challenges in the state centered approach (Barron *et al.*, 2005). The idea is that local communities are the key players in resources allocation through water laws in rural areas within developing countries (Butterworth *et* *al.,* 2007). According to URT (2002), the policy statement support that the provision of rural water supply needs active participation and support of the beneficiary communities which leads to effective awareness to the community's role as beneficiaries.

The Tanzania National Water Policy direction: communities are empowered to initiate, own, manage, operate and maintain their water schemes. The responsibility for operation, maintenance and contribution to capital investment costs lies in the communities so as to improve the sustainability of rural water supply systems (World Bank, 2007). In the new water policy the importance of community participation and management in on-going and new projects has been mentioned. In order to improve water supply services at the village level, the role of the government and other stakeholders has been summarized in the water policy.

At the village level, small-scale water supply projects are to be operated and managed by the village authorities. Operation and management costs are met with funds raised within those communities. The emphasis is on management by participation through formulation of village water committees that oversee and manage the utilities on behalf of community members. The communities agree upon the operational modes with specific emphasis being paid to women participation at all stages of water project development and management. For the district level, the water is required to facilitate training of water managers and attendants/mechanics at the village level. The department is expected to maintain a pool of experienced technicians who will collaborate with village level mechanics in servicing and repairing established utilities. Another role of the water department at the district level is to make sure that necessary spare parts are available when needed.

Under the stated policy goal, the strategy for community ownership and management will be to take some initiatives that involve the community through raising awareness and prepare guidelines in the operation of community owned organizations. There are serious challenges, for instance from increasing number of users ("the tragedy of the commons"), in enforcing rules ("the free rider problem"). Nevertheless, there is little doubt that actual community-based water management systems do have some success as they contribute to sustaining the livelihoods of many people (Lein and Tagseth, 2009).

2.6.3 Water management through market

The fourth principle in the Dublin statement on water and sustainable development states that water has an economic value in all its competing uses and should be recognized as an economic good (Savenije and van Der Zaag, 2006). In modern welfare economics which is the basis for environmental and resource economics, markets are the way economies are mainly organized in production and consumption in human societies. Welfare economics theory points a set of circumstances on how the system of free markets would sustain an efficient allocation of resources. There is a need of institutional arrangement to assume that the actors in that system behave in certain ways. Firms are assumed to maximize profits and individuals maximize utility that makes both agents as maximizers (Common *et al.*, 2011; Veetil, 2011).

There are motivations for water pricing as an instrument of stimulating resource allocation and manage the demand for water supply. It can be used to recover the cost of providing the service, provide an incentive for the efficient use of scarce water resources and to be used as a benefit tax on those receiving water services. Also, allocation of water through pricing leads to maximization of efficiency which is the highest and best use from the perspective of the economy as a whole (Gurria, 2009; Perry, 2001). Water measurement is made possible through specialized tools such as gauging plates, meters and recorders used for charging based on the volume of water used. It is a tradition in economics to consider many important variables including costs and benefits as functions of a single variable under control. The incremental benefits from increasing its value is referred to as marginal benefit (Lewis and Tietenberg, 2012).

Under the market system water allocation in rural areas is done through establishment of local water institutions that are largely independent (Farolfi *et al.*, 2006; Le Quesne *et al.*, 2007). These locally established institutions help in designing a decentralized and locally managed water rights, sharing and management which are very crucial for achieving policy goals of economical, equitable, efficient and sustainable use of water resources (Veetil, 2011; Mehta, 2010). However, there are two important aspects distorting the functioning of the market: that the water supplier is always a monopolist and in those urban and some rural centres applying an increasing block tariff. The most essential and most highly valued uses are priced lowest (the first block), whereas other less essential uses are priced highest (subsequent blocks) such as commercial uses (Bao and Jia, 2014; Kayaga, 2006; Savenije and van Der Zaag, 2006).

2.7 Optimality in water resources allocation

The efficiency of water allocation is determined through the concept of optimality but a resource use is optimal if it maximizes that objective given any relevant constraints that may be operating. Therefore, the allocation of water resources cannot be optimal unless it is efficient and hence efficiency is a necessary condition for optimality. Efficiency in general, is the measure of the extent that is achieved in implementing certain goals or objectives. Efficiency in allocation is different from technical efficiency in production. In allocation, efficiency requires three conditions to be fulfilled which are consumption, production and product-mix efficiency (Common *et al*., 2011). An optimal water resources allocation model is based on supply constraints. Optimization focuses on evaluation of allocation efficiency and finding the optimal solution from millions of possible alternatives given certain constraints. An example of such an algorithm is linear programming (Droogers, 2013). The optimum solution derived is predicted on perfect knowledge of each of the parameter value. The exogenous parameters of a linear programming are not usually known with certainty and estimated by statistical techniques.

2.7.1 Assumptions of linear programming

According to McCarl and Spreen (2011), there are seven important assumptions that support the Linear programming relative to the problem being modeled. The first three assumptions deal with the appropriateness of the formulation and the last four deals with the mathematical relationships within the model.

The first assumption is objective function appropriateness. Secondly, is the decision variables appropriateness which is the specification of the decision variables that have been included in the model. Thirdly, is constraint appropriateness where there are sub-assumptions and the constraints must identify fully the boundary that is placed on the decision variables. The fourth assumption is proportionality which deals with the contribution per unit of each decision variable to the objective function. The fifth assumption is based on additivity which deals with the relationships among the decision variables. The sixth assumption is divisibility which refers to all problems formulation assumes that all decision variables can take any non-negative value including fractional ones. The seventh and the last assumption is certainty which requires that parameters be known constants.

After developing a linear programming model, a sensitivity analysis is conducted by varying one of the exogenous parameters and observing the sensitivity of the optimal solution of that variation. Objective (goal) function is to optimize through consumer satisfaction in water demand for domestic uses such as consumption, hygiene, amenities and production uses (Bao and Jia, 2014). Before embarking on using linear programming it is necessary to know various aspects such as information on water consumption, supply and the cost of water. Basically, linear programming has three components which are decision variables which under the research quantity, price and sources for both obtaining and provision water services will be taken into consideration as the evaluation parameters.

2.7.2 Assumptions of linear regression

According to Andren (2007), there are seven assumptions guiding the simple linear regression model. The first assumption is that the relation between Y and X is linear and the value of Y is determined for each value of X. The second assumption is that the conditional expectation that the residual is zero. Furthermore there must not be any relationship between the residual term and the X variable which means that they are uncorrelated. This further means that the variable left unaccounted in the residual should have no relationship with the variable X included in the model. Thirdly, the variance of the error term is homoscedastic. This means that the variance is constant over different observations. Since Y and μ only differ by a constant, their variance must be the same. The fifth assumption is that the covariance between any pair of error terms is equal to zero. Sixth assumption is that X cannot be constant within a given sample since we are interested in how the variation in X affects variation in Y. The seventh assumption is that μ is normally distributed with the mean and variance. This assumption is necessary in small samples. The assumption affects the distribution of the estimated parameters.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Description of the study area

The study was conducted in Kirua-Kahe located in Moshi Rural District. Moshi Rural District lies between longitude 37° to 38° East and latitude 2° 30’ - 50° south of the Equator. The district is bordered to the north by the Rombo District, to the west by the Hai District, to the east by Mwanga District and Kenya, and to the south by the Moshi Urban District. The 2012 census, the population of the Moshi Rural district was 466 737 and Kirua-Kahe area had 52 023 people which occupy 11.146% of the district. Moshi Rural District is divided into 4 divisions, 31 wards, and 145 villages (Fig. 2).

This study was only limited to Kirua-Kahe due to the vastness of Moshi Rural district area. Also, there are well organized water supply boards in Kirua and Kahe where enough information was collected. Kirua-Kahe area was selected because of its geographical variations which covers the highland and the lowland areas thereby it was enough to represent Moshi Rural district which has both characteristic conditions that allow a fair representation. Also Kirua-Kahe has water Boards running the water projects to restore the supply systems which were required to undertake their efficiency.

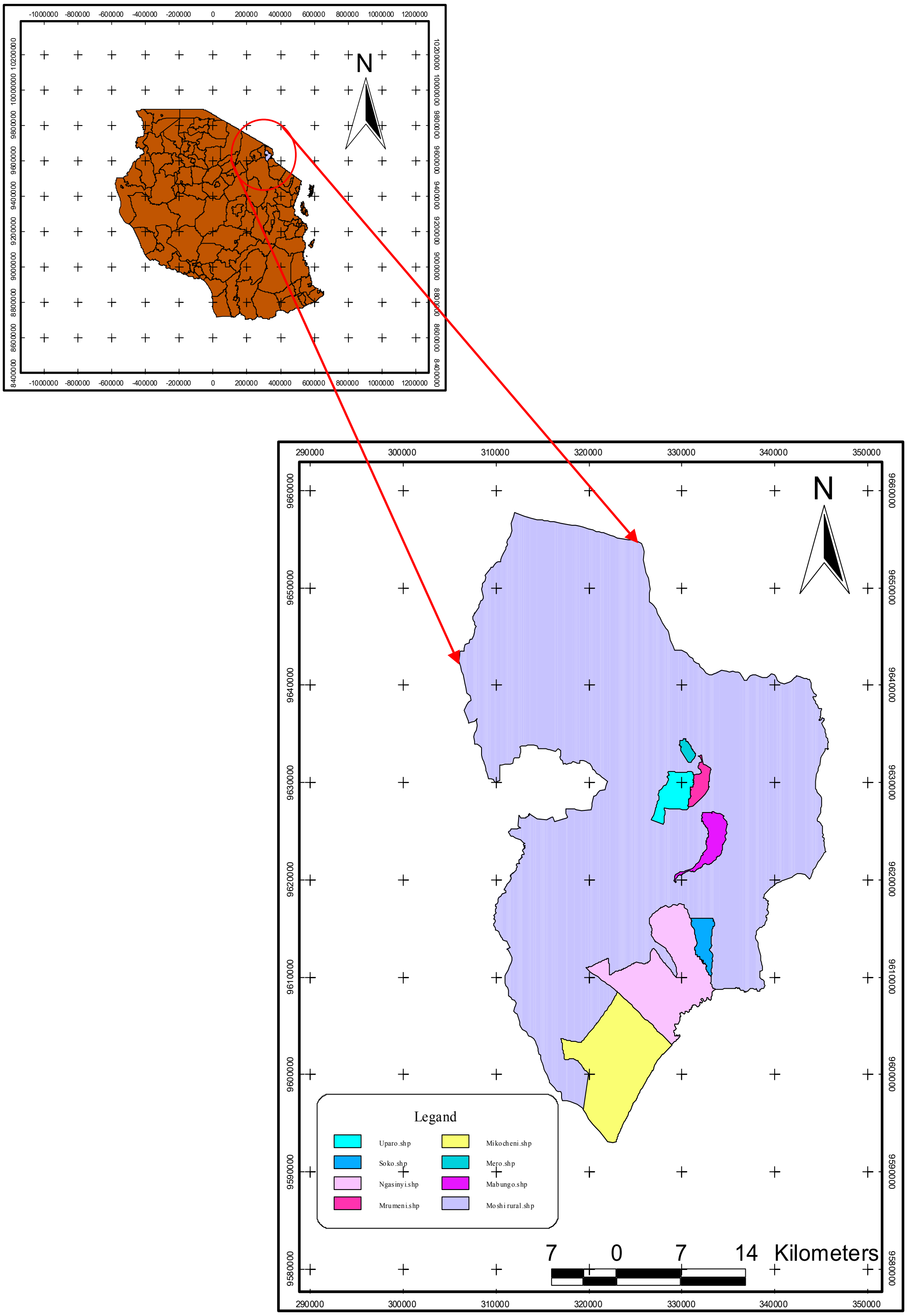

Figure 2: Map of Moshi Rural district showing the study site

3.2 Research design

The cross-sectional research design was used in this study. Cross-sectional research design is sometimes referred to as survey design, usually connects people's minds with questionnaires and interviews. It refers to the collection of more than one case at a single point in time collecting quantifiable data with two or more variables that are connected and examined to detect pattern of their association. It has three distinctive features such as no time dimension, a reliance on existing differences rather than change following intervention. Groups are selected based on existing differences rather than random allocation. The cross-sectional design can only measure differences between or from among a variety of people, subjects, or phenomena rather than change (Bryman, 2003; Lavrakas, 2008).

The study used quantitative approaches which were mainly used to present results while qualitative data were used to some of results in order to supplement the quantified data. For the purpose of harmonizing the two approaches, both quantitative and qualitative data, were merged and the results were interpreted together to provide a better understanding of a phenomenon of interest as recommended by Kothari (2003).

3.3 Population

The target population consisted of officers of Kirua-Kahe Water Supply and Village Authorities who were the key informants and households. The category of Kirua-Kahe Water Supply involved Managers who were in charge of overseeing almost all water allocation matters and activities such as administration, planning, management and control. The group of Village Authorities involved Village Executive Officers who were involved in participation of water allocation matters. For the household, the study involved family heads who shared their experiences and direct users of domestic water.

3.4 Sampling techniques

The study sample was clustered into two areas which were Kirua and Kahe where there are gravity water and pumping water supply systems respectively whereby Kirua had 18 customer villages and Kahe had 15 customer villages. Simple random sampling was used to pick four villages from each cluster which made a total of eight sampled villages. The sampled villages were villages form Kirua-Kahe gravity were Mero, Mrumeni, Kilototoni and Uparo while Kirua-Kahe pumping area Mikocheni Kubwa, Ngasinyi, Mwangaria and Soko were picked. The final stage of this process involved implementation of a simple random sampling of 12 households from each village which made a total of 96.

Villages and households were selected randomly for the purpose of obtaining the sample population and households were divided basing on gender (Allan *et al.,* 2004). Therefore heads of household were picked during data collection and if both were present they were selected randomly basing on gender while the other head was there to make sure that the data collected are more accurate. Purposive sampling was employed to gather data from village officials and water project officials who were key informants and who were expected to increase the reliability of data.

3.5 Sample size determination

In this study, selection of the sample is determined by many aspects including time, financial condition, and nature of the required information and homogeneity of a potential study population. Since it is difficult to deal with the whole population, minimum sample of 30 respondents is proposed to be enough (Bailey, 1994). Therefore, the study was objectively confined to 110 respondents as a sample size for data generation based on the available respondents who provided enough information (Table 1). The sample included three water officials from each sub office and eight village authority officers as key informants and 96 households from the eight sampled villages. These three officials were managers, Technical and accountants.This sample was enough to represent the population of Kirua-Kahe in Moshi Rural District.

Table 1: Sample size

	Water officials		Village officers		Households		Total	
	M	F	M	F	M	F	M	F
Kirua-Kahe gravity	02	01	02	02	14	34	18	37
Kirua-Kahe pumping	03	00	04	00	14	34	21	34
Total	05	01	06	02	28	68	39	71

Note: M- Male, F- Female

3.6 Methods of data collection

The study involved both primary and secondary sources of data. A variety of data collection methods was used to generate information as no single research method is considered to be completely enough.

3.6.1 Interviews

Interview is the most common and flexible way of asking people basing on their own opinions and experience (Moriarty, 2011). In this study, semi-structured interview questions were used to gather data from village officials (Appendix 1) and from Moshi Rural Water Supply Officials (Appendix 2) for the purpose of generating reliable data regarding performance of water projects. Semi-structured interviews were employed because of their flexibility as they consist of open and closed-ended question together with the checklist for items that have been interviewed. The methodology first called for interviews with key informants about the strengths and weaknesses of existing water-supply schemes and their management.

3.6.2 Questionnaires

In this context, a combination of both open and closed ended questions were used to collect information in order to get detailed information (Dawson, 2002). They were used for Village Officers (Appendix 3), and households (Appendix 4). These instruments were pre-tested through pilot testing and asked to other people before being used so as to improve their reliability. Questions were asked regarding the Kirua-Kahe domestic water allocation efficiency as well as regarding consumer satisfaction with the services and management of the water utility.

3.6.3 Direct observations

This is the most straightforward method of data collection which is more economical, simplest, most accurate and quickest way of gathering data (Babin and Zikmund, 2013). This method helps to provide detailed records of what people actually do on the field during an event of collecting data so as to make relevant information. This method helps to see the environment where things were taking place in order to increase understanding of the situation hence it is subjected to checks and control of the research (Kothari, 2003).

3.7 Data analysis procedures

Data were mainly quantitatively analysed; the qualitatively analysis was employed to supplement the quantitative data and to qualify the quantitative data. Quantitative data were analyzed through optimization model for evaluating the efficiency of domestic water allocation from each sampled village.

3.7.1 Optimization analysis

In calculating the quantity of water demand and supply in each sector, objective units of enquiry were employed to organise the data. Also the total quantity of water requirements for domestic uses were calculated by ascertaining the daily demand and supply amounts of each household and used it to multiply for the number of days in the month to arrive at the monthly supply and demand of each household.

The employed model primarily included the objective function to allocate domestic water to minimize the economic, social and ecological costs of both the supplier and the deficient consumption sectors which are home, public and commercial sectors. Linear Programming is a mathematical model designed to help institutions and individuals to make better decisions based on how to allocate resources or (they have been allocated), activities and choose decisions for their circumstances.

3.7.2 Linear programming analysis

Considerable research has been directed toward incorporating uncertainty into programming models. LPWYE is linear programming computer software specifically designed for modeling linear optimization problems. It can handle large and complex problems. It is also powerful and flexible where the user can change the formulation quickly and easily with little trouble.

The objective function is usually denoted by Z and constraints or limited resources which are strictly linear. Constraints that are needed to satisfy will be the available minimum amount of water resources that will be obtained from the field such as the available water from the supplier. A thorough study on water demand was conducted and the collected data were used to formulate the model below.

Minimize Z $= 0X_1 + 0X_2 + 0X_3 + 3\,888X_4 + 14\,000X_5 + 22\,500X_6 + 2\,000X_7 + 5\,500X_8 + 150\,500X_9 + 218\,500X_{10} + 95\,500X_{11} + 171\,500X_{12} + 0X_{13} + 0X_{14} + 0X_{15} + 0X_{16}$ ……(1)

Subject to

$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 \leq$ **6 568**……………………………….(2)

$X_9 + X_{10} + X_{11} + X_{12} + X_{13} + X_{14} + X_{15} + X_{16} \leq$ **147 744**………………………..(3)

$X_1 + X_9 \leq$ **7 188**

$X_2 + X_{10} \leq$ **18 500**

$X_3 + X_{11} \leq$ **11 475**

$X_4 + X_{12} \leq$ **11 963**

$X_5 + X_{13} \leq$ **1 558**

$X_6 + X_{14} \leq$ **3 116**

$X_7 + X_{15} \leq$ **1 558**

$X_8 + X_{16} \leq$ **1 558**

Where $X_i \geq 0, i = 1,2,3,\ldots,16$

X_1 = Amount of water to be allocated to Uparo-Kawawa through pumping;

X_2 = Amount of water to be allocated to Mero-Kileuo through pumping;

X_3 = Amount of water to be allocated to Mrumeni-Urenga through pumping;

X_4 = Amount of water to be allocated to Kilototoni through pumping;

X_5 = Amount of water to be allocated to Mikocheni-Kubwa through pumping;

X_6 = Amount of water to be allocated to Kahe/Ngasanyi through pumping;

X_7 = Amount of water to be allocated to Soko through pumping;

X_8 = Amount of water to be allocated to Mwangaria through pumping;

X_9 = Amount of water to be allocated to Uparo-Kawawa through gravity;

X_{10} = Amount of water to be allocated to Mero-Kileuo through gravity;

X_{11} = Amount of water to be allocated to Mrumeni-Urenga through gravity;

X_{13} = Amount of water to be allocated to Mikocheni-Kubwa through gravity;

X_{14} = Amount of water to be allocated to Kahe/Ngasanyi through gravity;

X_{15} = Amount of water to be allocated to Soko through gravity;

X_{16} = Amount of water to be allocated to Mwangaria through gravity;

3.7.3 Multiple regression analysis

Multiple Regression Model was used to analyse the effectiveness of domestic water allocation at Kirua-Kahe through establishing household demand function for water. Therefore, a multiple linear regression model was applied to analyse the relationship between water usage with other factors such as family size, sex of respondent, water scarcity, water bone diseases, distance to the source and duration to water availability. In order to perform test we need to know their distribution. Therefore, the Household Demand Function for water use using Multiple Regression Analysis is modeled below with factors which were affecting the household water demand.

$$Y = \beta_0 + \beta_1X_1+\beta_2X_2 +\beta_3X_3+\beta_4X_4 +\ldots\ldots\ldots\beta nXn + \mu \ldots\ldots\ldots(4)$$

Y = Household water use in cubic meters per day

X1 = Sex of the respondent

X2 = Household size

X3 = Water Scarcity

X4 = Water bone diseases

X5 = Average distance to water source (Km)

X6 = Duration of water availability (Hrs)

$\beta_1 - \beta n$= parameter coefficient

μ = error term

The measurement and analysis of satisfaction has nowadays received much consideration in various disciplines including economics and marketing (Abebaw *et al.,* 2010). This is due to its necessity in measuring the effectiveness of water services that are being provided. Consumers' satisfaction was also analyzed and summarized in terms of water quality, quantity, tap pressure and consumer services.

Statistical techniques were used to analyze data obtained from the field. The quantitative raw numerical data were coded systematically and analyzed. Some of the computer software applications used for the survey was LPWYE Software, Statistical Package for the Social Scientists (SPSS), and MS Excel. LPWYE Software was used to analyze the optimization data to determine the efficiency of domestic water allocation for Kirua-Kahe looking to meet conditions of water demanded and supplied for every village. SPSS software was used to analyze the multiple linear regression model that analysed the relationship between water usage with family size, sex of respondent, water scarcity, water bone diseases, distance to the source and duration to water availability. The results were presented in both quantitative and qualitative terms. Other data were in the forms of frequency tables, histograms, bar graphs and pie charts using MS Excel that were supplemented with the economic models that were used. Inferences and calculations were made from these measures and compared with the existing literature to arrive at the conclusion of the study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

This Chapter presents research findings which are divided into three major parts. The first section analyzes the situation, trend and the usual allocation activities in the study area. The second section discusses the economic efficiency of domestic water allocation in Kirua-Kahe Water Project to both the suppliers and customers. The third section covers customers as well as suppliers' satisfaction to evaluate the effectiveness of Kirua-Kahe domestic water allocation services for the purpose of increasing the efficiency of water supply.

4.1 Socio-economic profile of Kirua-Kahe community

4.1.1 Characteristics of sampled population

Socioeconomic factors have been shown to have an impact on water use patterns whereby Kirua-Kahe pumping area has 15 customer villages while Kirua-Kahe Gravity water supply has 18 customer villages including Uchira Water Users Association (UWUA). The sampled population was 8 villages where there were 96 household heads.

Table 2 shows the sample population of households was based on gender whereby 29% were male respondents and 71% female respondents and the average household number was 6 members which does not differ much from National Bureau of Statistics (2002). Findings also show that households' size has a direct relationship to water demand which is different from ENVC (2011) that is based for developed societies. Female respondents were much expected because most of them were expected to give information since they usually stay at home most of the day and mostly concerned with family caring and all daily household needs. According to the respondents, 91.7% of the customers spend less than 30 minutes to fetch water since most of water taps are less than 0.5 km from home. This indicates very great achievement compared to the study conducted by Meena and Sharif (2008) for Kilimanjaro Region which showed that 87.1% spent less than 30 minutes and only 6.8% spent more than one hour and mostly were done by women. Also water sector targets were 53% to 65% of the people by the year 2010- 2011 to have access to clean and safe water as well as spending less than 30 minutes to collect water. The aim was to help customers to walk not more than 400 meters for fetching water.

Table 2: Household socio-economic characteristics

Variable	Percentage
Sex of respondent (%)	
Male	29.2
Female	70.8
Average household members	6
Age of respondent (%)	
<40	10.5
41-50	37.5
51-60	43
>60	09
Average distance to the water source (%)	
<0.5 km	91.7
0.5 to < 1 km	8.3
Average time for water collection (%)	
< 30 min	91.7
≥ 30 min	8.3
Hours of water availability per day	15.05

The findings in Table 2 show that majority (80.5%) of the respondents fall within the age group of 41 to 60 years. This is the active and working population implying economic age group, which indicates that the respondents are well aware of the domestic water service improvements. However, 70.8% of the respondents are females who had much contribution in water usage at the family level.

4.1.2 Family members responsible for fetching water

The responsibility of fetching water was divided among family members who were divided as male head, female head, boys and girls with the role of daily fetching water. Within the family, many studies shows that female households are mostly responsible for fetching water especially in the developing world (Ali *et al.,* 2015). From these findings women in each village were mostly involved in fetching water and villages such as Mero, Mikocheni Kubwa, Ngasinyi and Soko were lead by female heads. Villages such as Uparo, Mikocheni Kubwa, Ngasinyi and Soko show that male heads were not concerned with daily water usage. When the husband expressed sharing responsibility for fetching water data from the wife's response was used because women had usually more exposure to and knowledge about water usage and quantity for domestic use because they are mostly affected with water usage in the household. The graph in (Figure 3) shows that more than 70% are females leading in responsibilities of fetching water than males heads followed by girl children.

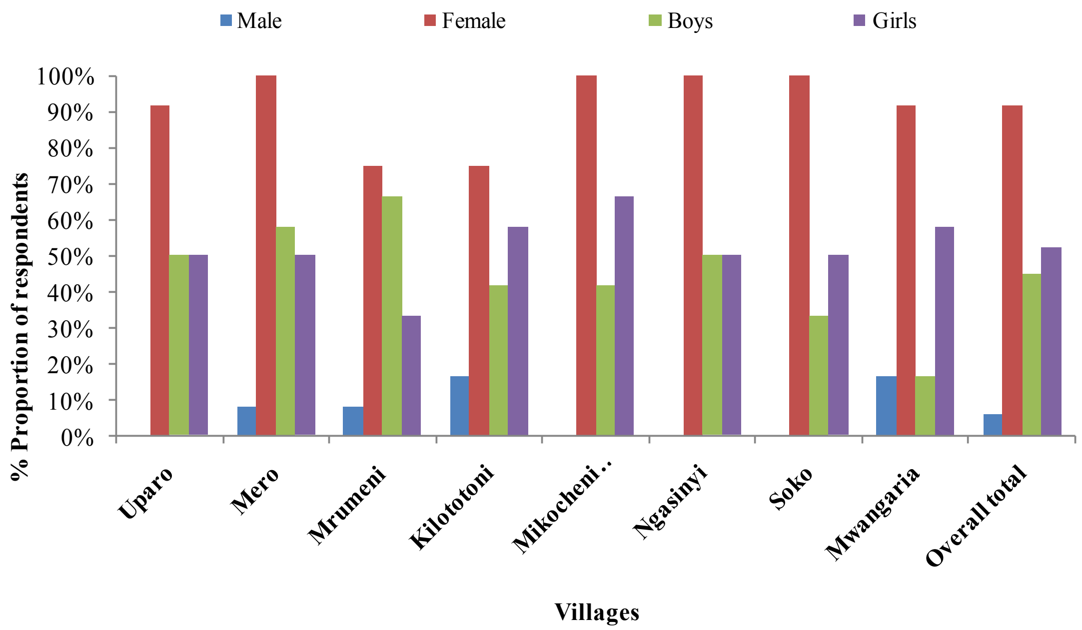

Figure 3: Proportion of fetching water based on gender

Note: Male= Husband, Female= Wife

4.2 The process of domestic water allocation in Kirua-Kahe water supply

Kirua-Kahe has a Water Supply Project which is bounded within Moshi Rural District where the area and the organization is limited to beneficiaries of this area who are customers served by this project. The interview that was conducted with managers shows that the domestic water supplied within this area is divided into two sub areas with their offices located within the area. These are Kirua-Kahe Gravity Water Supply Trust and Kirua-Kahe Pumping Water Supply Trust. In the Kirua Gravity water there is also one pumped system mixed with Gravity water supply serving at Kilototoni village due to the area being situated in the lower areas with high population pressure which demands high amount of water. The Gravity water Supply has lower running costs compared to the pumping water because in pumping more energy is needed for operation of machines, security of infrastructures and other running and operation costs than the Gravity system which has even fewer sources. The water supplied from both sources is mainly intended for domestic use and efforts are made to ensure safe and clean water for human consumption.

4.2.1 Objectives of the project

The main objective of this project is to provide adequate, clean and hygienically safe potable water; also to improve the hygienic situation for the rural population of Kirua and Kahe wards thereby improving the standard of living.

4.2.2 Water management

Domestic water allocation in Moshi Rural District is managed through water boards which are formulated by village chairmen forming water committees where chairmen and vice chairmen are being elected and managers are secretaries of the committees. These village boards conduct meetings and discuss on the proper ways of domestic water services provision in their villages. The board aims to maintain cooperation between suppliers and their customers to make sure that the allocation is run smoothly. The Municipal Council is advisor to the board and auditing is conducted both internally from the District and externally from other board such as Hai District Water Supply. The outcome is that awareness increases compared to previous time when some equipments were even given for free though it was still difficult for people to accept. There are Public Relation Officers of the respective board who links customers with the board.

Water trusts are run by the respective management who is in charge of all the allocation matters in respective area. Managers work in cooperation with the District Water Engineer (DWE) who provides technical assistance to the board. The manager is in charge of the technical, financial as well as the public relations (Figure 4). The technical team works on installation and maintenance of water infrastructures where there are meter attendants who are also concerned with meter readings and reporting to the management. The Public Relations Officer is in charge of ensuring there is good relation between the board and customers as well as providing knowledge and information to customers. For the case of Kirua-Kahe Pumping there is only a Personal Secretary because there is still little number of customers. Accountants from each board collect monthly payments from all sub-offices and the main offices. There are weekly staff meetings that are conducted in every friday to analyze and propose activities that have been conducted and what needs to be done.

The board adops skills from other water boards such as Hai District Water Supply and Lyamungo Water Supply from the same region. These boards are run very efficiently though there are some geographical administrative differences with Kirua-Kahe water supply.

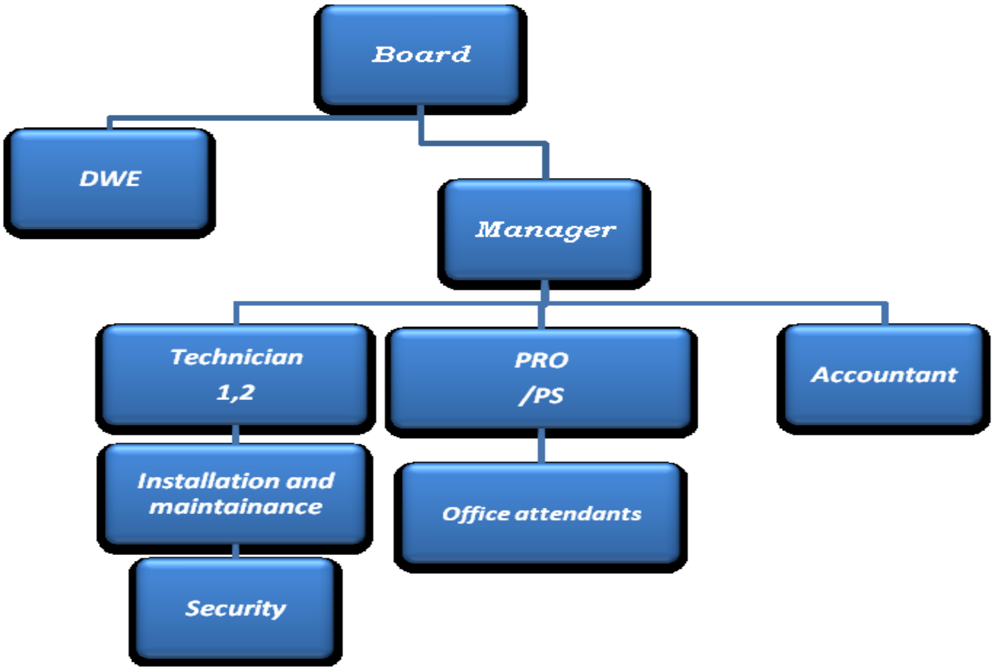

Figure 4: The organization chart of Kirua-Kahe water supply system
Source: From the field

4.2.3 Gravity water supply

Kirua-Kahe Gravity water supply system started in mid June 2013 consisting of 8 working intakes, 2 boreholes equipped with solar system located at Kilototoni. Also, there are 44 reservoirs, 202 pressure reducing tanks (PRT), 2 bulk connections, 249 public taps and around 4 124 private connections with 315 Km of primary pipelines. The system is targeted to supply water to 66 270 beneficiaries by the year 2020. There are a total of 9 intakes and 1 borehole at Kilototoni. Currently, 3 gravity intakes are operating supplying enough water to all customers at Kirua Gravity Water Supply where Mue is the largest and the main intake draining almost 0.032 m^3/S.

Other intakes in the gravity system are Kineng'ena and Monyo producing 0.005 m^3/S each and the five remaining produce 0.003 m^3/S. The smallest intake is Kombishi with the capacity of producing 0.003 m^3/S and Kilototoni boreholes produce 0.006 m^3/S. The small intakes sometimes become dry where the Mue intake which is the largest and depended produces water all the time.

Mobile payments have also been established since the target of the project is to help a customer not to spend much time to make payment at the offices. Apart from mobile payments there are 5 sub offices for Kirua-Kahe Gravity area that have been constructed. In order to avoid differences between sub offices computer network is used for collection and sent to the main computer at the office. Also for Kirua-Kahe Pumping there is a system of payments through mobile phones using Vodacom M-Pesa. In this service, customers are instructed how to make payment.

Plate 1: Kirua-Kahe gravity water intake at Mue

4.2.4 Pumping water supply

The Kirua-Kahe Pumping water Supply system consists of 15 small pumping water supply schemes where water is pumped from sources mainly boreholes and 1 spring. The schemes pump water into raised tanks from where it is distributed to customers. Pumping takes place through the use of renewable energy mainly solar system and 1 water wheel while generators are used occasionally. The whole system consists of 19 boreholes and 2 spring abstractions with 18 solar pumping stations. Also there are 30 raised tanks 3 underground tanks with 1 siphon line with siphon head. There is 1 water wheel equipped with piston pumps. Kirua-Kahe pumping water system is foreseen to supply 46 400 beneficiaries by the year 2020.

Water production through pumping system is not measured directly in the raised tanks to avoid friction loss, therefore it is done in the outflow of all tanks. Energy that is needed for pumping at each station is about 1.5 Kw for both pulling and pushing water to the raised tanks and the pumping speed changes according to solar power but it averages to about seven hours with the pick of 7.42 m^3/h. In order to improve the monitoring of production and to check the bulk water meters working readings are taken three times a month. The average water loss during the reporting period lays around 13%.

Plate 2: One of the pumping stations at Mikocheni-Kubwa village

4.2.5 Participation in the project

Financing of the projects was also divided among the beneficiaries, the government and donors. Villagers make cash contributions towards capital costs and operation costs. They also contribute their time, labor, local materials and ideas in their village meetings with the board (Table 3). The initial amount of money contributed to a project by a village has been standardized and agreed by the villagers with their leaders apart from manpower contributions.

Findings in Table 3 shows that 58.6% did not attend yearly meetings but 85.2% contributed their labour in water project activities. Also 41.9% of the respondents contributed through money instead of participating in other activities such as meetings and labour. This is because most of village members are not well informed on the importance of participating in domestic water services as their responsibility for their livelihoods.

Table 3: Proportion of contribution to the water project

Days of meetings attended	0	1	2	3
Yearly attendance (%)	58.6(253)	19.2(83)	18.5(80)	3.7(16)
Participation	**Yes**	**No**		
Meetings (%)	39.6(171)	60.4(261)		
Ideas (%)	34(147)	66(285)		
Money (%)	41.9(181)	58.1(251)		
Labour (%)	85.2(368)	14.8(64)		

Note: The numbers in brackets are frequencies and total not necessarily add up to 100% due to multiple responses

4.3 Domestic water usage and customer's connections

Until January 2015, Kirua-Kahe Gravity had a total of 5 403 customer connections that are being supplied with domestic water. Also, there were 401 customer connections at Kirua-Kahe Pumping area. Customers are classified into four main groups namely Public, House, Social Institutions and Commercial connections (Table 4). Results shows that to a large extent of usage is based for house use which is the same to the developed communities such as the study conducted by ENVC (2011) which will result into lower per capital demand throughout the year. Public connections are operated through agents who are given the authority for selling water to customers and each month they submit the cash to the board and given a percentage of that selling. The bulk water that is being produced is supplied to Uchira where there is another supplying organization. This organization buys the bulk water because they do not produce enough water to sustain their customers demand. There are about 12 dormant working connections while other customers have shifted form house connection to public connections since is cheaper.

Findings also show that majority of the water users depend more on house followed by public connections which is related to Dagnew (2012) who surveyed Northern Ethiopia's households and found that, 71% of the households obtain water from private piped connections, but from among households who use other sources, more than two third (78%) use public stand pipes while the remaining 22% use water from vendors as the primary source of water supply for their households.

Table 4: Number of connections and usage until January 2015

Connections	**Number of connections**		**Usage (m^3)**	
	Gravity	Pumping	Gravity	Pumping
Public	243	139	8 085	5 018
House	5 096	226	59 029	1 654
Social Institutions	62	36	2 666	566
Commercial centres	2	0	711	0
Uchira	2	0	12 241	0
Total	**5 405**	**401**	**82 732**	**7 238**

Table 4 also shows that majority of water users among the customers are for domestic purposes which is similar to other studies like Kayaga (2006) who reported for Acraa where domestic consumers make 85% of service connections, and contribute about 50% of revenue collection. Commercial and industrial customers, who constitute about 1% of the customer base, contribute about 34% of the revenue collected.

4.4 Water usage and pricing system

4.4.1 Domestic water usage

Monthly water usage is being collected from meter attendants and recorded in order to generate information on the progress of service provision trend from all areas. Three months water usage was recorded and summarized in Table 5.

Table 5: Usage and number of customers from October-December 2014

Month	**October**		**November**		**December**	
Source	**Gravity**	**Pumping**	**Gravity**	**Pumping**	**Gravity**	**Pumping**
Number of customers	5 282	358	5 360	392	5 379	718
Usage (m^3)	51 627	6 233	45 836	5 564	48 639	8 136

The daily usual usage for customers was divided mainly for cooking, drinking, domestic irrigation and washing which are the usual daily uses of domestic water at household level. The findings show that all respondents from all sampled villages use water for drinking followed by a large number who use water for washing (Table 6). A very few number of respondents use the supplied water for irrigation which is not the priority of the service and also they use of alternative sources. Most villages under the Kirua-Kahe Gravity use the supplied water for other purposes apart from drinking. This is because there are few alternative sources which lead to more dependence on the tap water supply.

Table 6: Daily domestic water uses

Village name	Proportion of respondents on uses of water supplied per day (%)				
	Irrigation	**Washing**	**Cooking**	**Drinking**	**Livestock**
Uparo	33.3(4)	100(12)	100(12)	100(12)	41.7(5)
Mero	25(3)	100(12)	100(12)	100(12)	66.7(8)
Mrumeni	33.3(4)	100(12)	10012)	100(12)	50(6)
Mabungo	25(3)	10012)	100(12)	100(12)	50(6)
Mikocheni Kubwa	8.3(1)	100(12)	100(12)	100(12)	33.3(4)
Ngasinyi	0(0)	58.3(7)	100(12)	100(12)	0(0)
Soko	0(0)	66.7(8)	91.7(11)	100(12)	8.3(1)
Mwangaria	8.3(1)	66.7(8)	91.7(11)	100(12)	0(0)
Overall percentage	**16.7(16)**	**86.5(83)**	**97.9(94)**	**100(96)**	**31.2(30)**

Note: The numbers in brackets are frequencies and total not necessarily add up to 100% due to multiple responses

4.4.2 Water pricing

Volumetric pricing is done for consumers mainly as contribution towards sustainability of the project and services as well as making discipline in the usage of water (URT 2002). The price of water plays a very important role in water consumption because price is inversely proportional to usage (Bao and Jia, 2014; Mann, 2008). There are Public connections, home connections, social institutions and commercial connections.

Water tariffs are connection charges which is 175 000 Tshs for each customer and 20 000 Tshs for application. A nice proposed water tariff also improves the allocation efficiency and equity objective could be easily achieved to redistribute water to different income levels and also used as recovery costs (Gurria, 2009; Hodgson, 2006; Kayaga, 2006). There are also monthly usage charges through water bills applied mainly for running the service through public and home connections. For Public taps charges are 350 Tshs per unit of water which account for 5 buckets of 0.002 m^3 equivalent to 20 litres of water. Public charges are lowest compared to other charges because the project is mainly targeted low income people.

Water usage is categorized on user groups have been increasing like urban areas and developed countries (Gurria, 2009; Mann, 2008). For home connection the charge is 400 Tshs per unit for consumers of 1-15 units. More than 16- 50 which fall in the group of Social Institutions and Commercial users pay 600 Tshs per unit and more than 50 units 1 150 Tshs per unit. The service charge for each customer is included within usage a charge which is 500Tsh (Table 7).

Table 7: User charges

User	Range in m^3	Price in Tshs per m^3
Normal User	1-15	400
Special charge	16-50	600
Commercial User	51-Above	1 150

Bills are issued monthly according to usage per each customer. The process of working with bills is in the schedule for the whole month (Table 8). This activity is done with the meter attendants and the Personal Secretary who enter the bill readings and produce them. There are challenges from wrong readings mostly high bills where these problems are dealt through negotiations with customers.

Table 8: Bills processing time table

Date	5 – 10	11 – 17	17 - 23	23 - 30	01 - 05
Activity	Distribute Bills	Payment of Bills	Meter Reading	Enter Readings	Collection of Bills

Bills are calculated and prepared by subtracting the current reading from the last reading in order to get the new reading using the Quickbook computer program. At the beginning of the project the equipments were free but after the establishment of the board, customers are supposed to pay for the equipments. Therefore, the current connection charge is 214 900 Tshs apart from pipe line which costs 1 200Tshs per meter.

4.5 The economic efficiency of domestic water allocation

Economic efficiency analysis was carried out through demands and water supplied for the sampled villages as well as collection efficiency for all villages. This was assisted through evaluation that was conducted with assistance of the accountant from the computer in order to make information for the month. There are different rates according to customer's category such as house connections, public connections, social institutions and commercial centers.

4.5.1 Optimization analysis

A thorough study on the demand and supply data were also extracted from both Kirua-Kahe pumping and gravity offices and the aim was to determine water allocation schedule from the selected villages in order to minimize the cost of water supply. Each village has its own demand and supply therefore the supply for each village depends on the number of connections and usage. The supply for each village was compared to household monthly demands that were determined and analysis was made by optimization using linear programming in order to obtain the efficiency of the allocation (Table 9). Customers' demands were compared to what they are supplied with in order to determine the allocation efficiency since domestic water demand focuses on what is being produced and the efficiency with which it is produced.

Findings show that all constraints and optimality conditions were satisfied for each village (Table 9). Monthly customer's demands did not exceed the quantity of water supplied. Mero, Mrumeni Uparo and Kilototoni villages were under gravity system except Kilototoni village had both gravity and pumping system. Ngasinyi, Mikocheni Kubwa, Mwangaria and Soko were under pumping water supply. Most of the customers from pumping supply use public connections compared to those under gravity supply system whose usage is minimal because most of them use water mainly for drinking and washing. Also Kirua-Kahe pumping had different alternative sources especially springs and rivers.

Table 9: Optimization results on monthly demanded water with allocation

Village	Average demand (m^3)	Allocated water (m^3)	Satisfaction
Kilototoni	11 963	11 550	Satisfied
Mero	18 500	16 500	Satisfied
Mrumeni	11 475	10 093	Satisfied
Uparo	7 188	7 188	Satisfied
Ngasanyi	1 558	1 550	Satisfied
Mikocheni kubwa	3 116	2 988	Satisfied
Mwangaria	1 558	1 498	Satisfied
Soko	1 558	1 510	Satisfied

There was also an enormous difference in water demand among different water use sectors in each village (Table 9). The main reason for this difference was the discrepancies in the level of economic development, the usage, natural conditions, populations and life styles. Generally, villages form the Gravity system have the greatest total water demand probably because of the dense population and the relatively higher level of economic development. Apart from the Kirua-Kahe water supply, household demands in villages vary according to seasonality with the support of alternative sources as shown in Figure 5.

4.5.2 Collection efficiency

The collected information is helpful to make details on the average daily usage, maximum usage periods as in other communities (ENVC, 2011). Collection efficiency reports are expressed in percentage using Quickbook computer program by considering various criteria such as the collection amount, increase in number of customers and debts collection. Therefore both the use of technology and allocation efficiency improvement is needed through making reports so as to evaluate the production and collection (Table 10 and 11). The issue of special collection happens when water sold exceeds the level of the user's limitation. Sometimes before adjustment there are wrong readings because there are some adjustments which are done through checking before another reading. Leakages are reported and therefore 25% is deducted from the bill which makes adjustment to the customers and it is being authorized and the expectation of the project is mainly for domestic consumption. Efficiency data were extracted from monthly collection efficiency data from both offices from April 2014 to January 2015.

Kirua-Kahe Pumping seems to have higher collection efficiency than Kirua-Kahe gravity water supply. This is because of the nature of the area and the number of customers who are easly manageable. The pumping area has fewer customers as well as usage compared to gravity area which is easy to manage. There are also more public connections in the pumping area than in the gravity area (Table 10 and 11). However, Kirua-Kahe Gravity system generates more income than the pumping system.

Table 10: Kirua-Kahe gravity monthly collection

Month	Water sold (m^3)	Bill amount (Tshs)	Adjustment	Special charge	Remaining	Minus outstanding (Past -Current)	Total collected (with special charge)	Collection efficiency with adjustment (%)	Collection efficiency without adjustments	Difference (%)
Jan-15	1 874 783	855 660 055	-5 681 216	62 100	850 040 940	89 509 279	760 531 661	89.54	88.88	0.66
Dec-14	1 779 400	800 450 200	-5 572 616	62 100	794 777 584	83 223 400	720 245 620	90.65	90.12	0.53
Nov-14	1 731 928	788 025 250	-5 572 616	62 100	782 514 735	80 298 214	702 216 521	89.81	89.10	0.71
Oct-14	1 683 756	764 210 370	-5 552 316	62 100	758 720 155	67 256 984	691 463 171	91.20	90.47	0.73
Sep-14	1 629 568	738 653 995	-5 275 466	62 100	733 440 630	65 882 489	667 558 141	91.08	90.37	0.71
Aug-14	1 580 480	714 806 165	-5 275 466	62 100	709 592 800	51 776 884	657 815 916	92.76	92.02	0.74
Jul-14	1 530 294	690 884 815	-4 763 594	62 100	686 183 325	64 934 564	621 248 761	90.60	89.91	0.69
Jun-14	1 489 960	670 398 690	-3 741 923	62 100	666 718 867	59 216 797	607 502 070	91.17	90.61	0.56
May-14	1 451 453	652 506 030	-3 347 923	62 100	649 220 207	64 737 487	584 482 720	90.08	89.57	0.51
Apr-14	1 419 501	635 438 915	-3 277 423	62 100	632 223 592	71 474 522	560 749 070	88.75	88.24	0.52

Source: Kirua-Kahe gravity water supply trust (2014-15)

Note: The monthly collection is done cumulatively

Table 11: Kirua-Kahe pumping monthly collection

Month	Water sold (m^3)	Bill amount (Tshs)	Adjustment	Special charge	Remaining	Minus outstanding (past+current)	Total collected (with special charge)	Collection efficiency with adjustment (%)	Collection efficiency without adjustments	Difference (%)
Jan-15	241 900	329 427 200	-223 250	27 250	329 231 200	14 908 300	314 322 900	95.47	95.41	0.07
Dec-14	234 662	318 970 200	-223 250	27 250	318 774 200	6 894 100	311 880 100	97.84	97.77	0.07
Nov-14	227 908	309 141 200	-223 250	27 250	308 945 200	12 919 300	296 025 900	95.82	95.75	0.07
Oct-14	222 344	301 040 950	-223 250	27 250	300 844 950	13 177 300	287 667 650	95.62	95.55	0.07
Sep-14	216 600	292 220 000	-223 250	27 250	292 192 750	12 000 500	291 996 750	96.25	96.32	0.07
Aug-14	210 805	284 296 950	-223 250	27 250	284 100 950	11 047 500	273 053 450	96.11	96.04	0.08
Jul-14	205 443	276 652 700	-223 250	27 250	276 456 700	9 951 650	266 505 050	96.40	96.32	0.08
Jun-14	200 359	269 178 950	-223 250	27 250	269 178 950	9 623 950	259 555 000	96.43	96.34	0.08
May-14	195 448	262 419 700	-223 250	0	262 419 700	9 470 700	252 949 000	96.39	96.31	0.09
Apr-14	190 823	255 864 950	-223 250	0	255 641 700	9 735 850	245 905 850	96.19	96.11	0.09

Source: Kirua-Kahe pumping water supply trust (2014-15)

Note: The monthly collection is done cumulatively

4.6 The effectiveness of domestic water allocation

4.6.1 The demand of domestic water allocation

Regression analysis is also a useful diagnostic tool for exploring water use behaviours (Parker and Wilby, 2012). Since all village demands were satisfied, there were no occurrences of water shortage throughout the year. The demand function was determined using Multiple Regression analysis and the independent variables shown and the dependent variable was the average daily usage for each household (Table 12).

Table 12: Water demand function results with expected results

	Unstandardized Coefficients		Standardized Coefficients		
Variables	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	87.809	30.473		2.882	0.004
Sex of the respondent	-0.071	5.693	0	-0.013	0.990
Number of household members	2.233	2.098	0.045	1.064	0.288
Water Scarcity in the household	-26.193	10.663	-0.11	-2.456	0.014*
Cases of water bone diseases	-0.67	9.914	-0.003	-0.068	0.946
Average distance to water source	-23.068	9.322	-0.118	-2.475	0.014*
Average time for water collection	48.894	9.603	0.24	5.091	0.000**
Average hours of water availability	4.118	0.351	0.515	11.72	0.000**

Note: Dependent Variable: Daily average water usage, R^2 = 0.295, Adjusted R^2 = 0.283, Significance = 0.05

Table 12 shows the value of R^2 = 0.295 which indicates how much of the variance in the dependent variable (Daily average water usage) is explained by the model. For smaller samples it is much better to use the adjusted R^2 which is 0.283. The model reached a statistical significance of < 0.05 and each of the variables included were also examined to see which of them contributed to the prediction of the dependent variable. It was better to look at the standardized coefficients whose values corresponded to the expected changes in the dependent variable.

Results show that water scarcity, average distance to water source, average time spent for water collection and average hours of daily availability of water were significant predictors of daily average water usage which conform to the water sector targets (URT, 2008). This means that they have their own strong unique contribution in explaining the dependent variable daily water usage contrary to sex, household size and water bone diseases in the household that were not significant which means they were considered to have any effect on water demand which is similar to a study by Dagnew (2012).

4.6.2 Customers satisfaction to water allocation

From the sampled villages, customers were asked on their average daily domestic water use with their satisfaction and for each village the demand was summed up to get the average demand for each village. These results were compared to the monthly allocated water so as to compare the percentage of households' satisfaction (Table 13). Customers were satisfied with the domestic water supply services in terms of water quantity, quality, tap pressure and customer services. These results are similar to those found in Ethiopia by Dagnew (2012) which also showed satisfaction but it was based on quantity and quality; and the quantity of 3.5% which was very poor compared to quality which accounted for 76.1%. This is because the studies were conducted in two different geographical areas.

There is a positive relationship between poverty and adequate water because they contribute to achievement of human development indicators. Most poor households frequently do not have access to quality water in terms of sources and methods of water treatment, which makes them vulnerable to water-borne diseases. However, advances in disinfection technology have improved human health throughout the developed world (Ali *et al.,* 2015). Unit cost of water was not much satisfactory to some of customers and they suggested the cost to be lowered especially for home connection. In the same holds true for many of the poorest developing countries, water bills may represent a more significant portion of the income, and this is also the case in some OECD countries. However, in a number of emerging economies, for example Egypt, even the poorest households pay significantly less than 2% of their income for water which is affordable. Also customers' problems and cooperation is not much considered especially when there are any technical problems the management does not deal with them properly.

Table 13: Customers' satisfaction on water supply services

Satisfaction	Hours	Quantity	Tap Pressure	Quality	Costs	Service
Highly satisfied	76.6(331)	74.3(321)	75.7(327)	58.6(253)	8.6(37)	14.8(64)
Satisfied	22.2 (96)	25.5(110)	24.1(104)	39.6(171)	44(190)	56(242)
Partially satisfied	1.2(5)	0.2(1)	0.2(1)	1.9(8)	36.6(158)	28.5(123)
Not satisfied	0(0)	0(0)	0(0)	0(0)	10.9(47)	0.7(3)
Total	100(432)	100(432)	100(432)	100(432)	100(432)	100(432)

Note: The numbers in brackets are frequencies for each response

Since Table 13 and Table 14 shows a very large percentage of customers are satisfied with domestic water services, this means a greater indication of achievement of water policy objective which insists on providing adequate, affordable and sustainable water supply services to the rural population (URT, 2002).

4.6.3 Village officials' satisfaction on the effectiveness of domestic water allocation

Village officials who were asked about the domestic water allocated in their villages indicated their satisfaction with the service based on the availability and balance in the areas of their villages whereby 75% were satisfied while 25% were not satisfied with the services. In the case of the safety, water charging and improvements on the services, 100% were satisfied in all villages (Table 14).

Table 14: Village officials' satisfaction on domestic water supply

Satisfaction	Water availability	Balance	Safety of water	Water charging	Improvements
Yes	75(6)	75(6)	100(8)	100(8)	100(8)
No	25(2)	25(2)	0(0)	0(0)	0(0)
Total	100(8)	100(8)	100(8)	100(8)	100(8)

4.6.4 Customers alternative sources

A household is considered to have access to improved water source if it gets water from private stand pipes, public taps and other protected sources. Findings shows more than 60% of the customers have alternative sources which are not safe because they are unprotected and this makes the domestic water supplied in danger of being contaminated; therefore it is not potable for human consumption though there are other uses such as hygiene and amenity. The use of other sources has been observed as a common practice especially for those who use public taps and the main reason is to minimize cost of the supplied water and the increase in demand of water at household in order to serve the daily needs.

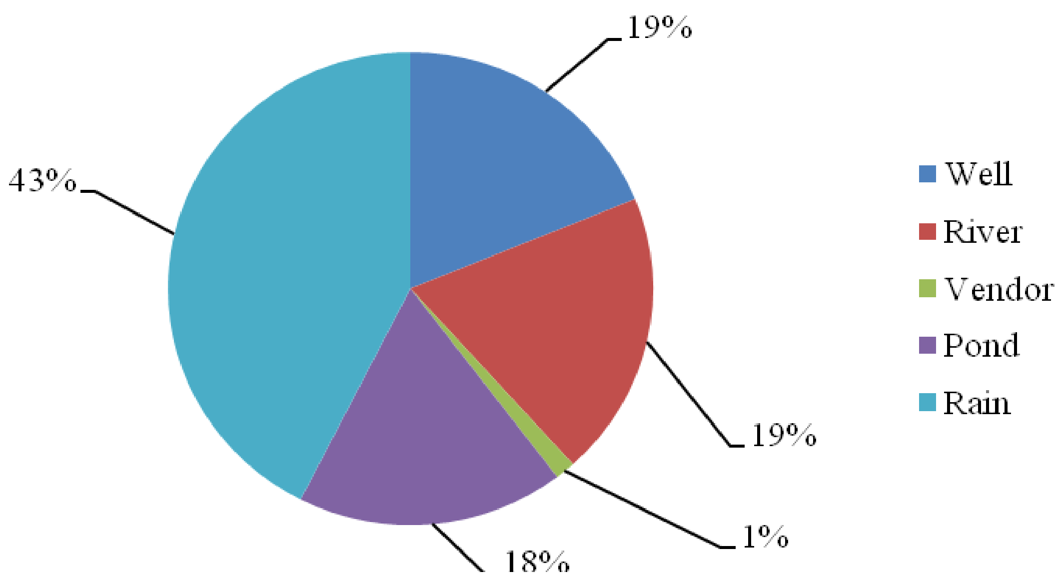

Figure 5: The relative percentage of alternative sources of water usage

The chart in Figure 5 shows that rain water is mostly used as alternative source especially during the rainy seasons by 43% of the respondents. Rain water is regarded as the alternative source widely used and safe for consumption apart from the water supplied from taps.

Also due to the availability of alternative sources contributes to a slight decrease in monthly usage and collection especially during most of rainy season. Water from rivers and wells follow as the alternative sources occupying 19% of the users followed by ponds with 18%. These sources were widely observed in the lower areas where water is mostly supplied from pumping. Therefore alternative sources are helpful to customers because they help them to supplement the allocated water and also to reduce bill.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study has revealed that water is an essential resource for life after evaluating the process of domestic water allocation of Kirua-Kahe water supply that makes it to be scarce in various aspects in the sense that it cannot fully satisfy demand for all its alternative uses. Therefore domestic water supply services has been well organized and run.

The efficiency of domestic water supply is considered and maintained so as to make sure that customers demands are met and there is sustainability of water projects as well as considering the welfare of all consumers. Pumping water sources are boreholes and wells which are being drawn and supplied to customers Therefore conservation programs are made sustainable in every period of the year for both areas.

The study has also verified that currently there has been a major push to expand access to enough clean and safe water by promoting water quality improvements, particularly point of use and water treatment technologies such as filtration and chlorination. Therefore, water is treated through chlorination and safety is tested in the laboratory. Also efforts are made to ensure enough and balanced supply of water availability all the time.

5.2 Recommendations

In view of the above discussion and conclusions, this study recommends the following that would be beneficial to the efficiency of domestic water allocation in the study area and elsewhere.

- There is a need to move with technology in providing the supply service to customers in order to expand services through a network of meters which can be easy to read, monitor and make comparison so as to increase efficiency in collection and reduce labour costs.

- There is need to design more service delivery models and technological innovations that support efficiency in domestic water allocation in Moshi Rural District. Also, future evaluations should incorporate randomized prices which are easily justified as promotional discounts such as the use of block tariffs that will facilitate the allocation efficiency.

- In order to ensure enough, clean and safe water the intakes and the purifying chambers need to have closer monitoring including repairing and replacement of infrastructures as well as enough security. Unused water sources should also protected for future use.

- Additionally, the government should encourage more water projects in different areas of the country and within the same supplied areas thereby creating competition in the market where customers can make choices.

- The safety of water that is being consumed from alternative sources is not clear and there are doubts of contamination from pesticides and artificial manures form famers especially in Kahe where villagers use water from irrigation schemes for domestic uses. There is a need to conduct more research on the safety of alternative water sources.

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APPENDICES

Appendix 1: Semi-structured interview guide for village officials

Name of the Village ________________ Date________________________

Dear Sir/Madam,

This interview is a part of the research regarding the economic efficiency and effectiveness of domestic water allocation in Moshi Rural District: The Case of Kirua-Kahe The researcher is from the Sokoine University of Agriculture. He feels honored to be given an opportunity to talk to you regarding this matter. He is kindly asking for your cooperation so as to obtain relevant and reliable information about the problem under scrutiny.

Basic Questions

1. What is the general situation of water availability in your village?
2. In your opinion, what do you think must be done to increase water availability?
3. What measures do you think are appropriate for efficient water allocation?
4. Are there any problems (Administrative, Social, Technological) facing effectiveness in water allocation? If yes what are they?
5. Is the daily water availability enough? If it is not enough what is your concern about this problem?
6. How many days/ months in a week or year do people get water?
7. Do some of your village members have the problem of water scarcity? In what extent?
8. What are your opinions on the effective water allocation measures that are being used?
9. What measures are you taking in order to ensure there is enough domestic water?
10. Do you think scarcity of water has any effect to economic activities of village members?
11. Do you recognize any efforts made in order to overcome water scarcity?
12. In your own view, what measures are needed to ensure that there is efficient water allocation to your area?

Thank you very much for your cooperation!!!

Appendix 2: Semi-structured interview guide for Kirua-Kahe water officials

Name of the Officer ________________ Date________________________

Dear Sir/Madam,

This interview is a part of the research regarding the economic efficiency and effectiveness of domestic water allocation in Moshi Rural District: The Case of Kirua-Kahe The researcher is from the Sokoine University of Agriculture. He feels honored to be given an opportunity to talk to you regarding this matter. He is kindly asking for your cooperation so as to obtain relevant and reliable information about the problem under scrutiny.

Basic Questions

1. What is the general situation of domestic water availability at Moshi Rural District?
2. In your opinion, what do you think must be done to increase water availability?
3. What efforts do you make to ensure there is clean and safe water?
4. Is there any charging for the supply services? If yes, what kind the charge used?
5. What measures do you think are appropriate for efficient domestic water allocation?
6. Are there any challenges (Administrative, Social, Technological) facing effectiveness in domestic water projects? If yes what are they?
7. What areas have the problem of domestic water scarcity? In what extent?
8. What are your opinions on water pricing for effective domestic water allocation measures and how should be carried out?
9. What other measures that can be taken in order to ensure effective domestic water allocation?
10. Do you think scarcity of domestic water has any effect to economic activities in Moshi Rural District?
11. Do you recognize the efforts made in order to overcome water scarcity? If yes, what are they?
12. In your own view, what has been done and has to be done to ensure that there is efficient water allocation and sustainability in Moshi Rural District?

Thank you very much for your cooperation!!!

Appendix 3: Questionnaire for village officials

Name of the Village___________ Date__________ Name __________ (optional) Sex______

This questionnaire is part of the research work namely: The economic efficiency and effectiveness of domestic water allocation in Moshi Rural District: The Case of Kirua-kahe The study is carried out by the researcher from Sokoine University of Agriculture. The researcher is delighted to have your opinions to investigate the problem.

Answer the following questions as instructed

1. Is there enough domestic water allocation in your village? Put a tick. Yes [ ] No []
2. Is there a balance in domestic water availability in your Village?

   Put a tick. Yes [ ] No [ ]
3. Is the water allocated clean and safe? Put a tick. Yes [ ] No [ ]
4. Currently, what are water sources in your village? _________________(fill in the blank)
5. Do you think water charging for services will ensure effective water allocation? Put a tick. Yes [ ] No [ ]
6. What problems do you think contribute to scarcity of water?______________,______________,_______________, ___________, __
7. What other efforts do you think have been taken to increase water availability?

   ____________________,__________________, _______________
8. Is there any improvement or prospects in water availability in your Village? Put a tick (a) Yes [ ], (b) No [ ]. Specify______________________

22. Mention any other solutions that will increase efficiency in domestic water allocation (a)_______________ (b) _________________ (c) ________________

Thank you very much for your cooperation!!

Appendix 4: Questionnaire for households

This questionnaire is part of the research work namely: The economic efficiency and effectiveness of domestic water allocation in Moshi Rural District.: The Case of Kirua-Kahe. The study is carried out by the researcher from Sokoine University of Agriculture. The researcher is delighted to have your opinions about investigate the problem.

Name of the Village _____________ **Date**_________ **Name**___________________ (optional) **Age**_____ (Years) **Sex**_________ Education ____________ Occupation ____________

Answer the following questions as instructed

1. What are domestic water uses at your home and the minimum quantity in litres per day? Put a tick (a) Irrigation (Watering) [ ]___ (b) Washing [ ] _____(c) Cooking [ ] ___ (d) Drinking [ ] ____ (c) Livestock [ ] _____(e) Other(s) Specify _________________
2. Do you think domestic water is important for poverty alleviation? (a) Yes [ ] (b) No [ ]
3. How many are you in your household? _____. Who is usually responsible for fetching water (a) Male household [ ] (b) Female household [ ] (c) Boy(s) [ ] (d) Girl(s) [ ]
4. What is the average daily expenditure of the family? _______________ Tshs.
5. Is there any scarcity of domestic water in your village/home? (a) Yes [ ] (b) No [ ]
6. Are there any cases of waterborne diseases in your household? (a) Yes [ ] (b) No [ ]
7. Which months do you receive enough water? __________, ________, _________
8. What is the average amount of liters do your household consume per day? _________
9. What are sources of water do you use? (a) Well [ ] (b) Collective Tap [ ] (c) Yard Tap (compound) [ ] (d) House connection [ ] (e)River Water [ ] (f) Vendor [ ] (g) Pond[ ] (g) Rain [ ] (h) Others. Specify _____________________________________
10. What is the average quantity of water for each use will you like to obtain at your home in litres per day? Put a tick (a) Irrigation (Watering) ___ (b) Washing _____(c) Cooking ___ (d) Drinking ____ (c) Livestock ____(e) Other(s) Specify_

11. What is the condition of the water source? a) Good (b) Bad/ Destroyed [ ]
12. Are you satisfied with the daily reliability, quality and quantity of water? (a) Yes [ ] (b) No [ ]
13. What is the average distance from where you take water? Put a Tick. (a) At home [ ]
    (b) ½ km [ ] (c) 1km [ ] (d) 1½ km [ ] (e) 2km [ ] (f) More than 2km [ ]
14. What is the average time consumed in collecting water? Put a Tick. (a) Less than 30 min [ ] (b) More than 30 min [ ] (c) More than 60 min [ ]. Others. Specify __________
15. What is the minimum time do you spend in obtaining water for various purposes in minutes (a) Irrigation (Watering) ____ (b) Washing ___ (c) Cooking ___ (d) Drinking ____ (c) Livestock _______ (e) Other(s) Specify _________________
16. What is the average hours per day there is availability of water? Put a Tick. (a) 24 hours [ ] (b) 12 hours (c) 6 hours [ ] (d) Others________ (specify)
17. Do you think that water pricing a good solution for ensuring efficient allocation of water? (a) Yes [ ] (b) No [ ].
18. What have you paid through before for water in order to have good services? (a) labour [ ] (b) Charges (money)[ ] (c) Ideas [ ] (d) Others (specify) __________________
19. Under what average amount in TZS per litre are you willing to pay to increased effective water services? Put a Tick. (a) Not willing (e) Others [ ]. Specify __________
20. What improvements are you willing to pay for? Put a Tick. (a) Quantity [ ] (b) Quality [ ] (c) Availability (c) Others. Specify ___________, ______________, ______________
21. Have you attended any water meeting? (a) Yes [ ] (b) No [ ]. If yes how many per year?
22. Mention any other solutions that will increase efficiency in domestic water allocation
    (a) _______________ (b) _________________ (c) ________________

Degree of satisfaction, trustworthness and affordability

Items	**Observations**			
	Highly	Satisfied	Partially	Not Satisfied
Hours and timing				
Quantity				
Tap pressure				
Quality				
Costs				
water services				

Categorisation of family status (income)

Asset	**Condition**			Quantity
	Good	Normal	Poor	
House				
Farm/plot				
Livestock				

Thank you for your cooperation!!!

Appendix 5: Distribution of number of customers by villages from October 2014-January 2015

Village	October				November				December				January			
	House	Public	Social Inst.	Commercial	House	Public	Social Inst.	Commercial	House	Public	Social Inst.	Commercial	House	Public	Social Inst.	Commercial
Kilototoni	306	10	2	1	315	10	3	1	316	10	3	0	328	11	3	1
Mero	407	20	4		412	20	4		413	20	4		413	20	4	
Mrumeni	176	9	4		177	9	4		179	9	4		178	9	4	
Uparo	282	9	6	1	284	9	6	1	284	9	6	1	285	9	6	1
Ngasanyi	3	12	8		28	12	3		29	12	3		30	12	3	
Mikocheni kubwa	16	7	5		16	7	5		16	7	5		16	7	5	
Mwangaria	1	6	4		1	6	4		1	6	4		1	6	4	
Soko	1	3	0		1	3	0		1	3	0		1	3	0	

Appendix 6: Distribution of water usage by villages from October 2014-January 2015

Village	October				November				December				January			
	House	**Public**	**Social Inst.**	**Commercial**	**House**	**Public**	**Social Inst.**	**Commercial**	**House**	**Public**	**Social Inst.**	**Commercial**	**House**	**Public**	**Social Inst.**	**Commercial**
Kilototoni	32	450	70	123	36	508	118	125	24	407	79	79	5 743	3 497	59	340
Mero	2 649	150	49	0	2 310	229	47	0	2 228	20	33	0	2 037	148	34	0
Mrumeni	1 339	111	229	0	1 079	79	318	0	1 338	90	119	0	2 956	118	61	0
Uparo	2 512	178	559	11	1 982	112	111	15	2 485	98	157	20	6 053	165	239	233
Ngasinyi	48	158	103	0	173	142	48	0	290	193	54	0	228	191	56	0
Mikocheni kubwa	147	1 163	275	0	137	973	251	0	154	192	259	0	178	1 242	321	0
Mwangaria	3	75	3	0	3	72	3	0	6	81	6	0	3	85	4	0
Soko	1	82	0	0	1	82	0	0	2	82	0	0	2	84	0	0