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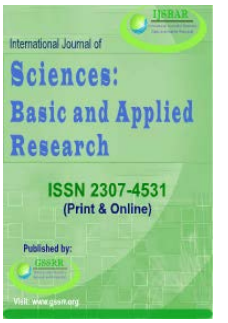

Assessment of Level and Quality of Water Supply Service Delivery for Development of Decision Support Tools: Case Study Asmara Water Supply

Kahsay N. Zeraebruk[a*], Alfred O. Mayabi[b], John M. Gathenya[c], Zemenfes Tsige[d]

[a]*Department of Civil Construction and Environmental Engineering, JKUAT, Kenya*

[b]*Department of Civil Construction and Environmental Engineering, JKUAT, Kenya*

[c]*Department of Biomechanical and Environmental Engineering, JKUAT, Kenya*

[d]*National Board for Higher Education of Eritrea, former University of Asmara, Eritrea*

[a]*Email: kahsayneg@yahoo.com*

[b]*Email: drmayabi@yahoo.com*

[c]*Email: mgathenya@yahoo.com*

[d]*Email: zemenfest@gmail.com*

Abstract

The available water sources in many parts of the world are becoming depleted and the problem is compounded by the rate at which populations and rate of demand are increasing. The scarcity of water for urban use is the major problem in many developing countries. With increasing pressures due to urbanisation, population growth, aging infrastructure, climate change, coupled with an unsustainable conventional water management, cities and urban areas in developing countries are facing enormous difficulties and will experience huge challenges in future to manage efficiently the scarcer and less reliable water resources. In some countries, water service quality may be low, service providers' financial capacity to deliver optimum services may be weak, and some segments of the population in most cases the poor may not receive water service at all. Piped water may be intermittent and, when available, may be unsafe for drinking.

The study sought to assess the quality of water supply service delivery in Asmara, the capital of the State of Eritrea, using sample data collected from each of the thirteen local area administrations of Asmara. The objectives of the study were to assess the levels of service quality delivery of water supply and sanitation and to provide Asmara

*Corresponding author: Kahsay N. Zeraebruk, Tel.: +254708 725 239.
E-mail: kahsayneg@yahoo.com

Water Supply Department (AWSD) with vital information for development of appropriate decision support tools in order to improve the services. A descriptive survey design was used and structured interviews through questionnaires were used as data collection instruments. Samples of 300 households were drawn from the population of the city using stratified systematic random sampling based on the location of the households within each local area administration, without making any category between them for instance according to the level of their income.

The major findings were that the quality of water supply service delivery was generally unsatisfactory. This was mainly attributed to inadequate and non-equitable water distribution system, unreliable supply due the rationing system, and poor management of water delivery services by ASWD. It was concluded that the quality of service delivery by ASWD in Asmara and surrounding villages fell far short of residents' expectations and the level of dissatisfaction was as high as 60%. The study recommended that for effective service delivery Administration of Maekel Zone (Central Region) and AWSD should adopt management strategies through performance evaluation and procedures to effectively reduce leakage losses. The current water supply should be increased to improve both the level and coverage of water services through rehabilitation of the treatment plants, pumping stations, and the distribution network.

Keywords:*Asmara; customers' satisfaction; decision support tools; stratified random sampling; water supply*

1. Introduction

Water is a precious natural resource, vital to sustain life, for economic and social development and for environment protection. Research works conducted in many developing countries have shown the interdependence between water availability and economic development and the link between water and poverty. Target ten of the Millennium Development Goals – 'Halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation'– is an evidence of this growing concern [1]. Access to safe drinking water can be a matter of life and death, depending on how it occurs and how it is managed. It can be an instrument for poverty alleviation lifting people out of the difficulties of having to live without access to safe water and sanitation, while at the same time bringing prosperity to all. However, when it is inadequate in either quantity or quality, it can be a limiting factor in prosperity and economic development.

Access to adequate water and sanitation is low in many countries in Africa resulting high incidence of communicable diseases that reduce vitality and economic productivity of the increasing population. Sub-Saharan Africa population is projected to be more than double by 2050, growing faster than the world population. The region's population is expected to grow from 840 million in 2010 to 1.3 billion in 2030, and further to 1.7 billion in 2050. The region will be responsible for about 30 percent (or 468 million) of the global population growth between 2010 and 2030, and for about 53 percent (or 445 million) between 2030 and 2050. Most of the population growth of Sub-Saharan Africa will take place in cities which will make the water supply crisis more critical [2].

One of the key challenges to the developing countries is increasing access to safe water supply to the rapidly growing urban population, consequently, billions of dollars have been invested in pursuit of the goal of 'universal service' and yet the realization of that goal is still elusive [3].The goal of the 'universal service' is to achieve self-sufficiency in water supply with increased access to safe water of adequate quantity and acceptable quality in sustainable way. The main challenges of increased water self-sufficiency for water managers are: controlling energy demands; controlling environmental impacts; ensuring high quality water and avoiding negative impacts on human health; ensuring public trust in the water supply; and ensuring cost effectiveness [4]**.**

The prevailing water stress in many developing countries especially in urban areas is not only due to source limitation and high growth rate in population but also due to other factors such as poor water distribution efficiency, inequalities in service provision between different sections of the city, and poor and ineffective management system. One of the main reasons is the high rate of unaccounted for water losses or Non-Revenue Water (NRW) in the water distribution network. Every year, more than 32 billion cubic meters of treated water physically leak from urban water supply systems around the world, while 16 billion cubic meters are delivered to customers for zero revenue [5]. Half of these losses are in developing countries, where public utilities are starving for additional revenues to finance expansion of services and where most connected customers suffer from intermittent supply [5]. Research and water utility reports indicate that the major challenge facing water supply providers in Sub-Saharan Africa is

high levels of non-revenue water. It is not unusual to find the NRW in the region to be as high as 40 to 50 percent, almost as twice as much as the best practice of 20 percent. Such losses are not only depriving of millions of people clean water but they incur huge financial losses to the water utilities.

To overcome the challenges in the water sector, policy makers and water agencies must first understand the underlying principles of good water governance, especially in the light of water scarcity and climate change. Sound governance can help create a favourable environment to increase both public and private sector investments and to ensure that much-needed investment is used correctly and efficiently [6].

Asmara water supply system is beset with several problems affecting large proportion of the city's population. The water related problems include low service coverage by the water distribution network, intermittent mode of supply, and long period of cut-offs. These problems are related mainly to limited or scarce water sources, substantial water losses due to leakage, limited hydraulic capacity of the water distribution system and ineffective system of management.

Customer satisfaction measurement allows an organisation to understand the issues, or key drivers, that cause satisfaction or dissatisfaction. Qualitative research techniques can be used to better understand a service through the customers' eyes, and to explore in depth their experiences and expectations. The qualitative research can be supported by quantitative research to provide numerical measures of customer satisfaction and come up with statistically representative findings to assess the performances and provide valuable information to decision makers to drive improved service quality.

In this study, a customers' satisfaction survey had been carried out to obtain first hand data and information directly from customers using face to face interview through a structured questionnaire. The overall purpose of the survey was to assess the customers' experiences and expectations regarding the water supply and sanitation situation in Asmara and surrounding areas. The information is vital for development of appropriate decision support tools for improvement of services.

The specific objectives of this study were to:

- Obtain primary data on the mode of water supply distribution and corresponding issues from customers in Asmara & surrounding villages in order to establish the current level & quality of water supply service delivery.
- Determine customers' level of satisfaction for water services and sanitation received in and around Asmara.
- Obtain vital information to assist decision makers in the water sector and authorities of Asmara Water Supply and Sewerage Department in order to improve services and management of the water supply system.

2. Study area and water services situation

The study area is based on the case study of Asmara water supply system conducted through survey of customers' satisfaction with the domestic water supply and sewerage services. Asmara is the capital of the state of Eritrea and the administrative centre of the Central Region known as Administration of Maekel Zone (AMZ). Asmara is located at an average elevation of 2325 m above mean sea level in the central highlands of Eritrea (see Fig.2.1 Map of Eritrea). Administration Maekel Zone is divided into 15 sub regions or local area administrations and 13 of them are part of the city. For this study, data had been collected from the 13 local sub zone administrations normally known as local area administration (LAA).

As a capital city and major business centre, Asmara has been growing relatively faster in recent years in surface area and population. Records indicate that the current population of Asmara, including the satellite villages, to be around 420,000 (from Database of Administration of Maekel Zone).

Since independence in May 1991, the Government of Eritrea allocated substantial amount of capital budget for infrastructure development to improve provision of water services in Asmara. Asmara Water Supply and Sewerage Department (AWSD) is the only public utility responsible for water and sewerage services in and around Asmara. Although efforts were made by AWSD in replacing old pipe lines and maintaining pumping stations, the current water supply distribution system is inadequate and unreliable and has many deficiencies to cope up with increasing demand.

Fig. 2.1 Map of Eritrea and neighbouring countries

In Asmara there are great contrasts and similarities between the housing typologies within the different parts of the city. Based mainly on geographical location, the type of housing typology or housing design within the city can provide some information on the social functioning of the neighbourhoods, the presence of modern infrastructure facilities such as water, road and sewerage, and the inhabitants' socio economic position. In the report 'Asmara Infrastructure Development Study' [7]the different types of housing settlements, excluding the central commercial district within MaekelKetema (city centre), had been classified into five residential or settlement categories.

- *Established residential area*: these types of neighbourhoods are characterised by well-established villa type of houses and recently built houses with modern facilities. Most of the areas within Travelo sub-region could be classified under this category.

- *Mixed residential area:* this are mixed type of residential areas with villa type typology mixed with courtyard housing typologies. Areas such as Gezabanda, Paradizo, Part of Gejeret and Edagahamus fall under this category.

- *Planned low-cost (popular planned) residential area:* These type of neighbourhoods are mainly the courtyard housing typology which are low cost housing constructed in a planned manner. Sembel, Acria, Maitemenay, and part of Godaif can be classified under this category.

- *Traditional spontaneous residential area:* These are neighbourhoods which were constructed in spontaneous way without planning. They are characterised with narrow and winding streets. Aba-Shawil, Arbate Asmara and some parts of Akria belong to this classification.

- *Traditional village settlement:* These are usually villages located just on the periphery of Asmara which have been absorbed by the city. To some extent these neighbourhoods are characterised with some sort of farming activities. Part of Gejeret village and Godaif village are classified under this category.

The infrastructure study conducted by the consultant BCEOM [7]also provides information on the percentage of the population living in each of the housing category including the population density as shown in Table 2.1 below.

Table 2.1Asmara housing typology, population density and level of income

Type of housing fabric (settlement)	Percentage of Asmara population living in each category	Average population density per hectares	Indicative level of income (relative)
Established residential	7	98	High income
Mixed residential	15	180	Moderate to high income
Popular planned fabric	55	387	Moderate income
Traditional spontaneous	16	1148	Low to moderate income
Traditional village	7	541	Moderate income

The major source of water supply for Asmara and the surrounding villages is surface water collected from rainfall occurring during the rainy months of summer. The runoff created from the rainfall over the drainage area joins streams and rivers and finally collected into dam reservoirs located around the city. Several dams such as Toker, Adi-Sheka, and Mai-Sirwa are located in the catchments area north of the city. These rivers are tributaries of Anseba River which flows towards the north. The Mai Nefhi dam is located south west of the city and drains the catchment areas south of the city which are tributaries of the Barka River. The size of the catchment areas and capacity of the reservoir serving Asmara with the water supply is shown in Table 2.2and their location in Fig.2.2.

Table 2.2: Catchments areas for Asmara water supply

Name of reservoir	Catchment area (Km^2)	Storage capacity (10^6 m^3)
Adi-Sheka	37.5	5.4
Mai-Sirwa	8.7	2.15
StrettaVaudetto	15	1.8
Beleza	6.15	1.2
Toker	140	13.6
Mai Nefhi	97	26

Ground water has not been widely exploited as a direct source of water for municipal use. This could be attributed to the limitation in its quantity as well as its quality which is mostly brackish in nature.

Asmara water distribution system is organized from the two northern Water Treatment Plants (StrettaVaudetto and Toker WTPs) and the New Sembel pumping station at the south which receives treated water from the Mainefhi pumping station. Water is pumped to the distribution reservoirs and provides predominant on-route service connections. The distribution network covers the major part of Asmara urban area with exception of some peripheral and recent developments as well as the high density sector of Aba-Shawil. A water tanker service is organized for the areas without piped connections.

In recent years the city has been under serious water stress conditions due to limited available water resources, unreliable rainy seasons due to climate change, growth in population, and aging infrastructure. For instance, in 2004 the demand for water was estimated at 36,000 m^3/day, whereas the average production from the water treatment plants was 24,000 m^3/day [8], indicating that the water production at the treatment plants for that year was only 75% of the demand.

To manage the situation of water shortage, AWSD has implemented distribution sectors and organized a rationing system with scheduled services. In every sector water is distributed only on some days each week and generally not as a continuous supply but for some hours of the day. Owing to the unreliable services provided through the rationing system, consumers were obliged to device their own storage facilities in their houses such as underground cisterns and roof tanks.

Due to the water shortage and hydraulic problems associated with extended intermittent system of supply, it became impossible to meet the demand in all sectors; some of which suffer a severe rationing leading to critical cases of

interruption for extended periods and many of the households have to cope with a limited supply. The shortage of water coupled with lack of proper management of the rationing system has resulted in the water tanker services to be extended to peripheral and previously piped sectors that were facing difficulties of distribution.

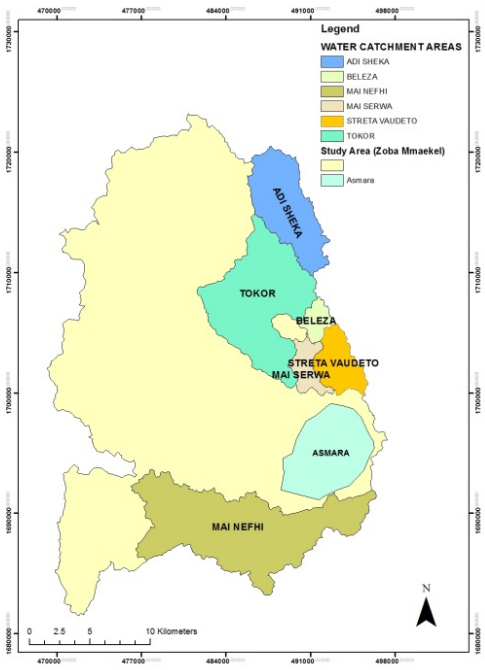

Figure 2.2: Asmara city and catchment areas developed for water supply

3. Research Methodology

3.1 Research approach

The research method applied in this study was a non-theoretical approach using interview schedules (questionnaires) that were developed by discussion and input from the local water supply experts. The survey was designed to gather data about customers' perceptions on water and sewerage services in Asmara and the degree of satisfaction of customers.

The survey was conducted in 13 Local Area Administration (LAA) within Asmara. Data was collected from randomly selected households by utilising structured face-to-face interviews. To show the location and spatial distribution of the data collected, GPS reading of each household interviewed had been taken as shown in Figure 3.1. The statistical software SPSS was used for data analysis to generate information.

The research method applied in this study was a non-theoretical approach using interview schedules (questionnaires) that were developed by discussion and input from the local water supply experts. The survey was designed to gather data about customers' perceptions on water and sewerage services in Asmara and the degree of satisfaction of customers.

3.2 The Questionnaire

The questionnaire consists of eight (8) sections and a total of forty nine (49) main questions with various sub-questions dealing with different issues related to water services such as: Area identification and address of household, Household identification and characteristics of the dwelling, Water supply services, Water quality, Sewerage service, Changes in quality of life, Satisfaction with service quality of the Asmara Water Supply Department.

3.3 Sampling

Since a complete listing of households in the survey area was not available, Stratified Random Sampling was utilised by drawing systematic random samples from each set of mutually exclusive data based on the location of the households without making any category among the households for example according to their level of income. For stratification, the existing Local Area Administration (LAA) was used as the smallest sub-area. As a result, thirteen (13) Local Area Administration entities were identified within Asmara proper. The boundaries of the sub-areas or the LAA were obtained from the regional administration (Administration of Maekel Zone) including the population and number of households.

Taking into consideration the resources and time available for this research, it was decided to take 300 samples. The sample size of households in each subarea or local administration was allocated proportional to the size of the population in that subarea.

Within the selected local area administration first the number of housing-blocks was counted from the map of Asmara and it was divided to the number of samples for that area to get the interval of sampling or the selection ratio 'k'. Within the boundary of a subarea, one block was selected randomly as a starting point by the data collectors. Every 'kth' household encountered was interviewed in terms of the predetermined selection ratio. The head of the household who had to be 20 years and older was interviewed. The procedure followed for substitution for no-one at home or households not willing to participate in the survey was to interview the next-door neighbour residing on the same block. Table 3.1 shows the sample size allocated for each subarea.

Table 3.1: Sample distribution of households in each Local Area Administration

	Name of Local Area Administration (MimhdarKebabi)	Number of households surveyed
1	Abashawil	29
2	Akria	38
3	Arbate Asmara	25
4	Edagahamus	23
5	Gejeret	29
6	Geza Banda	27
7	Godaif	31
8	MaekelKetema	15
9	Maitemenay	17
10	Peradizo	22
11	Sembel	13
12	Travelo	15
13	Tsetserat	15
Total		300

3.4 Data collection and analysis

Four persons were recruited as data collectors and they underwent through a training on issues such as objective of the survey, methodology of data collection, area to be surveyed including on how to use a GPS equipment to record the geographic coordinate of the household to be surveyed.

To assess the feasibility of the questionnaire and also to clarify and modify ambiguous and unclear questions pilot surveys were conducted. The results of the pre-test study were used to modify and amend some of the original questions.

The survey and data collection work covered thirteen (13) local administration areas within Asmara and surrounding villages which receive their water services from Asmara Water Supply Department (ASWD). A total of 300 households were surveyed which were selected randomly after allocating each local area administration with its share of households based on their corresponding size of population which was obtained from the database of Administration of ZobaMaekel for the year ending 2012.

The face-to-face interviews were of a structured type and the collectors were non-directive during the interviews and thus avoided expressions of approval or disapproval and refrained from offering opinions. The interviews were conducted in the official local language and utilised pen and paper system.

In this study, a blend of qualitative and quantitative data analysis approaches was used. In most cases descriptive statistical techniques were employed in order to explain customers' satisfaction with regard to water delivery and serviceprovision. The statistical analysis of data was done using the statistical software SPSS.

4. Results

Most of the residents of Asmara city receive water for domestic consumption from the distribution system covering the major parts of the urban area and some areas of the surrounding villages. This study showed that the connection rate to the water supply network is 78%, and study conducted during 2006 indicated that around 90% of the inhabitants of the Greater Asmara Area (Asmara proper and the surrounding satellite villages) are provided from the system by means of domestic connections for two thirds of the population, and water tanker delivery for the remaining one third [8]. The connection into residence is mostly shared by more than two families per connection. A service by water tanker provides water to those urban areas without piped distribution networks, mainly located in peripheral sectors.

The study also shows that the domestic water consumption in Asmara is quite low according to international standards. This is attributed to shortage of water and to the rationing system introduced in 2004 in order to distribute water to the different sectors of the city by rotation.

The result of the data analysis shows that the level of satisfaction of customers with the water supply services in Asmara was only 40%. The main reasons for the high level of dissatisfaction were unfair and non-equitable distribution of water and poor management system by ASWD.

4.1 Level of water connection

The study shows that the overall connection rate in Asmara is 78%.The areas with the low rate of connection are Aba-Shawil (62%) and Paradizo (59%). The primary source of water for the areas not connected to the network was mainly water tankers.

Table 4.1: Percentage of households connected to the water supply network

Local Area Administration	Connection to the water supply network (%)
Aba Shawul	62
Akriya	74
Arbaete Asmara	76
EdagaHamus	91
Gejeret	90
Geza Banda	85
Godaif	71
MaekelKetema	100
Mai Temenay	82
Paradizo	59
Sembel	69
Tiravolo	100
Tsetserat	67
Total	78

The low connection rate depicted in Paradizo was because of nearby villages of Adi-Segudo and Adi-Abeto, where the pipe network service coverage is substantially very low, are part of the Paradizo administration.

4.2 Domestic water consumption

The quantity of water delivered and used for households is an important aspect of domestic water supplies, which influences hygiene and therefore public health [9]. The rate of domestic water consumption is frequently used as performance indicator of the water supply to meet the needs of the population. Per capita water supplied, expressed

in l/p/d, shows the adequacy of the municipal water supply system in being able to source, treat water to potable standards, and to supply it into the distribution system.

Howard et al [9] summarised that for intermediate access through one tap on plot (or within 100m or 5 minutes total collection time) the average consumption is about 50 l/c/d. At this rate of consumption all basic personal and food hygiene are assured and the health risk is low.

This research showed that 72% of the households were using 15-25 l/p/d and 11% are below 15 l/c/d range, and only 17% are using above 25 l/c/d as shown in Table 4.2. If the 50 l/c/d could be taken as a benchmark, the majority of the population of Asmara were getting water below the minimum amount required for healthy living.

Table 4.2: Summary of daily water consumption

	Water Consumption (l/c/d)				
	10-15	15-20	20- 25	25 - 30	30 and above
Percentage of households	11%	44%	28%	5%	12%

The study shows that there was an indication that substantial portion of the population of Asmara are under critical water shortage situation. Areas worst affected include Aba-Shawil, Arbate-Asmara, and Akria as substantial percentage of the residents are in the lower range of the consumption rate.

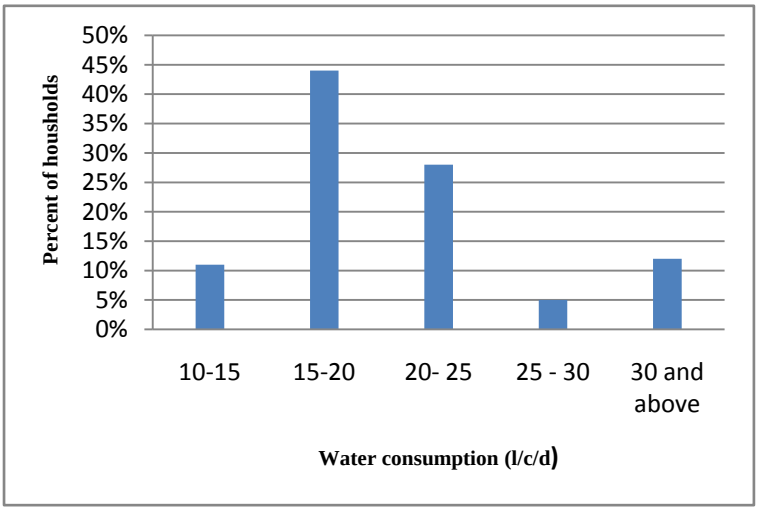

Figure 4.1: Summary of water consumption in litres per person per day (l/c/d)

4.3 Relationship between water consumption and connection to the pipe system

Table 4.3 shows the relationship between water consumption by households and state of connection the distribution system.

Table 4.3: Relationship between water consumption and connection to the pipe system

Water consumption (L/C/D)	Consumers with connection (%)	Consumers without connection (%)
10-15	9.4	16.7
15-20	41.9	51.5
20- 25	29.9	21.2
25 - 30	4.7	6.1
30 and above	14.1	4.5

Analysis of the data showed that there is little or no direct relationship between the rate of water consumption by households and whether the household is connected to the network or not. A Chi-square test showed that there is little interdependence between rate of consumption and connection to the network. While 80% of the households connected to the water supply network were using water below 25 l/c/d for the households not connected the percentage is around 90%. The main reason for independence was that many households that were connected to the system had no water for weeks continuously causing low water consumption.

4.4 Primary source of water

Around 67% of the households indicated that the pipe network as their main source of water; while 30% depended on water trucks as their primary source of water (see Table 4.4).

Table 4.4: Primary source of water

Primary Source of water	Households (%)
Borehole/Hand dug well	2.6
Neighbours from pipe network	6.0
Piped into residence	60.7
Water truck	30.7

Since the introduction of the system of water rationing in 2004, many parts of Asmara, even those areas which were connected to the WDN, became dependent on water trucks as their main source of water. Records of AWSD show that the volume of water distributed by water trucks is increasing annually as shown in Table 4.5 below.

Table 4.5: Volume of water distributed by water trucks

Year	2008	2009	2010	2011	2012
Volume in cubic meter (m^3)	786,147	811,987	914,341	915,575	911,577

Source ASWD

4.5 Frequency of water distribution through the network

The study showed that out of the households who claimed that the WDN as their primary source of water, 9% get water daily, 45% weekly and 46% monthly. In addition, the availability of water for customers who were in the weekly or monthly rationing category was between 1 to 3 days and for a maximum of 12 hours per day. The service delivery in each sub region is shown in Figure 4.2.

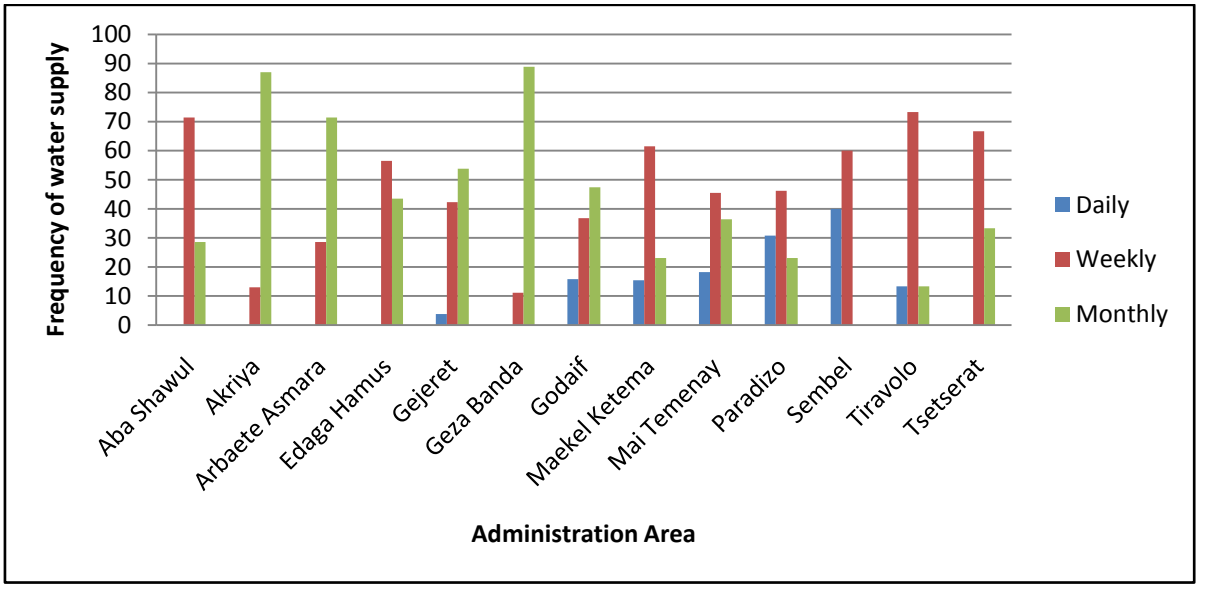

Figure 4.2: Frequency of water distribution through the WDN

There was a clear indication that the rationing system adopted by AWSD as a means of sharing water was not equitable. Many areas especially those that are located at higher elevation or at the far end of the pipe system were left unfairly without water due to low pressure and low flow velocity.

Furthermore, the rationing system had influenced people to develop tendency of speculation to storing water in large underground reservoir or ground containers. Once the system was on, the areas that are at higher elevation or at the far end of the network would not receive water before the storage reservoirs in the immediate households were filled up. In this way many households remained deprived of water services before the end of the rationing schedule.

4.6 Type of sewerage system and toilet facilities

The data analysis shows that 61% of the households are connected to the public sewerage system while 25% are served with private septic tanks. About 14% of the households have no sewerage facilities and as a result they do not own any type of latrine within their household, and they either use public toilets if they are available near the area they live or they have to opt for open air defecation.

Table 4.6: Summary of sewerage connection rate

Type of sewerage	Connection (%)
Public sewerage	61
Septic tank	25
No facility	14

Table 4.7: Type of toilet facilities available

Toilet facility	Available facility (%)
Own flush	47
Shared flush	39
No latrine	14

4.7 Level of satisfaction with water supply services

The analysis showed that, the overall level of satisfaction with the water supply services rendered by AWSD was as low as 34% with 62%he households indicating dissatisfaction.

The study tried to test the interdependence of the level of satisfaction vis-à-vis connection to the water supply network, frequency of water supply in the network, and rate of daily water consumption (l/p/d). In each case a Chi-square test of independence was carried out to show the relationship of the factors with the level of satisfaction. The results of statistical analysis were summarised as follows:

Connection to the water supply network: The results of the test indicated that there was close dependence of the level of satisfaction with connection to the pipe network. The value of the Chi-square test was 18.403 with 1 degree of freedom and $p<0.001$ showing that the population of Asmara without connection to the WDN are less satisfied with the water service provided by AWSD as shown in Table 4.8.

Table 4.8: Relationship between level of satisfaction and connection to WDN

Level of satisfaction	Connection to the water distribution network		Total
	No	Yes	
Satisfied	9%	39%	34%
Not satisfied	91%	61%	66%

Rate of daily water consumption (l/p/d): As it may normally be expected, the statistical analysis showed that the population with low rate of daily consumption were less satisfied with the services provided by the utility. The value of the Chi-square result was 11.920 with degree of freedom of 4 and $p=0.018$ (see Table 4.9).

Table 4.9: Interdependence between level of satisfaction and daily consumption

Level of satisfaction	Water Consumption Litres per person per day (L/C/D)					Total
	10-15	15-20	20- 25	25 - 30	More than 30	
Satisfied	9%	33%	41%	40%	42%	34%
Not satisfied	91%	67%	59%	60%	58%	66%

Frequency of water supply from the network: Availability of water for consumption on daily, weekly or monthly basis was found to be the main cause of satisfaction/dissatisfaction with water services rendered by the water utility in Asmara. The statistical analysis showed that the value of the Chi-square statistics was 99.419 with 5 degree of freedom and $p<0.001$ indicating that there was very high interdependence between level of satisfaction and frequency of water availability in the network as shown in Fig. 4.2.

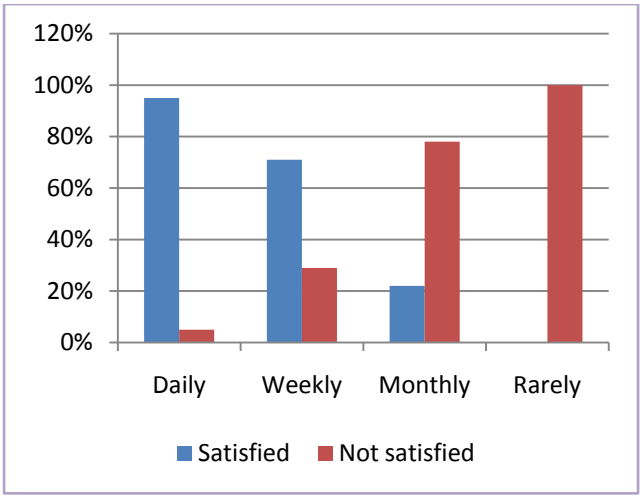

Figure 4.2: Relationship of level of satisfaction to connection to WDN

The statistical analysis showed that the households which were not connected to the WDN were more dissatisfied than those connected because they had limited access to the water supply services implying that they consume very low amount of water on daily basis.

82% of the respondents indicated that the main reason of their dissatisfaction with the water supply services was non-equitable distribution of water, 67% due to poor management of the water supply system, and 30% due to lack of information by the service provider.

Regarding the sanitation services, 94% of the respondents connected to the public sewerage system indicated that they were satisfied with the services provided by AWSD.

Finally the respondents were asked to provide their opinion on the overall level of satisfaction with all the services provided by AWSD, as a public utility company for both water and sanitation, and the results showed that only 40% of the households are satisfied and 56% are not satisfied with the services rendered by AWSD as summarised in Table 4.10.

Table 4.10: Overall satisfaction with services rendered by AWSD

Area Administration	Households satisfied with overall services by ASWD (%)
Aba Shawul	27.6
Akriya	7.9
Arbaete Asmara	24.0
EdagaHamus	56.5
Gejeret	40.0
Geza Banda	29.6
Godaif	25.8
MaekelKetema	66.7
Mai Temenay	70.6
Paradizo	54.5
Sembel	76.9
Tiravolo	80.0
Tsetserat	40.0
Total	40.0

The analysis also showed that the level of satisfaction in the areas with high population density, such as Aba-Shawul, Akirya, Arbate Asmara and Godaif, is below 30%. The population residing in those areas were the worst hit by the current water supply crisis.

5. Discussion

Asmara Water Supply Department is the only water utility company that provides water and sanitation services for Asmara city and surrounding areas. In the absence of reliable database and measured operational data for assessment of service performance, qualitative research techniques were used to better understand a service through the customers' eyes, and to explore in depth their experiences and expectations. Quantitative data were also collected from customers to provide numerical measures of customers' satisfaction and statistically representative findings to provide information, to decision making authorities, to drive improved service quality through development of appropriate decision support tools and performance indicators.

The current water distribution conditions in Asmara and the surrounding villages are constrained due to several problems affecting large proportion of the city's population. The problems include low service coverage by the distribution system, intermittent mode of water supply, and long period of cut-offs. These problems are related mainly to limited or scarce water sources, water losses due to leakage estimated at around 40%, limited hydraulic capacity of the water distribution system, and lack of efficient system of management. The weaknesses related to operation and maintenance and more generally to water management constitute a sensitive matter for the present and the future.

Access to safe water and sanitation is believed to be essential for health, security, livelihood, and quality of life, and is especially critical for women and children [10] (Duflo & Galiani, 2012). The minimum level acceptable standard for water supply service should be a household level water supply connection, that is, a direct piped connection for water supply within the household. Water provision to households by rotation (rationing) from the WDN or through water trucks cannot be considered as an acceptable long-term permanent service provision standard. The social costs and health effects of not having access to a continuous piped water connection, at the household level, are quite significant.

Parts of Asmara mostly affected by the current water supply system are Aba-Shawil, Akria, Arbate Asmara and Godaif and they are also the most densely populated parts of the city. AWSD should outline short term and long term strategies to improve the service coverage in these areas. Improvements in planning and delivery of services are essential to promote more efficient use of water resources [10] (Duflo& Galiani, 2012).The current water supply should be increased to improve both the level and coverage of water services through rehabilitation of the treatment plants, pumping stations, old pipes and extension of the water supply facilities and the distribution network.

The reduction in NRW,in terms of water being lost due to real and apparent losses, to acceptable levels is vital for the financial sustainability of the water utility. Real losses represent the physical water losses due to leakage on supply mains; treatment plants; distribution mains; storage tanks and service connections up to the water meter [11]. Apparent losses on the other hand represent the unauthorised use due to water theft, illegal use, meter and meter reading inaccuracies [11]. NRW can be reduced through appropriate technical and managerial actions, and therefore monitoring NRW can trigger such corrective measures. The reduction of real losses due to leakage can be used to meet currently unsatisfied demand or to defer future capital expenditures to provide additional supply capacity. Appropriate performance evaluation criteria must be introduced to improve quality of water supply service delivery throughout the city.

Lack of skilled and motivated staff is a hindrance to meet the needs of development and ensure efficient operation and effective management. Hence, capacity building program should be initiated by ASWD to strengthen the operation and management and to guarantee an efficient operation and to ensure long term sustainability.

The Water Resources Policy of Eritrea states as its specific objectives(MoLWE, 2007):

- Develop comprehensive and integrated national water strategic plans based on optimum allocation principles that incorporate efficiency in use, equity in access, resource sustainability and ecosystem stability.
- Ensure the provision of clean and safe water for human and livestock consumption.
- Create appropriate institutional framework for managing efficient and sustainable use of the national water resources.

Besides, it is essential to achieve the Millennium Development Goals (MDGs) in water and sanitation as much as possible. However, meeting the MDGs for water and sanitation in the next decade will require substantial economic resources, sustainable technological solutions and courageous political will [12]. We must not only provide “improved” water and “basic” sanitation to those who currently lack these fundamental services, but also to ensure that these services provide [12]:

- Safe drinking water,
- Adequate quantities of water for health, hygiene, agriculture and development
- Sustainable sanitation approaches to protect health and the environment.

As we move forward to meet these challenges, it is critical that we learn from past mistakes and identify creative new approaches to provide sustainable water and sanitation.

Effective water resources assessment and management are not possible without adequate information, including hydrologic information, water-use and quality data, demographic data, forestry and land management, and the capacity to assess the data. There is, therefore, a need for nationally and internationally agreed-upon and harmonized information systems that provide data needed for decision-making, as well as common ways of analysing the information[13].The authorities concerned with operation and management of Asmara water supply system should outline short and long term strategic plans for development of human capacity laying appropriate institutional framework. The people working for the water utility should be well trained in technical as well managerial aspects,I n order to improve the management, performance and efficiency of water supply system to achieve the objectives set by the National Water Resources Policy.

References

1. N. Prasad (2007) “Privatisation of water: A historical perspective.” Law Environment and Development Journal. [online]. Vol. 3/2, pp.217. Available: www.lead-journal.org/content/07217.pdf

2. M. Jacobsen, M. Webster and K. Variavamoothy (2012). “The future of water in African cities: why waste water?” (eds. 2012). [online]. Available: www.elibrary.worldbank.org/doi/pdf/10.1596/978-0-8213-9721-3

3. G. Wagah, G Onyango and J. Kibwage. “Accessibility of water services in Kisumu municipality, Kenya.” Journal of Geography and regional planning, Vol. 3(4), pp. 114-125 May 2010.

4. M. Rygaard, P. Binning and H. Albrechtsen. “Increasing water self-sufficiency: New era, new challenges.” Journal of Environment Management Vol. 92, pp. 185-194, Sep. 5, 2010.

5. B. Kingdom, R. Liemberger and P. Marin. “The challenges of reducing Non-Revenue Water (NRW) in developing countries, how the private sector can help: A look at performance-based services contracting.” Water Supply and Sanitation Sector Board discussion paper Series, Paper No. 8. Available: www.sitersources.worldbank.org, World Bank Dec. 2006.

6. A. Chiplunkar, K. Seetharam and C. Tan. “Good practices in urban water management: decoding good practices for successful future.” 2012 Asian Development Bank (ADB), National University of Singapore, ISBN 978-92-9092-741-9

7. Ministry of Public Works, BCEOM. (2005). The State of Eritrea Asmara Infrastucture Development Study Phase 2: Feasibility Study Housing, (September 2005), 96–145.

8. Ministry of Public Works, BCEOM. (2006 a & b). The State of Eritrea Asmara Infrastucture Development Study Phase 2: Water Sector Water Supply, (September 2006)

9. G. Howard and J. Bartram. “Domestic water quantity, service level and health.” 2003 World Health Organization. Internet: www.who.int/entity/water-sanitation 2003 [June 7, 2012]

10. E. Dflo, S Galiani and M. Mobarak. “Improving access to urban services for the poor.” J-PAL 2012, J-PAL Urban Services review paper. Internet: www.povertyactionlab.org/publication/improving-accce-urban-services-poor Oct. 2012 [11 Aug., 2013]

11. V. Karakouds, S. TSitsifli, P. Samaras, AZoubouls, and G. Demtria. “Developing appropriate performance indicators for urban water distribution systems evaluation at Mediterranean countries.” Water utility Journal, Vol.1, pp 31-40, 2011

12. Moe and R. Rheingans. “ Global challenges in water, sanitation and health.” Journal of Water and Health. [online], IWA publication 2006. Available: www.iwaponline.com/jwh/004/so41.pdf

13. M. Stephen and K. Donkar. “Development challenges of water resources management in Africa.” African Water Journal, A publication of UN-Water/Africa ISBN 92-1-125089. Pp 1-19, Dec. 2003.