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The Economic Efficiency and Effectiveness of Domestic Water Allocation in Moshi Rural District, Tanzania

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Abstract: Water is one of the scarce resources which is very important for the development for humankind hence efficient allocation is needed. The demand for domestic water as elsewhere is increasing as time goes according to records. This study was about the economic efficiency of domestic water allocation in Moshi Rural District, the case of Kirua-Kahe area. There were 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. The findings show that Kirua-Kahe uses Gravity water supply and Pumping system. Gravity water supply system has 8 working intakes, 2 boreholes. The Pumping water Supply system consists of 15 small pumping schemes being pumped from boreholes and 1 spring. From the sampled villages, the findings also show within the family female members were mostly concerned with water usage. 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 connections. Pricing is used for consumers as contribution for the sustainability of the project. The economic efficiency was carried out based on analysis of usage and collection efficiency and all constraints and optimality conditions were satisfied. Further research is needed to design service delivery models, technological innovations and education.

Keywords: Economic Efficiency, Effectiveness, Allocation, Collection, Supply, Demand

1. Introduction

Water is one of the scarce resources which require effective and efficient allocation due to economic characteristics it holds [1]. It is essential resource for both life and all economic activities, including agriculture, energy and industrial outputs [2]. Therefore water is necessary to be reliable, clean and sufficient not only for human health and well being but also essential for freshwater ecosystems.

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 [3]. Tanzanian projections show that water availability will reach $1500m^3$/capita/year by the year 2025 [4].

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 [5].

There has been an increase of human activities and one of the most affected areas are water sources and infrastructures which has resulted 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.

Currently there are initiatives that are been 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 has 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. Despite 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.

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 is no enough information on its efficiency. There are very few studies regarding to efficiency and effectiveness of domestic water allocation at ward or village levels whereby most information is generalized at national wise.

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 is 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.

2. Review of Literature and Theory

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 [5]. 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 [6-8]. 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 [7, 9]. In the [10] 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.

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 [11]. This is achieved through the allocation of water to uses that are of high value to society away from uses with low value [9, 12]. [11] 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.

2.2. 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 [7]. 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 [4].

2.3. 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 [13].

2.3.1. Methods for Economic Valuation

There is 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 [14].

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 cited by [15].

2.3.2. 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 [13]. 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 [16].

2.4. Optimality in Water Resources Allocation

The concept of optimality is related to efficiency 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 [13]. 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 [17]. 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.

2.4.1. Assumptions of Linear Programming

According to [18], 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 [19]. 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.

2.4.2. Assumptions of Linear Regression

According to [20], 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.

3. Research Methodology

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.

This study was only limited to Kirua-Kahe due to the vastness of the area. Also, there are well organized water supply boards where enough information was collected. The study area was selected because of its geographical variations nature 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.

3.1. Design

Cross-sectional research design is sometimes referred to as survey design, usually connects people’s minds with questionnaires and interviews. 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 [21].

3.2. Targeted 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.

3.3. Sampling Technique

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.

The study was subjectively confined to 110 respondents as a sample size for data generation. 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. This sample was enough to represent the population of Kirua-Kahe in Moshi Rural District.

3.4. 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

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.

3.5. Linear Regression Analysis

Linear 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 Linear Regression Analysis is modeled below with factors which were affecting the household water demand.

The measurement and analysis of satisfaction has now days received much consideration in various disciplines including economics and marketing [22]. 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.

4. Results and Discussion

4.1. Sampled Population Characteristics

Table 1 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 [10]. The findings show that households' size has a direct relationship to water demand which is different from [23] that is based for developed societies.

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 [24] 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 1. *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

4.2. The Process of Domestic Water Allocation in Kirua-Kahe Water Supply

4.2.1. 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.

4.2.2. 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.

4.2.3. 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.

4.2.4. Participation

The findings show that 58.6% do 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 livelihood.

4.2.5. 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 2.

Table 2. *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

Source: Field data

4.2.6. 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 [10]. The price of water plays a very important role in water consumption because price is inversely proportional to usage [19, 25]. 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 [7, 9, 26]. 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 3).

Table 3. *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

Source: Field data

4.3. 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 the 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.

4.3.1. 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. A thorough study on water demand was conducted and the collected data were used to formulate the model below.

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

Subject to

$$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 \leq 6\,568 \quad (2)$$

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

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

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

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

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

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

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

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

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

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;

The findings show that all constraints and optimality conditions were satisfied for each village (Table 4). 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 4. *Collection Efficiency.*

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

The collected information is helpful to make details on the average daily usage, maximum usage periods as in other communities [23]. 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 5 and 6). 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. 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 5 and 6).

Table 5. *Kirua-Kahe gravity monthly collection.*

Month	Water sold (m^3)	Bill amount (Tshs)	Adjustment	Special charge	Remaining
Jan-15	1 874 783	855 660 055	-5 681 216	62 100	850 040 940
Dec-14	1 779 400	800 450 200	-5 572 616	62 100	794 777 584
Nov-14	1 731 928	788 025 250	-5 572 616	62 100	782 514 735
Oct-14	1 683 756	764 210 370	-5 552 316	62 100	758 720 155
Sep-14	1 629 568	738 653 995	-5 275 466	62 100	733 440 630
Aug-14	1 580 480	714 806 165	-5 275 466	62 100	709 592 800
Jul-14	1 530 294	690 884 815	-4 763 594	62 100	686 183 325
Jun-14	1 489 960	670 398 690	-3 741 923	62 100	666 718 867
May-14	1 451 453	652 506 030	-3 347 923	62 100	649 220 207
Apr-14	1 419 501	635 438 915	-3 277 423	62 100	632 223 592

Table 5. *Continued.*

Month	Minus outstanding (Past -Current)	Total collected (with special charge)	Collection efficiency with adjustment (%)	Collection efficiency without adjustments	Difference (%)
Jan-15	89 509 279	760 531 661	89.54	88.88	0.66
Dec-14	83 223 400	720 245 620	90.65	90.12	0.53
Nov-14	80 298 214	702 216 521	89.81	89.10	0.71
Oct-14	67 256 984	691 463 171	91.20	90.47	0.73
Sep-14	65 882 489	667 558 141	91.08	90.37	0.71
Aug-14	51 776 884	657 815 916	92.76	92.02	0.74
Jul-14	64 934 564	621 248 761	90.60	89.91	0.69
Jun-14	59 216 797	607 502 070	91.17	90.61	0.56
May-14	64 737 487	584 482 720	90.08	89.57	0.51
Apr-14	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 6. *Kirua-Kahe pumping monthly collection.*

Month	Water sold (m^3)	Bill amount (Tshs)	Adjustment	Special charge	Remaining
Jan-15	241 900	329 427 200	-223 250	27 250	329 231 200
Dec-14	234 662	318 970 200	-223 250	27 250	318 774 200
Nov-14	227 908	309 141 200	-223 250	27 250	308 945 200
Oct-14	222 344	301 040 950	-223 250	27 250	300 844 950
Sep-14	216 600	292 220 000	-223 250	27 250	292 192 750
Aug-14	210 805	284 296 950	-223 250	27 250	284 100 950
Jul-14	205 443	276 652 700	-223 250	27 250	276 456 700
Jun-14	200 359	269 178 950	-223 250	27 250	269 178 950
May-14	195 448	262 419 700	-223 250	0	262 419 700
Apr-14	190 823	255 864 950	-223 250	0	255 641 700

Table 6. *Continued.*

Month	Minus outstanding (past+current)	Total collected (with special charge)	Collection efficiency with adjustment (%)	Collection efficiency without adjustments	Difference (%)
Jan-15	14 908 300	314 322 900	95.47	95.41	0.07
Dec-14	6 894 100	311 880 100	97.84	97.77	0.07
Nov-14	12 919 300	296 025 900	95.82	95.75	0.07
Oct-14	13 177 300	287 667 650	95.62	95.55	0.07
Sep-14	12 000 500	291 996 750	96.25	96.32	0.07
Aug-14	11 047 500	273 053 450	96.11	96.04	0.08
Jul-14	9 951 650	266 505 050	96.40	96.32	0.08
Jun-14	9 623 950	259 555 000	96.43	96.34	0.08
May-14	9 470 700	252 949 000	96.39	96.31	0.09
Apr-14	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 cumulativelly

4.3.2. The Demand of Domestic Water Allocation

Therefore, the Household Demand Function for water use using Multiple Regression Analysis is modeled below with factors which were affecting the household water demand.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots\ldots\ldots\ldots \beta n X n + \mu \quad (4)$$

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 [22]. 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.

Regression analysis is also a useful diagnostic tool for exploring water use behaviours [27]. Since all village demands were satisfied, there were no occurrences of water shortage throughout the year. The demand function was determined using Multiple Linear Regression analysis and the independent variables shown and the dependent variable was the average daily usage for each household (Table 7).

Table 7. *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 7 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 [4]. 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 conducted by [28].

4.4. Effectiveness of Water Allocation

4.4.1. 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 8). 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 [28] 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. 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 8. *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)

Since Table 8 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

4.4.2. 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. The findings show 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.

Rain water is regarded as the alternative source widely used and safe for consumption apart from the water supplied from taps used by 43% of customers. Water from rivers and wells follow as the alternative sources occupying 19% of the users followed by ponds with 18%.

5. Conclusion

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.

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