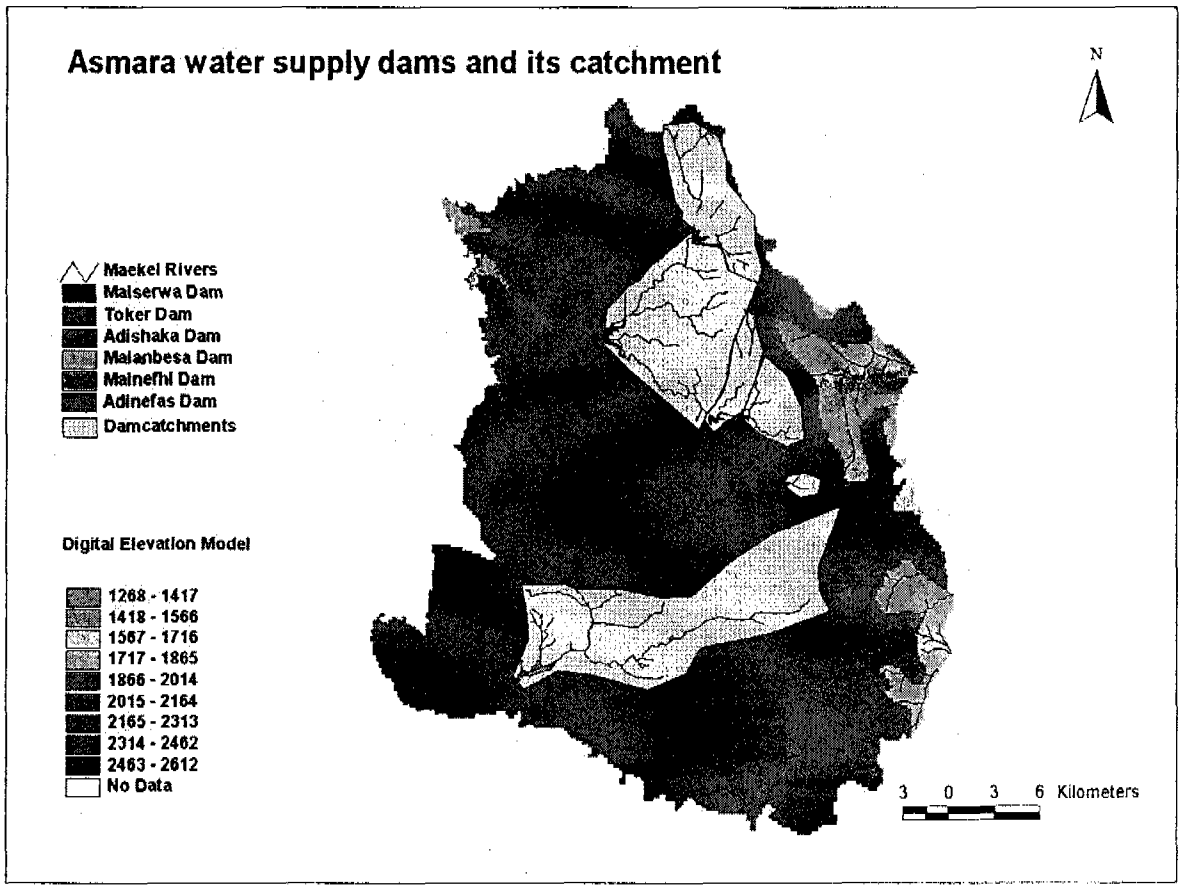
WATER HARVESTING AND CONSRVATION

TITLE: ***PRESENT SITUATION OF ASMARA WATER SUPPLY AND ITS FUTURE CHALLENGES***



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Topic of Presentation: ***PRESENT SITUATION OF ASMARA WATER SUPPLY AND ITS FUTURE CHALLENGES***

ABSTRACT

The city of Asmara is growing very fast in recent years. As a capital city and major business center with relatively better transportation and communication facilities, it is attracting investment. The housing development undergoing inside and surrounding Asmara is clear indication on how the city is growing both in surface area as well as population.

Although a lot of work has been done to improve services by building new water sources and replacing the old pipe lines, the supply and quality of water is inadequate and unreliable compared to the demand.

In future the demand for water will be increasing because all the inhabitants of the new housing development would consume large amount of water and the consumption of water would also increase as a result of improvement of the existing water distribution system and due to improved standard of life.

In light of the limited water resources, unreliable rainy season, fast population growth, and expected fast economic development, proper water resource management and development to sustain the supply of water for Asmara in equitable manner would be crucial for the future development of the city.

This paper tries to briefly explain the existing source of water and present distribution system of Asmara. It is also expected to predict the challenges ahead and identify feasible ways of water harvesting and water conservation methods that could be adopted as part of the integrated water resource management.

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1. Introduction

Asmara being a capital city and in better situation to provide modern communication, educational, business and entertainment facilities, is the most populous city in Eritrea with relatively high population growth rate. The growth rate was also compounded by new influx of people from other parts of the country seeking better life and job opportunity. Besides, the Tesa and housing development under going in and around Asmara has increased its size, both in population and surface area. All these developments would require adequate water supply and proper sanitation facilities.

The source of Asmara water supply is surface water which occurs in the rainy months of summer stored by dams constructed across river basins. The relatively short and unreliable rainy season, frequent droughts and long dry months that cause high evaporation, coupled with the steady growing rate of consumption are putting a lot of strain to the limited water available for supply.

Water requirement and consumption for various purposes have been increasing from time to time. This is because of the ever increasing population, and high consumption resulted from improving living standard and also due to the relatively growing industrial and commercial activities (investment) in and around the city.

On the other hand, the present available sources of water supply could not satisfy all the daily water demands for domestic, industrial and public consumption uniformly throughout the year. Consequently, with out implementation of proper water management and development programs the water crises in the coming few years would not be difficult to predict.

The gab between the supply and consumption (also future demand) should be addressed sooner than later through drafting practical integrated water policy aimed at equitable and sustainable distribution of water as well as conservation objectives. Implementation of efficient water use methods, minimizing water loses, and development of new resources as well as introducing effective water harvesting methods are crucial strategic objectives that should be considered.

Large area of the present day Asmara has not been exploited as a source of surface water due to the use of the rivers inside Asmara which drain to Maibela as a means of sewage collection. This could be attributed to the unavailability of waste water treatment plants, and lack of diversion structures to direct the surface water towards to the existing reservoirs. As a result huge quantity of water has been drained with out use to Mai-Bela river and then to Anseba River.

In the light of limited water resource and increasing water consumption and demand it becomes crucial to study the water resource potential of Asmara and its surrounding for efficient exploitation in the short term and integrated development and conservation in the long term. To achieve this goal an integrated water resource and sanitation development and management programs supported by practically oriented water and sanitation policy would be important.

2. Recent Surface Area Growth of Asmara

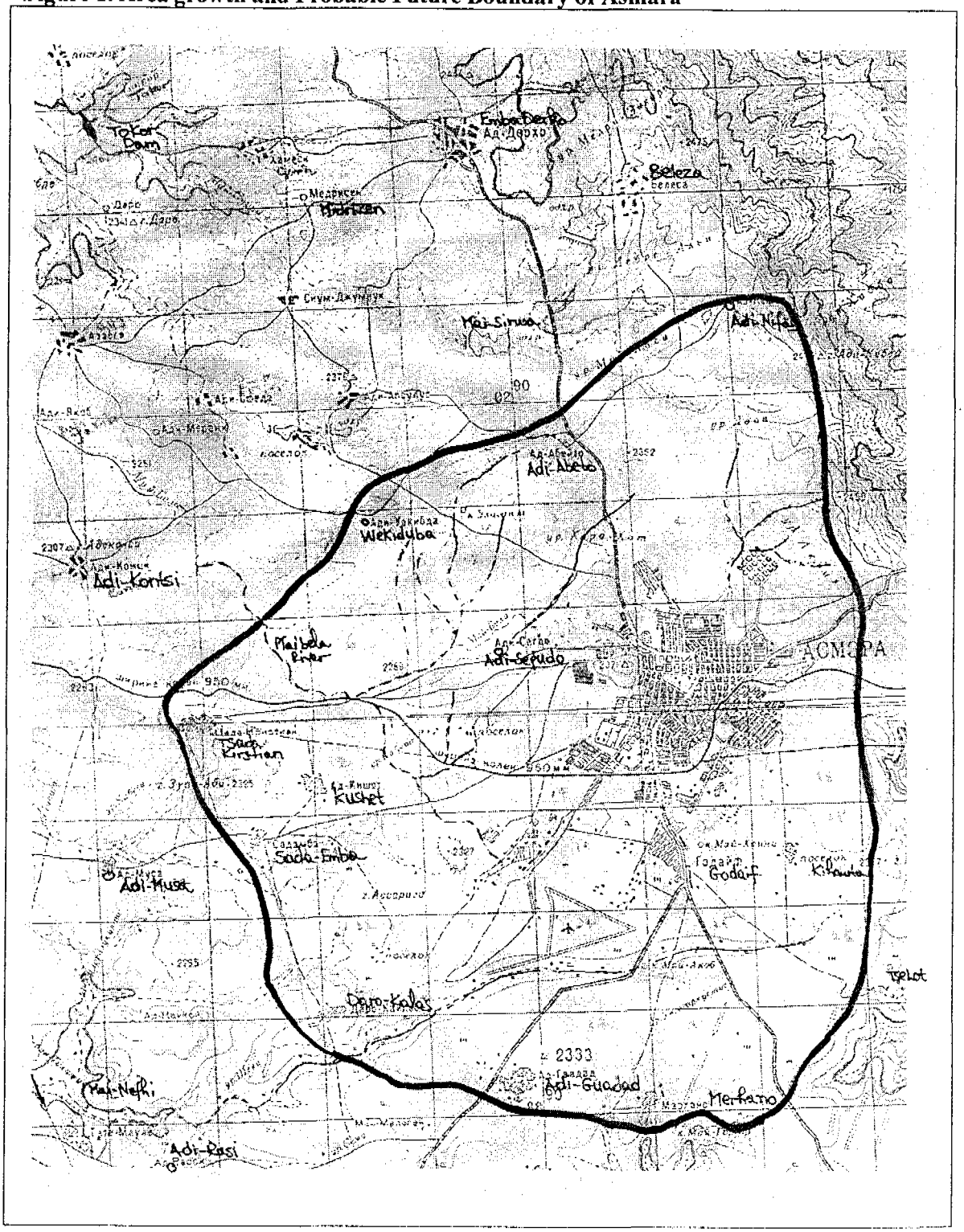
In recent years Asmara is growing fast in surface area. The housing development undergoing within and around the city has extended the area coverage tremendously. The Tesa-development in particular and private and public housing developments in general going on in the nearby villages have changed Asmara from a large town to the rank of a city of moderate size.

As a result of the fast housing development a number of the nearby villages have been incorporated as part of the city and they have already started to share almost all the public services and other opportunities the city could provide. The villages which so far could be considered as part of Asmara are: Adi-Nifas, Adi-Abeto and Wekiduba to the north, Adisegudo, Tsada-Kirstian, Kushet and Tsadamba to the west, DaroKawlos, Adi-Guadad and Merhano to the south.

Upon incorporating all those nearby villages within its boundary, the size of Asmara would be roughly around 110 sqkm. Figure 1 shows the probable boundary of Asmara including the villages incorporated within it. Hence from now on, in this paper, Asmara is meant including all the villages within the boundary shown in Figure 1.

Potable water supply and sanitary disposal of residential, commercial and industrial waste water are recognized as one of the most critical needs of society. Hence, the inhabitants of the housing developments including the villagers and the flourishing small scale industries around these areas would directly or indirectly depend on the Municipality of Asmara for their water supply and sanitation needs.

Figure 1. Area growth and Probable Future Boundary of Asmara



3. Present Water Supply Sources of Asmara

The natural water source of Asmara is from storage reservoirs collected out of surface water through dams built across major rivers. The rivers are flowing only during the short periods of the rainy summer months extending from June to September.

3.1 Precipitation

Assessment of water resources for Asmara requires analysis of all available historic rainfall data. Unlike in the other parts of the country which suffer due to sparse network of stations, compounded by incomplete data of rainfall, there is some how adequate rainfall data record in Asmara. Nevertheless, that does not mean that the estimation of runoff for any given drainage area would be simple and straightforward.

Long term monthly and annual average precipitation for Asmara is shown in Table 1. Although the rainy season spans from June to September, more than 70% of the total annual rainfall is received during July to August.

Table 1. Mean monthly and annual precipitation, Asmara

Month	Rainfall (mm)
January	2.54
February	2.54
March	10.16
April	30.48
May	33.02
June	33.02
July	160.02
August	152.4
September	25.4
October	12.7
November	10.16
December	0
Annual	***472.44***

(Source: Water Resources Policy and Management for Eritrea Dr. Woldezion Mesghinna July 1991)

As far as water resources is concerned the only months with excess rainfall producing exploitable runoff are the wet months of July to September. The small precipitation amounts recorded in the other months are completely lost by evaporation with out creating any significant runoff.

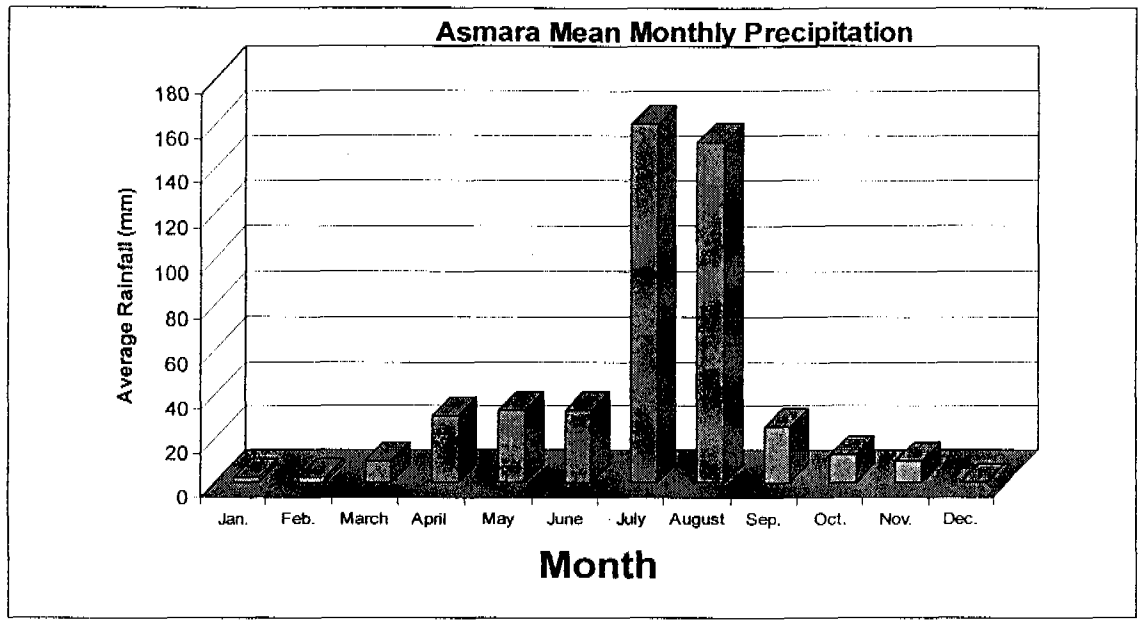


Figure 2. Mean monthly precipitation, Asmara

Unlike the precipitation, the mean monthly temperature in Asmara is almost constant which is around 18 ^{0}C.

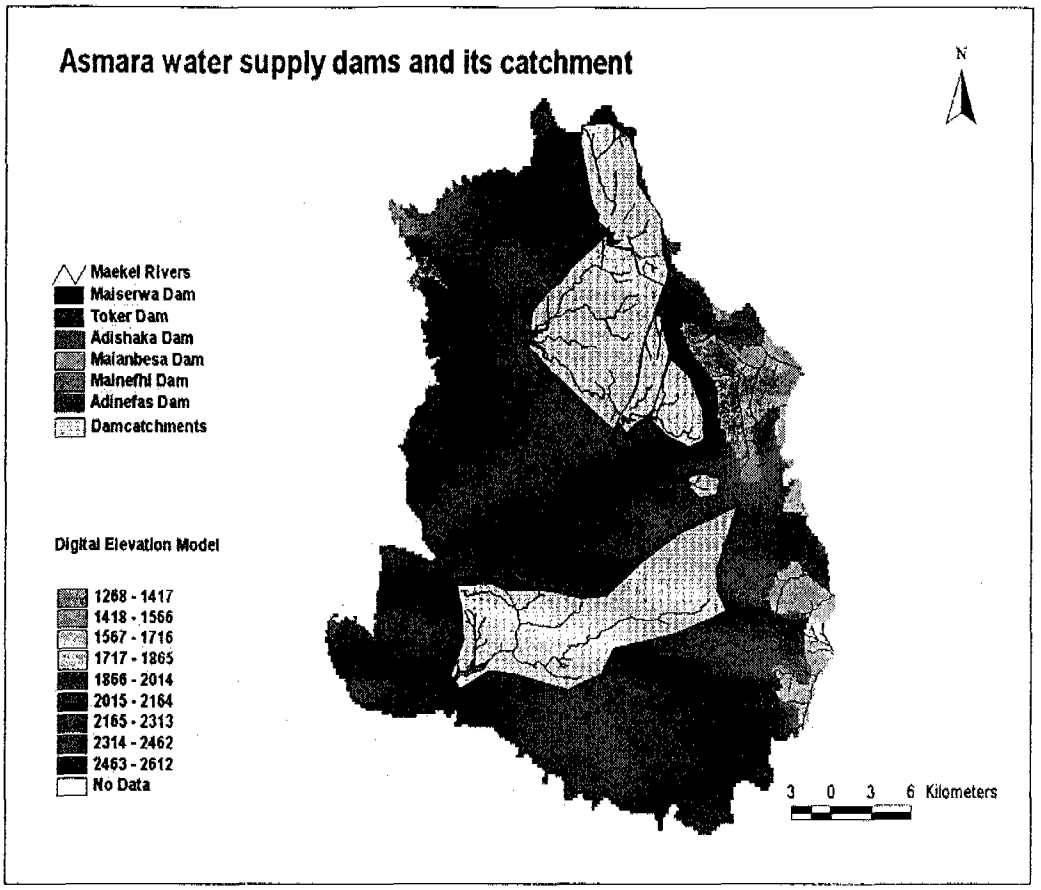
3.2 Water Supply Sources

The source of water supply for Asmara is rainfall occurring during the rainy months of summer. The runoff created from the rainfall over the drainage area joins to streams and rivers and finally collected into storage reservoirs located around the city formed by dams constructed across the rivers. Ground water has not been exploited as a direct source of the municipal water. This could be attributed to the quality problem which is mostly brackish in nature. Upon detailed assessment and quantity and quality investigation the ground water may be utilized for different purposes which require lesser quality of water.

The surface reservoirs which are supplying Asmara for municipal use are:

1. Mai-Nefhi reservoir located southwest of Asmara.
2. Toker reservoir located northwest of Asmara.
3. Adi Sheka reservoir located northeast of Asmara.
4. Mai-Serwa reservoir located north of Asmara about 5 Km from the city center.

Table 2 shows the potential flood runoff that can be harvested at the major water storage reservoirs, and Figure 3 shows the catchment area of the reservoirs and surrounding rivers drainage areas.



Source: Water Resources Department

Figure 3. Asmara water supply reservoirs and drainage areas.

Table 2. Size of drainage areas and potential flood runoff of existing reservoirs

Name of Reservoir	Catchment Area (Km^2)	Mean Annual Precipitation (mm)	Runoff Coefficient Percentage*	Average Runoff Volume (Mm^3)
Mainefhi	105	470	40	19.7
Toker	67	470	35	11.1
Adisheka	33	470	35	5.4
Maiserwa	11	470	35	1.8
Total	***216***	***470***	***35-40***	***38.0***

* Values for runoff coefficient suggested from computation made by WRD.

Consequently on the long term average the combined exploitable flood runoff from the drainage areas of the reservoirs would be around 38 million cubic meter of water. But it should be known that this amount of water is not readily available for supply. The recurrent drought, the high rate of evaporation during the long dry months and also seepage loss from the reservoirs must be taken into account.

All these reservoirs are integrated with the water distribution network and they have their own treatment plants.

Mainefhi and Toker are the major reservoirs feeding the city with its water supply and sanitation needs. The full capacity of the reservoirs and volume of water stored in the reservoirs is shown in Table 6.

There are three water treatment plants currently under operation. Mainefhi treatment plant is situated just downstream of the Mainefhi reservoir currently treating 600 -700 m^3 per hour.

Water from Adisheka and Maiserwa is treated at the old Adi Nefas treatment plant, usually known as Valineki. This plant is currently supplying treated water at a rate of 350 m^3 per hour.

The water from Toker Dam is pumped for a distance of 10 km to the new treatment plant of Adi-Nefas, which has the ultimate capacity of 1000 m^3 per hour. Currently the treatment plant is working at 700 m^3 per hour. The daily volume of water treated by the plants is shown in Table 3.

Table 3. Asmara water supply treatment plants current output*

Name of Treatment Plant	Water Source	Volume Treated	
		M^3/Hr	M^3/Day
Mai-Nefhi	Mai Nefhi Reservoir	700	16,800
Old Adi Nefas (Valeneki)	Adi-Sheka & Mai-Serwa Reservoirs	350	8,400
New Adi-Nefas	Toker Reservoir	700	16,800
Total Volume Pumped		**1750**	**42,000**

*Source: Asmara Water Supply Department

4. Asmara, Present and Forecasted Population Size

Asmara being a capital city and in better situation to provide modern communication, educational, business and entertainment facilities, is the most populous city in Eritrea with relatively high population growth rate. The growth rate was also compounded by new influx of people from other parts of the country seeking better life and job opportunity. Besides, the Tesa and housing development under going in and around Asmara is expected to increase the population.

The present population of Asmara including the surrounding villages is estimated to be between 500,000 to 600,000. Assuming annual growth rate of 3.0%, the population size would reach as high as 700,000 to 800, 000 and around 900,000 to 1,000,000 in the coming ten and twenty years respectively.

Table 4. Asmara summary of forecasted population

Year	Estimated Population Size	Remarks
2003	500,000 – 600,000	Base population used
2013	700,000 – 800,000	Assumed 3% growth rate
2023	900,000 – 1,000,000	Assumed 3% growth rate

5. Asmara Water Supply Distribution and its Coverage

Currently the water supply distribution network does not cover all parts of Asmara. There are large parts of the city still without or with only partial connection to the distribution network. Besides, the areas under intensive housing development on the lands acquired through the Tesa system are largely with out direct supply of water.

Even in the parts of the city where the water lines pass it does not mean that each household has been connected to the system. The data obtained from Asmara Water Supply Department indicated that currently there are only 26,840 households are connected to the network system. From this is possible to deduce that large portion of the community indirectly served either from neighbouring households or water tankers.

The area coverage of the distribution system is improving slowly. To have comprehensive and reliable data about the supply network more detailed investigation would be required.

6. Present Consumption and Estimated Demand

Demand for water supply varies according to the type of supply area but may be generally considered under the three headings of domestic, industrial and agricultural. Within the year, monthly and weekly totals will vary considerably due to seasonal effect (wet or dry periods) and socio-economic effects (e.g. holiday periods, festivals, growth seasons). There will also be daily variations within each week and peak hours during each day.

6.1 Domestic Consumption

Domestic consumption assessments are very important for design purposes of the distribution system, service reservoirs and for proper management of the available water for supply.

Domestic consumption have got several components and it would be advisable to come up with an average rate of consumption for each component.

Some of the components include drinking and cooking, dishwashing and cleaning, laundry, personal washing and bathing, closet flushing, car washing, garden use and recreation.

There is no reliable data available in domestic water consumption based on actual measurement made. If equitable, distribution of water has been assumed the present average daily rate of domestic consumption is estimated to be between 35 l/c/d (liters per capita per day). If the water consumption in public and governmental institutes, such as schools and hospitals added to the domestic demand the rate could be as high as 50 l/c/d .

Assuming present domestic (including public) consumption rate of 50 l/c/d as a base demand and 3%-5% yearly per capita demand increment the consumption was forecasted to reach as high as 80 l/c/d and 100 l/c/d in the next ten and twenty years respectively.

6.2 Industrial and Commercial demand

No generalization can be made as the industrial consumption in each town varies considerably according to the nature of the industry both in quantity and quality requirements. The water is generally required during the working day and this factor must be taken into account in the design of the water distribution system and other accessories. As general guidance the following examples are typical.

(1) For brewing, the quantity of water is substantially the amount brewed.
(2) Canning needs anything between 20 and 40 l/kg canned.
(3) The dyeing industry requires soft, iron-free water, and about 100 l/kg, mercerizing textiles takes 250 l/kg.
(4) Leather requires 80 l/kg of raw hide tanned. Rubber requires 70 l/kg processed.
(5) Paper or cardboard manufacture requires anything between 60 and 360 l/kg.
(6) A ton of soap requires about 2200 l of water in its manufacture.

The above typical figures indicate that the water consumption by industries should not be neglected and availability of ample amount of water should be taken into account in the planning process of future industrial developments.

The data obtained from Asmara Water and Sewerage Department indicates that the total monthly consumption of the relatively bigger industrial, commercial and public enterprises is about 86,000 m^3 giving rise to a daily consumption of around 3000 m^3. That accounts about 7.0% of the total quantity of water currently pumped daily from the treatment plants. But this figure does not include the water used by smaller enterprises as well as industries and public enterprises which are not connected to the distribution system served with water tankers.

6.3 System Losses and Wastage

Some consumption of water by waste is inevitable and few municipalities can seriously claim a figure of less than 10%. Water loss or waste may be due to a number of factors including (1) leakage from reservoirs, mains and other works of an undertaking, and from consumers' pipes and fittings through apertures, defective joints; (2) faulty washers and valve fittings; (3) bad design, failure to turn off taps; and (4) in all cases leakage and waste are intensified by unduly high pressures.

Waste can be detected by detailed examination of the distribution system or house-to-house inspection, apart from a detailed check on the main reservoirs and aqueducts.

Regarding Asmara water supply, there is no thorough study particularly made to find out the causes of loss and quantify the water lost in the whole system. However, it was estimated that the wastage may amount to as much as 50% or more. Recently, the municipality of Asmara has invested a lot of money and work force in replacing the old water mains and it is expected that the loss to be lowered as much as 30%.

7. Summary of Daily Water Demand

Having estimated the present and forecasted future population and also identifying the different components of water consumption, the daily water requirement can be obtained from the simple water balance equation shown below:

Total Water Consumption = ***(Domestic & Public Use) + (Industrial & Commercial Use) + Loss***

The estimated water balance equation given above is summarized in the Table 5 shown below

Table 5. Summary of estimated daily water consumption

Year	Domestic Consumption			Industrial & commercial consumption (m^3/day)	Losses (m^3/day)	Total Daily consumption (m^3/day)	Annual Demand (Mm^3/year)
	Population	Demand (l/c/d)	Daily consumption (m^3/day)				
2003	500,000	50	25000	5000	12,000	42,000	15.3
2013	700,000	80	56,000	16,800	21,840	94,640	34.5
2023	900,000	100	90,000	27,000	35,100	152,100	55.5

7.1 The Present Water Gap

Water demand in Asmara and its vicinities, as explained before, is expected to increase, and the resulting water gap between the) available volume and consumption will call for comprehensive water resource management which involves treating all the activities that use water irrespective of whose mandate it is.

Table 6. Capacity of the storage reservoirs and present available water

Name of Reservoir	Description				
	Catchment Area (Km^2)	Full Capacity (Mm^3)	Present Stored Volume(Mm^3)	Dead Storage (Mm^3)	Volume available for use, Live storage (Mm^3)
Mai-Nefhi	105	26.2	3.8	1.1	2.7
Toker	67	16.0	8.25	2.55	5.7
Adi-Sheka	33	0.8	0.7	0.1	0.6
Mai Sirwa	11	2.1	1.25	0.35	0.9
Total		***45.1***	***14.0***	***4.1***	***9.9***

Source: Asmara water Supply Department (Mm^3 = million cubic meter)

The water currently available for supply in the storage reservoirs, as indicated in Table 6, is 9.9 Mm^3 and the average daily rate of water intake by the treatment plants which is pumped into the distribution system is 42,000 m^3 (from Table 3). If this daily rate of water pumping continues at this rate and neglecting water loss from the reservoirs due to seepage and evaporation the available water for supply would be enough for seven months only.

Water loss from the reservoirs due to evaporation and seepage was estimated to be as high as 20-30% (normally taken a depth loss of around 2.0 m per year) of the total volume of water. Taking these losses into account the actual volume of water currently available for supply would be not more than 7.5 Mm^3. Compared to the 15.5 Mm^3 present annual water requirement of the city the available water would only be enough for six months.

This water deficit would incur huge challenges to the Water Supply Department to make sure that the available water is distributed in a sustainable and equitable manner with utmost consideration given to water security.

Besides, water conservation methods such as creating awareness among the communities to reduce water use voluntarily and water rationing must be introduced as soon as possible. It has been reported that such measures in many parts of the world reduced water use by 10 to 40 percent without creating any serious problems for the residents. It appeared that significant reductions in water use can be achieved through educational programs.

7.2 The Development Gap (Future Challenges)

As explained before, water demand in Asmara and adjacent areas is expected to show dramatic increase and the ensuing development gap between the existing resources and forecast demand will call for mobilization of additional resources. This would be a huge challenge to water authorities in particular and the government in general.

Competition for the limited water supplies – between individual users, and between sectors of water use – will pose an even greater challenge in the future as population and economic growth increase demands for this vital resource.

Part of this gap can be closed by additional exploitation of water resources. This includes proper management and operation of the existing water systems, designing efficient water harvesting methods and exploring unexploited sources of water.

The future water supply gap in Asmara may be closed if the following water development activities have been considered:

1. Enhancing the water intake of the existing reservoirs through catchment treatment and exploring the possibilities diverting potential rivers.

2. Development of the Maibela river water shed which includes large part of Asmara and its surrounding villages.

Maibela water shed has not been used as a source of water for municipal use. This is because all the domestic, commercial and industrial wastewaters of the city are dumped to the river without treatment. This vital water shed should be developed either partially or fully either through treating the waste water or by introducing structures to divert part of the surface water towards the existing reservoirs.

8. Measures That Should Be Taken To Ensure Long Term Water Security

To minimize the impact of the water crisis and ensure sustainable and equitable water supply to whole community the following measures are recommended to be taken by the water authorities:

8.1 Water Resource Development and Management

i. Enhance water capacity of the existing reservoirs through efficient water collection from the catchment area and if possible diverting rivers from other drainage basins.

ii. Integrated water resources development, assessment, measurement guidelines for economic and substantial use.

iii. Introducing water resources conservation and management system and creating awareness among the community the importance of water saving.

iv. Minimizing the loss of water through the distribution system and identify black spots and take on time maintenance works.

v. Introducing proper water pricing.

vi. Research and human resource development for design, operation, management and maintenance.

8.2 Water Supply Policy

i. Recognize that water supply is an integral part of the overall water resources management and incorporate overall water resources management and incorporate water supply planning in the domain of comprehensive water resources management undertakings.

ii. Promote the development of water supply on participation driven and responsive approaches without compromising social-equity norms.

iii. Create and promote a sense of awareness in communities of the ownership and their responsibilities for operation and maintenance of water supply systems and develop participatory management practices.

iv. Develop the appropriate water supply planning parameters, design criteria and standards along with acceptable, desirable and permissible ranges and limits.

v. Build technical capacity in terms of water source investigation, design engineering, water quality control, operation and maintenance, construction technology and facilities.

vi. Ensure that tariff structures are site-specific and determined according to local circumstances.

vii. Ensure that tariff structures in water supply systems are based on equitable and practical guidelines and criteria.