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SCHOOL OF GRADUATE STUDIES

HOUSEHOLD WATER CONSUMPTION PATTERNS;  
THE CASE OF GONDAR TOWN.

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HOUSEHOLD WATER CONSUMPTION PATTERNS:

THE CASE OF GONDAR TOWN.

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Household Water Consumption Patterns:  
The Case of Gondar Town

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## LIST OF ABBREVIATIONS

ADA	-	Amhara Development Association
CSA	-	Central Statistical Authority
CSO	-	Central Statistical Office
EMA	-	Ethiopian Mapping Agency
WSSA	-	Water Supply and Sewerage Authority
MMHWC	-	Mean Monthly Household Water Consumption
MPCWC	-	Mean per Capita Water Consumption
GWSS	-	Gondar Water Supply Service
EWCA	-	Ethiopian Water Works and Construction Authority
NUPI	-	National Urban Planning Institute

## LIST OF AMHARIC WORDS OCCURING IN THE PAPER

<i>Birr</i>	-	Ethiopian Dollar
<i>Kebele</i>	-	The Lowest Level of An Administrative Unite
<i>Wereda</i>	-	An Administrative Unit which is between Kebele and Zone
<i>Zone</i>	-	Administrative Unit which is Between Wereda and National Regional State
<i>Weina Dega</i>	-	Sub-Tropical Climate
<i>Bega</i>	-	Dry Season
<i>Kiremt</i>	-	Rainy Season

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## ABSTRACT

This research paper tries to assess household water consumption patterns in Gondar town based on primary data collected mainly through questionnaire administered to 307 (12%) sample households from four randomly selected Kebeles (03,06,08 and 15) of the town. In order to get acceptable result, data concerning average monthly household water consumption for 12 months was collected.

Sources of potable water for the community are stream, springs and bore holes. The distribution net-work was installed by different organizations and the density of pipe line net-work is not equally distributed over the built-up areas of the town.

At present the large majority (about 87%) of the sample households use pipe water. Whereas, the remaining households are still depend on traditional sources like springs, wells and river. Thus, the mean monthly household and per capita per day water consumption of the dwellers of Gondar is 2636.56 and 15.63 liters respectively.

In order to assess the variation in consumption, the researcher selected eight socio-economic and physical factors as independent variables and household as well as per capita per day water consumption as dependent variables. For analysis he was applied simple correlation, multiple regression, coefficient of variation and t- test. Maps and diagrams are used

to illustrate the results and or indicate places for interpretations as well.

The results of the analysis indicate that mean monthly household water consumption was found statistically significant with household size, household monthly income, occupation of the household heads, number of room occupied by the household, and distance of the housing units from the water point. While mean per capita water consumption was significant only with occupation of the household heads number of rooms occupied by the household and the distance of the housing units from the water point. In addition to this inter Kebele variation in pattern of water consumption were also observed which can be attributed to physical and socio- economic factors.

## CHAPTER ONE

### INTRODUCTION

#### 1.1 The problem

Water which is a substance composed of the chemical elements hydrogen and oxygen, existing in different forms (solid, liquid and gaseous), is the most vital resource for human survival. Man, plants and animals cannot survive on this planet with out water. King has stated the importance of water as "...of all the substances that are necessary to life as we know it on earth, water is by far the most important, the most familiar and the most wonderful" (1953:30).

Even though, water is a basic resource for life to exist on earth and is found in abundant quantity on the earth surface, it is unevenly distributed. As a result, fresh water resource is abundant in some regions of the world, whereas, scarce and or completely lacking in others. Concerning this Gebre-Emanuel argues that:

Water is the most widely occurring substance in the world. Over 72 per cent of the earth' surface is covered by water. Out of the 72 per cent or so of the earth's surface water, 97.2 per cent is in the ocean, unfit for human consumption and too salty. Another 2 per cent of the whole water lies frozen in glaciers in ice caps, and useless. The tiny usable portion left, that is about 0.8 per cent of the total, is neither evenly distributed nor properly used, (1974:19).

In this respect Reio has also argued that " enormous amount of water is available on the earth. However, only 0.62 per cent of

the amounts are fresh water, and only 2 per cent of the latter quantity is surface water where it is easily demonstrable and sizable", (1982:157).

In addition to its uneven distribution another fact inviting attention is that the supply had remained almost constant or has been reduced by pollution and or climatic changes, being experienced throughout the world. Added to it is the ever increasing trend in its consumption (total as well as per capita) due to population growth, industrial growth and expansion, rising living standards, etc. Thus, the problem of potable water has been a global problem and more so in the urban agglomerations. The water problem has now become truly global in character, encompassing even those regions that were thought to be abundantly supplied with water (Kudelin 1971:329).

Even if, access to safe water and high quality of water supply is crucial and basic to human survival, there are many people in the world who do not have access to safe drinking water. For example statistics from WHO reveal that "some 1.2 billion people, or 24 per cent of the world's population, lacks safe drinking water (Sikwibele, 1996:37)". Also in Africa in 1980 out of its rural and urban population which is estimated to be 334 and 135 million respectively only 73 million (about 22 per cent) of the rural population and 89 million (about 66 per cent) of the urban population had access to good drinking water, (UNECA,1989:3).

The magnitude of problem is evident from the fact that about 65 per cent of the total population of Africa (78 per cent of

rural and 34 per cent of urban) do not have access to potable water. Even if, providing people with potable water is a problem for many countries of the world, it is a necessary requirement to supply adequate amount of potable water for domestic consumption in order to maintain the health of a community, because the health of a community largely depends on the ample consumption of potable water. Lack of adequate amount of potable water intake has been found to contribute to various diseases which in many cases lead to death. Regarding this World Resource Institute has stated that:

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The most common tropical diseases are water related and caused by absence of potable water and adequate sanitation or transmitted through insects, parasites and other related diseases vectors. In the developing world 80 per cent of all illness is attributed to unsafe and inadequate water supplies and sanitation, and half the hospital beds are occupied by patients with water related diseases, (1990:131).

In addition to this, With water shortages, it becomes impossible for all household members to make daily bathes. The lack of water for sanitary purposes has resulted in a high incidence of diseases such as dysentery, diarrhea, cholera, malaria, T.B, and other communicable and infectious diseases (Sikwibele 1996:38). Therefore, in order to overcome such serious social problems a better way is to provide the community with ample potable water along with proper environmental sanitation services.

Apart from the shortages of water at the sources the urban community is also suffering from problems related to Water supply systems. Some of such problems are the time taking

queuing at public stand pipes, irregular water supply, taking longer walks for water, water supply interruptions, etc.

Like most of the developing parts of the world, the provision of safe and reliable supply of drinking water is a major challenge for economic development and welfare of the societies in Ethiopia. Till now, as a result of the low level of development, a significant proportion (28 per cent) of the urban population of Ethiopia has no access to safe and adequate potable water supply. They still restrict themselves to the use of what nature has provided in the form of rain, springs, rivers, lakes, ponds, etc. As a result, people largely suffer from water-borne and water-washed infections. Regarding this, the EMA has stated that:

Like all other economic and social establishments water supply also tends to concentrate in the towns of more important industrial and commercial regions. As a result the aggregate urban population of Ethiopia supplied with water is 3.0 million, which is equivalent to 72 per cent of the total urban population (4.7 million) of the country (1988:55).

According to the figure given by the NWRC, WSSA and the Ten-Years Perspective Plan, only 12 per cent of the total Ethiopian population were expected to have some access to clean and safe drinking water by 1983/84. Only 6 per cent of the rural population and 19 per cent of the urban population were adequately served with safe drinking water. Another 50 per cent of the urban population have some access to safe water, although not in sufficient quantity nor of satisfactory quality, (Alula, 1984:3).

completion of Angereb Project the exploitation of the ground water in Kahai Valley was proposed, (Ministry of Interior, Municipality Department, 1967:93). Major problems of the town of Gondar were also emphasized by Dr. Seyom G/Egziabher, the Mayor of Gondar, in his speech to the people of the town on October 23<sup>rd</sup> 1966 E.C, as "... for the historical town, Gondar, the two most challenging problems that hinder the development of the town are water supply and road problem. Thus, these problems must be solved within the near future", (Gondar Municipality of Public Relation Department, 1974:1). The Water Supply and Sewerage Authority, (1991:5) has also articulated the problem by stating that:

The existing water supply is a combination of springs and bore holes. The yield of the bore holes have been abandoned because they have dried up so Gondar has now an acute problem of water supply. The present water supply system is inadequate, unsafe and also subjected to frequent interruption, especially during the dry seasons creating heavy inconveniences to the people and constraining industrial development.

Springs and bore holes are the present water supply sources of the town. The bore holes have dried up, as a result the town is faced with acute shortage of potable water.

The elevation of the built-up area of the town ranges from 1800 to 2150 meters above sea level, (NUPI,1995:1). This means that there is a range of about 350 meters within the built-up area of the town. This topographic nature of the town is adversely affecting the equitable distribution of tap water resource among the inhabitants of the town. As a result, availability of

tap water varies from *Kebele* to *Kebele* because of the variation in elevation. Regarding this NUPI (1995:53) stated that:

The distribution of water supply net work of the town is unfair. The main reason for unequitable distribution among *kebeles* is the nature of topography. For instance most of the residents in *Kebele's* of relatively higher grounds such as *Kebele* 03, 04, 05 06, 09 and 11, generally receive less water than others.

In addition to these the population of the town which was 14,000 in 1938 (Mesfin, 1972:187) reached 156,407 in 1993 (CSO,1992:46) showing an annual average growth rate of 4.5 per cent. Consequently the built up area of the town is also growing fast in order to accommodate the growing population of the town.

According to the result of the 1984 population and housing census, 73.8 per cent of the total population of the town was making use of tap water supply service where as 26.2 per cent were using the traditional sources for domestic uses. Thus, although majority of the population of the town is tap water user, the existing water supply system is inadequate and also subjected to frequent interruptions.

These problems highly, irrespective of their living standards, affect the total as well as the per capita household water consumption of the inhabitants of the town. There are also intra and inter *Kebele* variations in water consumption mainly during the dry months of the year. Clearly this problem affects

the socio-economic well being of the population and hinders with industrial development of the town.

So far the researcher tried to highlight the existing tap water problem that the dwellers of Gondar face. In order to overcome the existing inadequate water supply and to cope with the future demand of the community, it requires the redesigning of water supply project which could identify the problems and incorporate ways to improve the utilization of water. Thus, a comprehensive data base research is needed on the existing water consumption patterns of the town with special emphasis on the impact of physical and socio-economic factors in spatial and temporal perspective so as to plan for sustainable development.

## 1.2 Objective of the Study

The objectives of the study are sub-divided into primary and specific objectives. The primary (central) objective of the study is to identify the patterns and determinants of household water consumption in Gondar town. The specific objectives of the study include the following;

1. To evaluate the historical background and current status of water supply and distribution system of the town,
2. To asses physical as well as the socio- economic factors that determine household water consumption patterns in Gondar,
3. To identify per capita per day as well as mean monthly households water consumptions of the town.

4. To identify the spatial and temporal patterns of household water consumption in Gondar.

### 1.3 Justification and Rational of The Study

Gondar town had been the capital city of the country and subsequently of Bege-Mider and Semien Province, but now it is the capital of North Gondar Administrative zone and Gondar Zuria Wereda.

In addition to its administrative importance, the presence of the castle of Fasilades and historical churches, which are famous as historic sites, as well as the presence of Semien Mountain National Park in the region, attract many tourists from different countries of the world. This naturally adds floating population, which has to be taken care of along with the population of the town itself. As a result of these and related factors, the town experiences fast population growth. The population of the town, which was 14,000 in 1938 increased to 35,331 in 1972, (Mesfin W/Mariam 1972:146), 80,886 in 1984, (CSA, 1990:80), 156,407 in 1993 (CSA, 1994:46) and is expected to reach 250,525; 266,019 and 282,247 at the low (3.5%), middle (4.0%) and high (4.5%) growth rates by the year 2014, (NUPI, 1995:42). In order to accommodate the growing population the built up area of the town is also expanding from time to time.

These trends are sure to increase the pressure on the existing water supply and distribution system. In this connection it may be pointed out that the existing water supply system, which seems to have remained static since long, is insufficient for the present water need of the city which is further aggravated by the nature of topography of the town as "...elevation within

the town ranges from 1,800 meters above sea level to 2,150 meter above sea level", (NUPI, 1995:74).

Thus, Gondar is experiencing shortage of potable water since long, which seems more acute during the dry months of the year. Hence, the researcher was motivated to undertake a research on this topic with the objectives already stated in the forgoing pages. The writer, being a resident of the town, has personal experience with the problems faced by the town dwellers.

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In addition to these the main reason that the researcher undertook this study is to close the research gap between studies that have been conducted on the town's water supply and consumption by giving the necessary detail information on household water consumption patterns based on socio-economic and physical factors of the town.

#### **1.4 Hypothesis**

Based on the objectives listed above and in order to facilitate the proper conduct of the study the following hypothesis are formulated.

1. Household water consumption is positively correlated with household size where as, per capita per day water consumption is inversely related with household size
2. Per capita per day and mean monthly household water consumption are positively correlated with households monthly income, educational level of the household heads and number of rooms that the household occupies. But

inversely related with the distance of housing units from the water point.

3. Per capita per day and mean monthly household water consumption varies significantly with the type of occupation of the household heads and type of the floor of house and source of water.

## 1.5 Methodology

### 1.5.1 Types and Sources of Data

The data sources of the study are both primary and secondary in nature.

#### 1.5.1.1 Primary Sources

The data used are mainly based on primary sources. Based on the research problem and objectives a field survey, using household questionnaire, was conducted in 1998. The questionnaires incorporated questions pertaining to socio-economic and demographic aspects, sources and types of water use, amount of water consumption of the households as well as its seasonal characteristics, etc. The questionnaires were prepared in Amharic language so that it might be understood by the enumerators as well as by the respondents.

The administering of questionnaires was accomplished by seven enumerators and the researcher himself. These enumerators were selected and employed with the co-operation of Kebele administrators on the basis of their qualification (at least

12th grade complete), knowledge of the study area and their individual behavior.

Before the enumerators started the actual field survey the researcher had arranged two days orientation programme which included the practical administering of the questionnaire also. To test the questionnaire a pilot survey had been conducted on 20 households in Kebele 08, in order to restructure the questionnaire before the final survey was conducted.

#### 1.5.1.2 Secondary Sources

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The secondary data that have been used were obtained from various sources, including official documents and records of Gondar WSS, North Gondar Zone Water , Mines and Energy Resource Development Office, NUPI, WSSA; official government statistical sources, reports, maps, books, journals, etc.

The data on population characteristics have been obtained from Population and Housing Preliminary Census of 1984 and from other recent publications of CSA.

# GONDER TOWN KEBELE BOUNDARIES

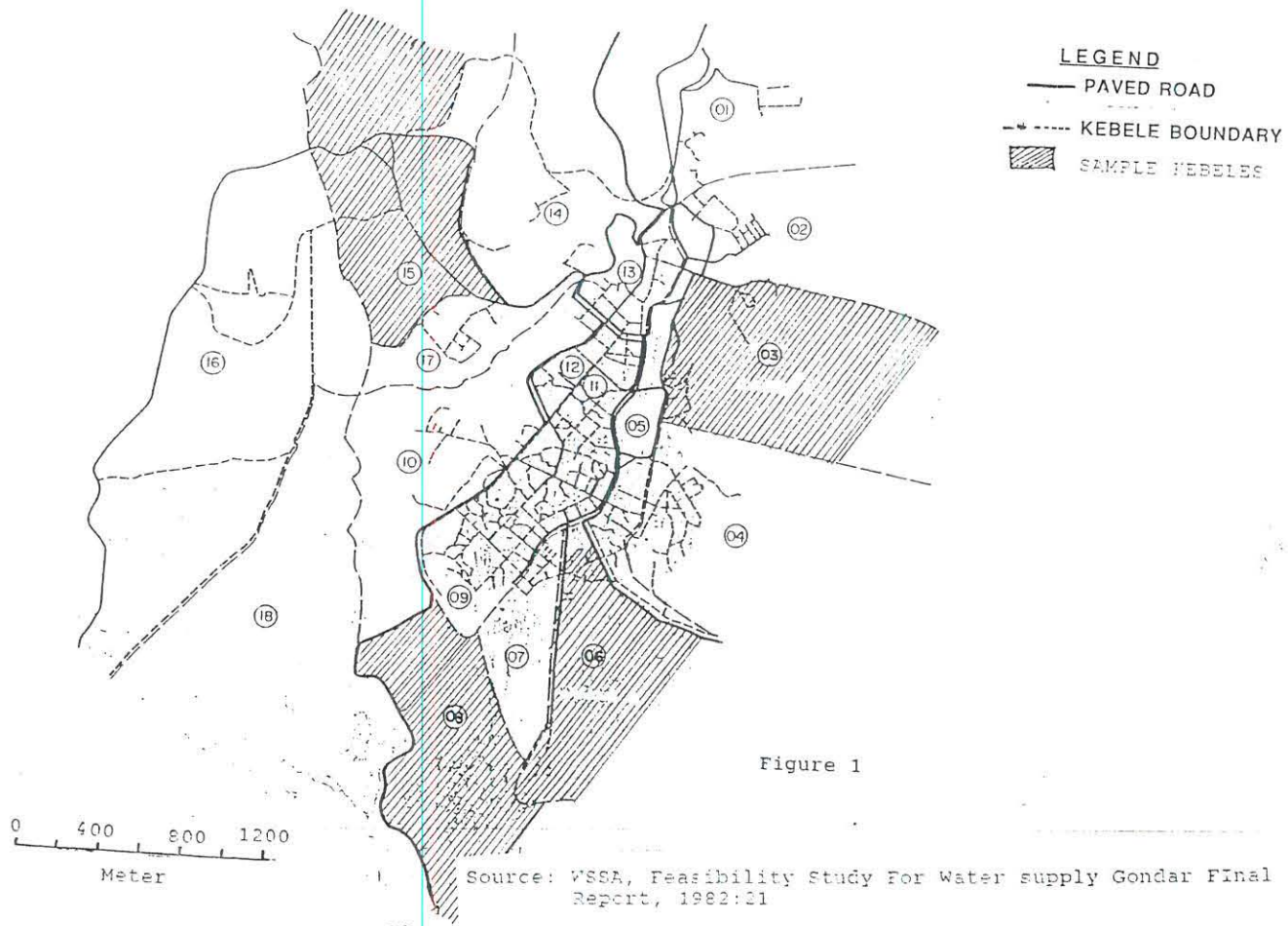


Figure 1

### 1.5.2 Sampling and Survey Design

In 1994 the total number of households, which were distributed in 17 administrative units (*kebeles*) of the town, were 18,066, (CSA, 1995:238).

To make the sample size manageable in relation to the available time, finance and other research materials the sample size of 12 per cent was proposed from four randomly selected *Kebeles* of the town. *Kebele* 03, and 06 were selected from the relatively higher area (03, 04, 05, 06, 07, 09 and 11) and *Kebele* 08 and 15 from relatively lower area (01, 02, 08, 10, 11, 12, 13, 14, 15, 16 and 17). This resulted in sample size of 308 households on which, 307 questionnaires were administered. When we administered the questionnaire one of the identified household head of the sample on *Kebele* 06 was expired hence, the number was reduced to 307.

After identifying the sample size of each randomly selected *Kebeles*, the sample households had been chosen by using systematic random sampling (a sample which contains every  $i^{\text{th}}$  element of the population) from the list of households of the selected *Kebeles* of the town.

Generally speaking women and adolescent girls are more familiar with domestic water uses, amounts, problems as well as distance of the water point ,etc. Thus the enumerators had mainly conducted the sample household survey by interviewing women and adolescent girls of the households and some male household heads. During the survey the enumerators collected data concerning monthly water consumption of each households from

the water bill for those who use meter connection and also interviewed those who had no meter connections.

### 1.5.3 Method of Data Analysis

All the data that had been collected through primary as well as secondary sources have been described and analyzed using tables and figures (maps). In fact tables have been used as important tools of analysis throughout the paper. The researcher's description is also supported by maps (figures) such as the location, relief, sources of water , water distribution network of the town, etc, throughout the paper.

In addition to tables and figures (maps) used, and in order to achieve the above objectives and to test the hypotheses set above, appropriate mathematical and statistical techniques such as simple correlation, multiple regression analysis, coefficient of variation and the T-test have been employed. To use such quantitative methods and techniques for the data analysis the dependent and the independent variables were:

#### 1 The dependent variables

( $y_1$ ) = mean monthly household water consumption in liters

( $y_2$ ) = per capita per day water consumption in liters

#### 2 The independent variables

( $x_1$ ) = household size

( $x_2$ ) = household monthly income

( $x_3$ ) = educational level of the household heads

( $x_4$ ) = occupation of household heads

( $x_5$ ) = number of rooms

( $x_6$ ) = Type of floor of the house

( $x_7$ ) = source of water

( $x_8$ ) = distance from the water point

### 1.6 Limitations

At present Gondar town is in the form of a twin township of Gondar and Azezo, nearly 12 km apart. The town is sub-divided into 21 Kebeles out of which Kebeles 1 to 18 (Kebele 18 is a reserve area which is left for the future expansion of the town) lie in original Gondar town and Kebele 19 to 21 constitute the town ship of Azezo which is excluded from the study.

The exclusion is based on the ground that Azezo is located 12 km south of the main town and has been supplied with tap water only since 1980's E.C. Besides, it has its own water distribution net-work and water sources (bore holes). Thus, the history and the problems of potable water, sources and distribution net-work of tap water ,etc differ from Gondar and the records of the past years are not available.

In addition to this, in order to investigate the temporal patterns as well as the average monthly household water consumptions of the study area, the study is confined to the household water consumption during the last twelve months of the year (September 1989 to August 1990 E.C.).

## CHAPTER TWO

### PHYSICAL SETTING AND HISTORICAL BACKGROUND

#### OF THE STUDY AREA

#### 2.1 Physical Setting

##### 2.1.1 Location and Topography

Gondar is situated in the north western part of Ethiopia. It is located at  $12^{\circ}30'N$  latitude, and  $37^{\circ}12'E$  longitude, about 750 km north west of the capital Addis Ababa via Debre Markos and Bahir Dar.

Gondar is hemmed by mountains that rise to 3000 meters or over in the north, east and west. In addition to its surroundings the town itself is rather hilly with general elevation ranging between 1800 to 2150 meters above sea level, lying, thus, in high altitude, (CSA,1966:2).

The whole town is physically divided into two, the northern part or Gondar proper, where the main administrative town, the central shopping and business center, the historical sights, government offices and other major urban services are located and the southern part which is the satellite town Azezo, about 12 km away to the south of the original town of Gondar mainly consisting of the military camp and the air port.

## CHAPTER TWO

### PHYSICAL SETTING AND HISTORICAL BACKGROUND

#### OF THE STUDY AREA

#### 2.1 Physical Setting

##### 2.1.1 Location and Topography

Gondar is situated in the north western part of Ethiopia. It is located at  $12^{\circ}30'N$  latitude, and  $37^{\circ}12'E$  longitude, about 750 km north west of the capital Addis Ababa via Debre Markos and Bahir Dar.

Gondar is hemmed by mountains that rise to 3000 meters or over in the north, east and west. In addition to its surroundings the town itself is rather hilly with general elevation ranging between 1800 to 2150 meters above sea level, lying, thus, in high altitude, (CSA,1966:2).

The whole town is physically divided into two, the northern part or Gondar proper, where the main administrative town, the central shopping and business center, the historical sights, government offices and other major urban services are located and the southern part which is the satellite town Azezo, about 12 km away to the south of the original town of Gondar mainly consisting of the military camp and the air port.

Previously Azezo was administered under Teda Wereda but after 1966 E.C the town is administered under Gondar municipality by the name Higher 4 and sub-divided into Kebeles 19, 20 and 21.

RELATIVE LOCATION OF GONDAR TOWN

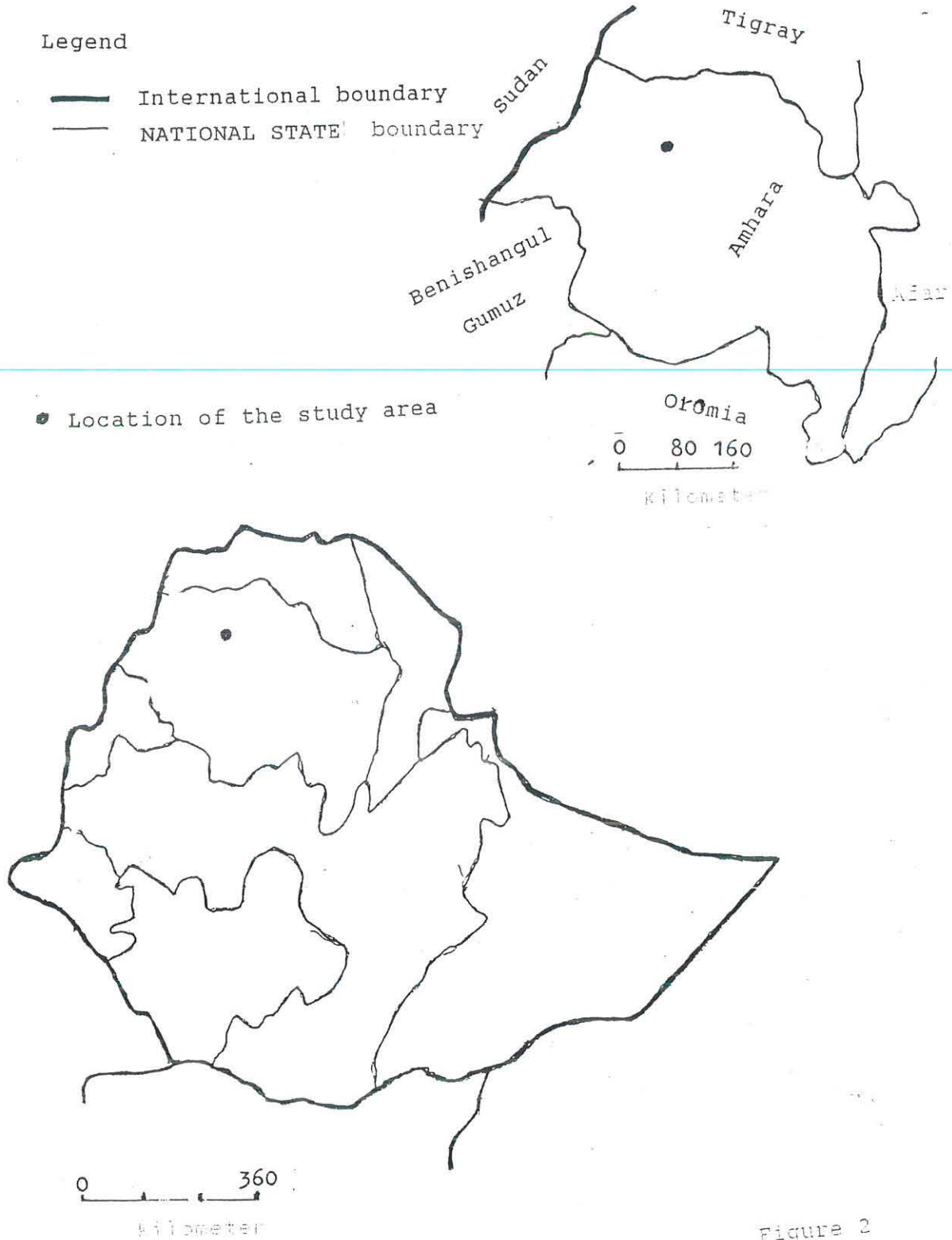


Figure 2

Source: CSA statistical Abstract 1995, (1996:1).

As a result of the physical disparity of the two towns, Gondar extends from north to south in the form of a linear strip along the main road from Addis Ababa to Axum for about 14 km leaving a large tract of open land in the middle.

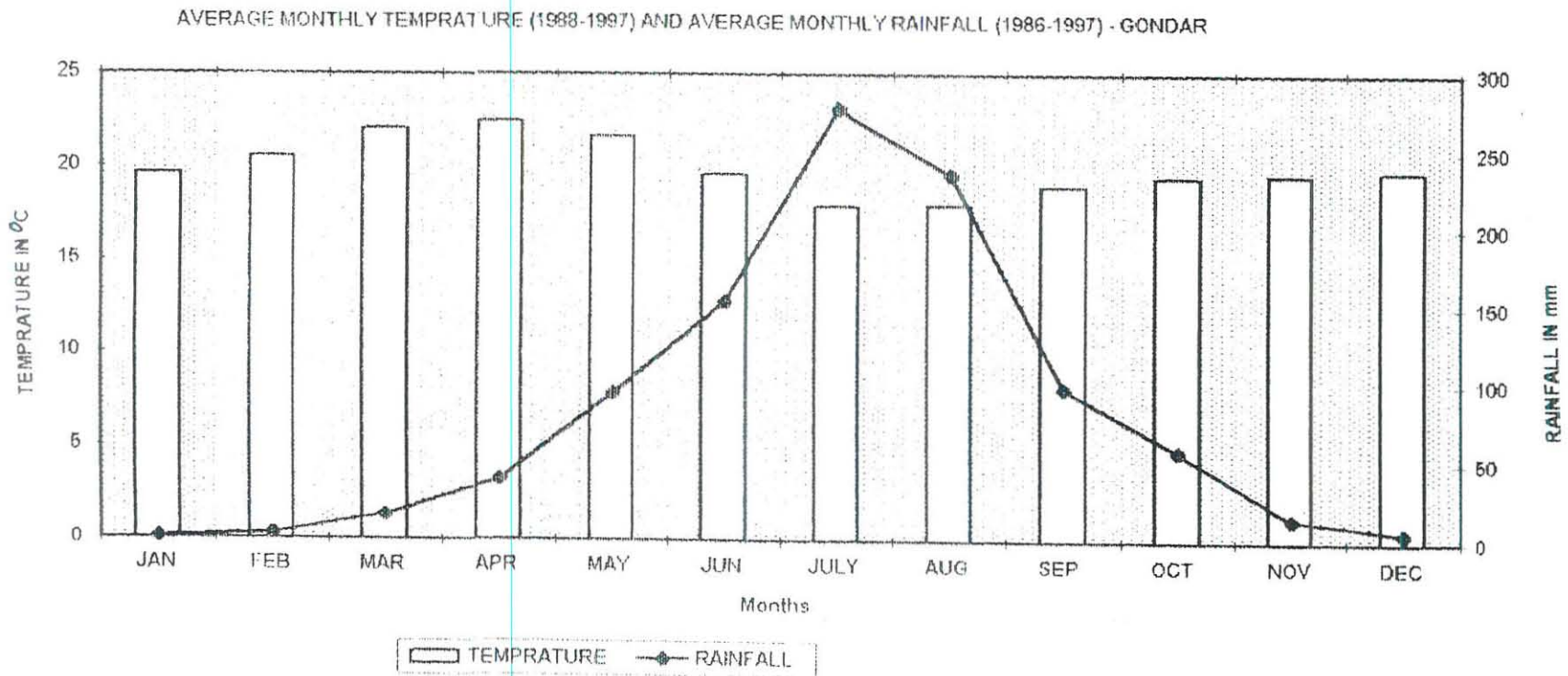
### 2.1.2 Climate and Hydrology

Generally speaking latitude, altitude, winds, humidity as well as the rugged configuration of the land have significant impacts in controlling the climatic condition of a region. But, of all these, altitude has the most critical control on climate in Ethiopia, (Mesfin, 1972 :57).

Gondar, mainly because of its altitude, belongs to *Weina Dega* Climatic Zone and has its rainfall mainly during the summer season. It receives an average annual rainfall of 1,200 mm and the mean annual temperature ranges between 16<sup>0</sup>c to 20<sup>0</sup>c.

The mean annual temperature in Gondar town varies between 16<sup>0</sup> c and 20<sup>0</sup> c. according to Ethiopian temperature zoning, Gondar belongs to *Weina Dega*. The absolute maximum temperature usually occur in March to May and minimum temperature in November to February. Average annual rainfall in Gondar town is 1,200 mm, (WSSA,1991:19).

The mean monthly temperature of Gondar for the years between 1988 to 1997 ranged between 17.94<sup>0</sup>c to 22.45<sup>0</sup>c. Maximum temperature in the town usually occurs between February and May while the minimum between July and August. The average monthly and annual rainfall, as per records of 1986 to 1997, is 83.0 mm and 988.3 mm respectively. Rainfall is seasonal with maximum in July (277.9 mm). The five rainy months (May to September) account for greater than 85 percent of the annual precipitation (Figure 3).



Source: National Metrological Service Agency

Figure 3

Many rivers flow through Gondar. The notable perennial rivers include the Angereb, Kahai, Shinta and Dimaza. Angereb River flows north to south on the east of the town. Kahai river flow from north west to south while, Shinta and Dimaza rivers flow from south west to south crossing the Gondar - Azezo highway at a distance of about 2, 7 and 12 km from the center of the town respectively. All of these rivers form tributaries of Megech River which flows to Lake Tana. In addition to these surface water resources the town has groundwater resource such as bore holes springs and wells mainly used for municipal uses of the town (figure 7).

## 2.2 Historical Background and areal expansion of the study Area

The origin of the name Gondar is still controversial. As to this three different arguments are forwarded by its elders. The first relates the name Gondar with the word "bagonider", which literally means "one should reside beside the other". Informants claimed that, there were two brothers, Wayne and Sayne, who had been quarreling over the land where Gondar now lies, and the elders, while negotiating decided that the one should reside beside the other "bagonider". Others say that it is the combination of two Qimant and Agew words "guang" and "dara" which means "between the rivers" (the two rivers being Angereb and Kahai).

The third version relates the name with two Qimant-Amharic words "gwand" and "dar". While "gwand" stands for ditch or well

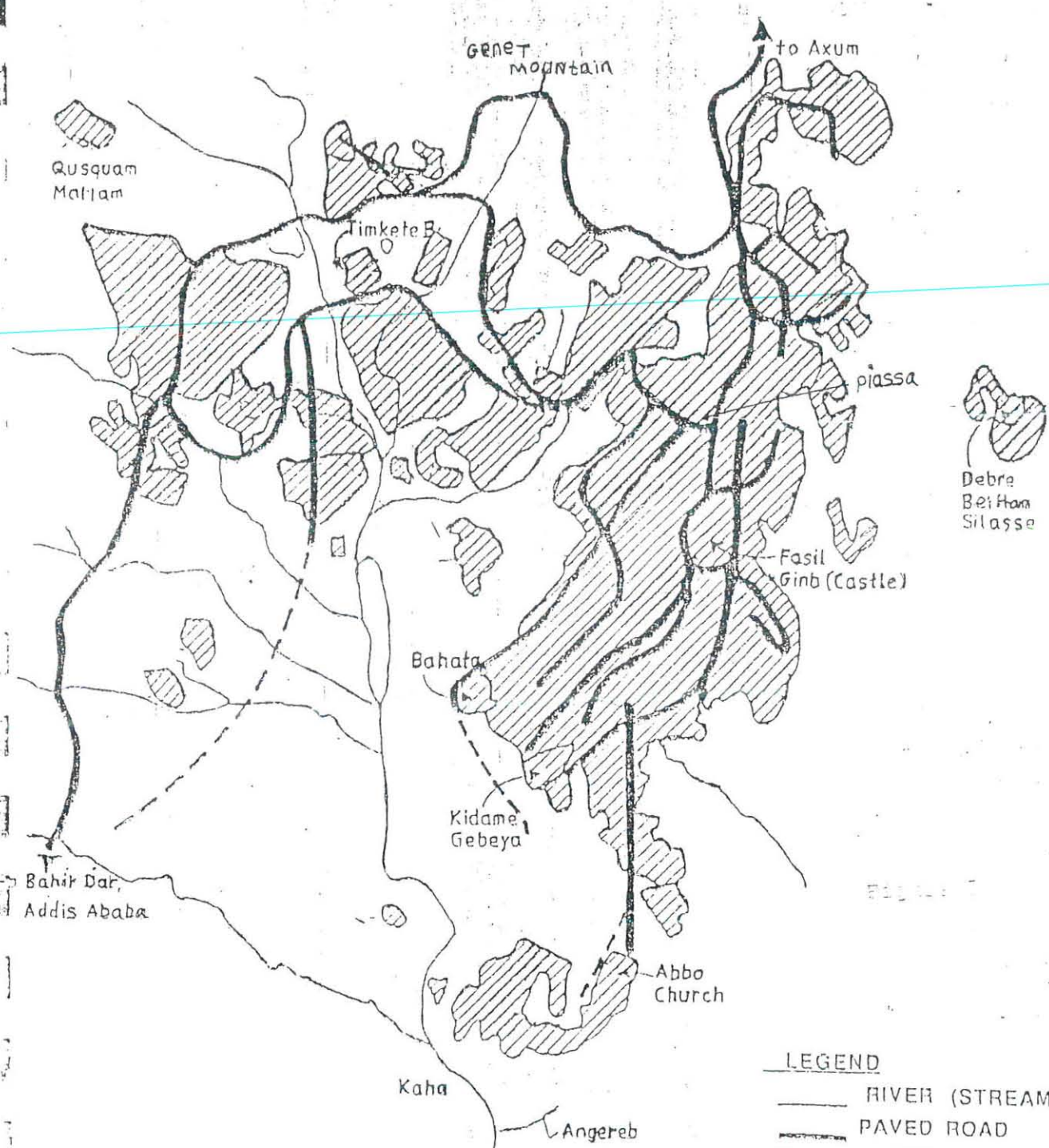
"dar" means edge or limit. Thus, the name is said to be given to show that Gondar is a land located on the edge of a ditch or well. Hence, the true origin of the name Gondar remains obscure until further investigation on this issue comes out with the answer, ( NUPI, 1995:16).

Gondar became the imperial capital in the 17<sup>th</sup> century, before which it existed as a market center. It was established as imperial capital by Emperor Fasilades (1632-1667) who changed his capital in the fourth year of his reign (1635/36), from Dengaz to Gondar, which was 32 km away to north west. He preferred Gondar instead of Dengaz because of several economic and strategic motives." The caravan trade routes from Sudan and Red Sea converged at Gondar" was sited as the prime factor which attracted Fasilades to settle at Gondar with main aim of controlling the trade. Added to it was the abundant resources in the form of trees, water, etc, around the town. Besides these, its location in the upland and encircled by mountain ridges enhances its strategic importance for which must have also influenced the choice of Fasilades (NUPI, 1995:189).

After the establishment of Gondar as imperial capital various buildings such as Fasil Castle, churches, mosques as well as residential dwellings were constructed around the castle by Emperor Fasilades and his followers. In addition to its administrative importance the town is historically famous in architecture, poetry, church music, etc. Its political importance declined ever since the establishment of the new capital Debre Tabor by Emperor Tewodros 2<sup>nd</sup> (1855-1868).

During the Italian occupation (1935-1941) Gondar was made the capital of Amhara Governorate General, (NUPI, 1995:2) .After the liberation it has served as the capital of Bege-Mider and Semien province which were later named as Gondar Administrative Region. Subsequent reorganization of the Administrative Regions made it the capital of North Gondar Administrative

# GONDAR TOWN IN 1967



SOURCE. NUPI: REPORT ON GONDER  
MASTER PLANE, 1995:28

**LEGEND**

- RIVER (STREAM)
- PAVED ROAD
- ▨ BUILT-UP AREA

0 1  
kilometer

Region in late 1980's. Currently, it is the capital of North Gondar zone and Gondar Wereda of Amhara Regional State.

Although, the data on the surface area of the town is not available, its area is calculated from the maps of 1935 and 1967 (figure 4 and 5) with the help of planimeter. The calculations show that the built-up area of the town was about 1.94 Km<sup>2</sup> in 1935 and about 2.88 Km<sup>2</sup> in 1967 showing an over all increase of 48.4 per cent and an average annual increase of about 1.5 per cent.

## 2.3 Demography

### 2.3.1 Population Size Sex Ratio and Age Structure

#### 2.3.1.1 Population

TABLE 1

Population Size and Average Annual Growth Rate,  
Gondar 1956 - 1993

Year	1956	1960	1962	1987	1993
Population	13528	17428	24674	91252	156607
Average annual growth rate %		6.54	18.97	7.08	3.24

source: various CSA report

The population of Gondar which was 13,528 in 1956 reached 156,607 in 1993, that is, more than eleven fold. However, the growth rates have been fluctuating between 3.24 per cent

between 1987 to 1993 to 18.97 per cent during 1960 to 1962 (table 1).

**TABLE 2**  
**Population Projection, Gondar 1994 - 2014**

Initial growth rate	1994	1999	2004	2009	2014
3.5 low	119,530	143,828	173,048	208,214	250,527
4.0 middle	119,530	145,994	178,318	178,798	266019
4.5 high	119,530	148,200	183,748	227,823	282,247

Source: NUPI, 1995:42

According to NUPI the population of Gondar which was 119,530 in 1994 will reach 250,525, 266,019 and 282,247 in 2014 with low (3.5%), middle (4.0%) and high (4.59%) growth rates respectively (table 2). From this it can be seen that the population of the town will more than double within twenty years. But according to population growth rate formula, ie

$$\log ( 100 + x ) = \log p_N - \log p_0$$

$$\frac{\log ( 100 + x )}{\log 10} = \frac{\log p_N - \log p_0}{\log 10} + 2$$

$$N$$

(Where  $p_0$  denotes the initial population,  $p_N$  population after  $N$  years and  $N$  denotes number of interval years), the table could hold true if the growth rates had been 3.8, 4.1 and 4.4

### 2.3.1.2 Sex Ratio

Sex ratio is considered as the number of male per 100 females. Theoretically the over all sex ratio is expected to be 100, (CSA, 1990:26). However, sex ratio for Gondar was significantly lower (73.59) in 1984 and showed an up ward tendency of 90.55 by 1993 but again declined to 84.36 in 1994 (Table 3). This lower proportion of male in the town could be described to the great mortality rate of aged males and dominant of female immigrants to Gondar.

### 2.3.1.3 Age structure

Concerning the population of the town by broad age groups, almost half of the population (48.5 per cent) is found with in 0-4 years age group and the least proportion (6.2 per cent) is found in the age group of 60 years and above. Therefore, people with productive age group that is between 15 to 59 years are about 45.2 per cent of the total population of the town indicating a dependency ratio of 1:1.2 (CSA:1990.23).

According to 1984 population and housing census, Gondar had "16,978 households with an average household size of 4.6. The number of households increased to 28.256 with an average household size of 4.13 in 1994" (CSA, 1990:64 and CSA,1995:238)

TABLE 4

Household Size (Based on Sample Households for Sample Kebeles) - Gondar 1998

Kebele	No of sample households	No of persons	Average household size
03	124	674	5.4
06	71	423	6.0
08	43	218	5.1
15	69	379	5.5
Total	307	1694	5.5

Source: Field Survey 1998

According to the field survey result of 1998 the average household size of Kebele 03, 06, 08 and 15 is 5.4, 6.0, 5.1 and 5.5 respectively. Thus, at present the average household size is 5.5 (Table 4)

### 2.3.2. Religion and Literacy Status

Regarding religious memberships of the town dwellers, Christians are in majority (85.3%) followed by Moslems (14.2%). Followers of other faiths are insignificant (0.5% only) (CSA,1990:37). However, the field survey results show that out of 307 households, 260 households follow Christian faith and 47 households the Islamic faith. Thus, at present 84.7 per cent of the population of Gondar is Christians where as, 15.3 per cent is Muslims.

As much as 26.2 per cent of housing units had still to fetch their domestic water from the traditional water sources like well, springs and rivers in traditional way. Out of these housing units about 33 per cent used protected wells or springs where as about 20 per cent used unprotected wells or springs and about 37 per cent used river water while 9.2 per cent have not stated any source (CSA, 1990:321).

According to population and housing census of 1984, there were 15,496 housing units in the town accommodating 16,967 households. The majority of the housing units (79.2 per cent) have earthen (mud) floors followed by cement concrete ( 9.6 per cent), cement tile (4.5 per cent). The other floor types include wooden tiles (3.6 per cent) and plastic tile floors (about 0.2 per cent) and 2.9 per cent are not stated (CSA, 1990:315).

As regards the distribution of housing units by number of rooms, housing units with single rooms are the dominant ones, accounting for about 55.7 per cent of the total. The housing units with two, three, four, five and six and more rooms constitute, about 21.1, 10.5, 4.1, 1.2 and 4.4 per cent of the total housing units of the town respectively. Where as 3 per cent are not stated (CSA, 1990:318).

Regarding the distribution of housing units of the town by type of bathing and toilet facilities it is observed that very limited number of housing units have bath tub ( 0.9 per cent), shower( 3.3 per cent) and bath tub and shower( 0.6 per cent) , (CSA, 1990:324). This shows that the dominant proportion of housing units that is about 93.6 per cent have no independent

bathing facilities of their own. About 1.6 per cent of households did not state about this aspect.

The presence of sanitary toilet facilities in each housing units is very rare in the town. The data obtained from CSA for 1990 reveals that about 64.2 per cent of the housing units have had no toilet facilities of their own. Whereas 4.7 per cent of the housing units have had private flush toilets and 0.7 per cent have had shared flush toilets. In addition to this about 14.9 per cent of the housing units have had private dry pit toilets and about 14.3 per cent had shared dry pit toilets (CSA, (1990:325)).

to day most of the large cities chlorinate their water (Kesete, 1968:17).

However, with time the demand has been increasing while the supply has remained constant or even have been reduced by growing pollution and quality constraints in general. It has been more so in urban areas due to accelerated urbanization. The problem was further aggravated by increasing per capita water use caused by technological advancements, (Jams, 1971:286).

Nowadays, as a result of technological development and high urban water need most of the urban centers have to diversify their water supply from sources small dams, wells and springs to longer water supply projects with large financed investment by the governments in order to carry water from great distances.

In the modern world man uses water for multitude of purposes. Among the major urban uses are domestic, industrial, commercial establishments and public facilities, etc., which in general, are broadly grouped into two, that is primary and secondary with this regard Bogert (1985:451) stated that:

The uses of water from water works are primary and secondary. Primary uses of water is for such strictly domestic purposes as drinking, preparation of food and beverages, bathing and watering of lawns and gardening. Secondary uses of water are comprising industrial processes, commercial protects, disposal of wastes, fire fighting, street sprinkling, swimming pools and public fountains.

Man's use of water for drinking and personal hygiene i.e. water use for household purposes is perhaps his oldest and most intimate relationship with water. Of all human uses of water it is the only use that can be defined as an essential requirement or need (Lee, 1971:202). From this it is clear that, since water is a daily necessity and a key factor in human health and well being, man has a long and initial relationship with the use of water for household purposes compared to other uses of water.

At present most of the urban centers of the world have tap water supply services. In urban centers as a result of the presence of tap water services household water consumption exceeds the other municipal water uses "...residential use of water takes the major share of water withdrawn by municipal water utilities" (Lee, 1971:202).

Although , water is supplied for domestic uses but out of this the total only a small proportion is used daily for drinking. A some what larger amount is used for cooking purposes and still larger amount for washing and bathing purposes (Assefa, 1966:6).

In the modern world, in order to make water available as well as accessible to the urban community and to collect water fee according to the consumption of each households water distribution system is either by means of meter connection (in-house connection and yard connection) or public stand pipes.

Globally 3,240 km<sup>3</sup> of fresh water are withdrawn and used annually. Of this total 69 per cent is used for agriculture, 23

exclusive or overlapping, are suggested by the World Resource Institute.

Countries have three basic options when fresh water availability is limited. They can re allocate available water to accommodate new competing demands. They can stretch the limited supply by improving efficiency of use through conservation (better management of the existing fresh water supplies) and re use, and they can increase the available supply of fresh water through traditional engineering solution such as building dams to capture and store more flood runoff, drilling wells (additional ground water) and transferring water from areas of surplus to areas of scarcity. (1988:131)

Thus, by applying either of this options countries can alleviate the present as well as the future water need of the urban community effectively.

### 3.2 Water Sources, Supply and Distribution system

#### 3.2.1 Sources of Water for Human Consumptions

##### 3.2.1.1 Rain Water

The sources of fresh water supply for human use vary from place to place because of physical and socio- economic factors. Although it is known that the ultimate sources of all water supply is rainfall, it can be considered as one of the many other sources of water for human use. And a very small portion of it is collected over impermeable surface through percolation, as is clear from the statement of Fair (1966:2.3) that:

the likelihood of its being free from disease causing microorganisms and its accessibility, and if properly protected and treated immediately after the completion of the construction, it can be used without further treatment. It is equally emphasized by Brown (1964:2.3) as:

Ground water is often cheaper to pump water from a few hundred feet bottom surface than to pump it a mile or more on surface. it is also more constant in temperature and quality and less likely to be polluted and consequently requires less expensive treatment than surface water.

Ground water has some disadvantages as well, such as, it normally needs pumping unless it comes from a spring and in certain localities ground water may contain excessive amount of undesirable dissolved minerals (Gebre- Emanuel 1977:31).

Table 6

Water Sources for Urban Centers-Ethiopia

Water sources	Towns number	Name
Lakes	2	BAhir Dar and Harer
Dam	4	Sokota, Addis Ababa, Hosain, etc
Well	58	Gondar, HUmera, Mekele, etc.
River	14	Metu, Awassa, Gore, etc.
Spring	25	Finote Selam, Asosa, etc.

Source: EMA, 1988:55

Like other cities of the world, the sources of potable water for Ethiopian cities also vary. The sources of potable water for Ethiopian towns are springs, rivers, wells, dams and lakes. There are two towns I.e. Bahirdar and Harer whose sources of potable water are lakes, four towns i.e. SeKota, Addis Ababa, Hosaina, and Asela whose sources of potable water are dams, fifty eight towns i.e. Gondar, Humera, Mekela, Axum, Desse, etc, whose sources of potable water are wells, fourteen towns such as Metu, Awassa, Gore, etc., whose sources of potable water are rivers, twenty five towns whose sources of potable water are springs such as Finote Selam, Asosa, Arba Minch, Sodo, etc( Table 6). Concerning the other towns of Ethiopia, proper records are not available. From this it can be understood that most of our towns get their potable water from wells, springs and rivers. In case of some towns like Gondar, there can be more than one sources.

The major sources of water supply in the town are bore holes and springs. Currently there are 15 bore holes with a total capacity of 70.7 m<sup>3</sup>/Sec. Potable water is supplied to the town from six different systems, Anghereb, Koremrem, China, Yugoslab ia, Shinta, and Azezo (NUPI 1995:52).

### 3.2.2 Water Supply and Distribution System

Preceding paragraphs indicated the common sources of fresh water for human use. The nature of these sources determine the water supply and distribution system as is evidenced by the statement of Fair (1966:2.3) that: " The sources of water commonly determine the nature of collection, purification, transmission and distribution works".

For any source of water in order to satisfy the demand of the community, effective water supply and distribution system is a necessary requirements. According to Dickinson, (1986:519)

Water supply system is an arrangement for transporting water from areas of abundance to areas of shortages. This includes work for the collection, transmission, treatment, storage and distribution of water for homes, commercial establishments, industry and irrigation as well as such public needs as fire fighting and street flashing.

Thus water supply system should meet all the necessary conditions in order to provide available water, both in quantity and quality, from the sources to the consumers.

For all the water supply works to transport water from the source to consumption area, the distribution system plays a decisive role.

Distribution system is the network of interconnection pipes extending from the pumping station, wells or the end of the transmission conduit to the consumers premises. Its function is to deliver to the consumer water in required quantities and at satisfactory pressure, under all conditions and despite a break in any pipe in the system (Bogert, 1985:455).

So, for any urban community to get safe and adequate amount of potable water with standard quality, in addition to sources of water, effective distribution system is also a determinant factor.

Two distribution systems emerge in accordance with the street plan as, "... a branching pattern on the outskirts of the

community, in which ribbon development follows the primary arteries of road and streets, and a gridiron pattern within the built-up portions of the community where streets criss-cross and water mains are interconnected. Hydraulically, the gridiron system has the advantage of delivering water to any spot from more than one direction and of avoiding dead ends" Fair (1966:2.22).

Even if the water leaving the water plant has an acceptable standard quality and adequate volume, the substandard water distribution system may adversely affect the quality as well as the quantity of water. Hence, the distribution system should be designed in order to provide adequate supply of water to the consumers.

### **3.3 Factors Affecting Household Water Use**

In urban community the problem related to household water consumption patterns involve various components. The effects of these factors vary between urban center and communities.

Analysis and evaluation of these factors will help to identify the factors which either are positively and negatively associated with the rate of per capita household water consumption. It will ultimately help to predict future water demands of the urban communities with adequate degrees of accuracies and arrive at economical and justifiable design of water supply systems.

For proper assessment and analysis of the factors the researchers and concerned experts have grouped them into two broad categories, i.e physical and socio-economic factors. Thus

of water is good consumption will be high" (Chatterjee, 1976:5).

#### 3.3.1.2 Physical Distance and climate

The other physical factor which affects the use of water within each households is the physical distances of housing units from the water point. Although surveys conducted in several countries do not indicate a linear relationship between per capita consumption and distance from the water point, the rate of water consumption was found to decrease beyond some critical distance. Rao although has not quantified the distance but has indicated that the amount of water carried from public stand pipe does decrease slightly with distance (1987:265). WHO defines reasonable access to safe drinking water in urban areas as well as to piped or to public stand pipe with 200 meters for a dwelling or housing unit (World Resource Institute, 1992:144). Mekonen (1983:53) also stated that: " According to White, et. al. (1972) large quantities of water are located within the critical distance of one mile and once the limit is passed, the amount of water drawn tends to decrease".

TABLE 7

Daily Water Consumption (liters per capita per day) by  
Type of Connection

World Health organization Region	Urban House con- nection		public connection	
	Minimum	Maximum	Minimum	maximum
Algeria, Morocco, Turkey	65	210	25	40
Africa	65	290	20	45
Central and South Africa	160	380	25	50
Eastern Mediterranean	95	165	25	50
South East Africa	75	165	25	50
Western Africa	50	365	30	95
Average	85	262.5	25	55

Source: Bahl, :1992:306

Bahl (1992) had thoroughly studied the relationship between the physical distance of the housing units from the water point by taking into consideration house connections and public taps. In his study he observed that the average minimum and maximum per capita per day water consumption for houses with pipe connections was 85 and 262.5 liters respectively whereas, for the houses using public stand pipes it was only 25 and 50 liters respectively. Thus the maximum per capita per day water consumption of houses with pipe connections is 5.6 times the maximum per capita per day water consumption of houses using public connections (Table 7). From the table and the preceding quotation it is clear that physical distance of the housing units from the water point has an inverse relationship with the amount of water consumption.

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The use of water is usually higher in summer, particularly in dry, hot climate. The high water consumption in hot climate can be caused by increased bathing, laundering and increased watering of lawns and gardens. Regarding this Chatterjee (1976:5) stated that " Water consumption tends to increase for a hot and dry place". James (1971:312) also argued that urban water use is longer in warm, dry climate than in cool humid ones.

#### 3.3.1.3 Altitude and Pressure

Urban centers vary in altitude. The variations in altitudes determine water distribution systems and pressure in the water supply systems. Under such conditions, the urban centers distribute water to the consumers in several different ways such as gravity distribution and pumping distribution systems.

Urban centers use gravity distribution system when the sources of supply are lakes or impounding reservoirs at some highest elevation above the city so that sufficient pressure in the mains can be maintained. This is the most reliable method for the conduit leading from source to city if it is adequate in size and well safeguarded against accidental breaks. The other one is pumping from storage, i.e. excess of water is pumped during periods of low consumption and is stored in elevated tanks. In addition, there is direct pumping method, i.e. pumps are used for supplying water without any storage and the water is forced into the main and then to the consumer (Chatterjee, 1976:56).

A city is fortunate if it can get its water from reservoirs in the mountains. Such water needs very little purification and it can flow down from mountains and up in to buildings by gravity unless it has to cross higher mountains on the way  
(Hirshleiter, 1960:62)

There are wide difference in the pressure maintained in the distribution system in varies cities. If pressure in the distribution system is high, that will cause a high rate of flow, and water could rise to multi storeyed building and thus may increase the per capita use (Chatterjee, 1976:60). This shows that the rate of water consumption increases with the increase in the pressure of the system. One of the problems of water supply system is inadequacy of pressure to satisfy the need of people residing in higher elevations of the town and in multi storeyd buildings.

In general, if water is available at the sources, cities with gravity distribution are lucky enough to have adequate volume of water in the system through out the year. But pumping distribution method needs energy to force the water from the sources to the mains and then to the consumers. This will incur power cost. Even multistage pumping might be needed which will increase the cost further. In addition to this, a power failure will mean complete interruption in the water supply system. From this it is clear that the consumption rate of the communities vary depending on the variations in the method of the distribution system i.e. gravity or pumping distribution systems.

### 3.3.2 Socio- Economic Factors

In collaboration with the physical factors, the socio-economic factors also determine the rate of household water use. Among the enormous socio- economic factors that affect household water consumption patterns the most significant ones are the urban growth, household income, household size and level of education and profession of the household heads. The effects of these factors on household water consumption patterns are reviewed in the following pages.

#### 3.3.2.1 Urbanization

People living in the small urban centers and fragmented farm families which have no access to modern supply system still use the nearby surface water for household purposes. But, presently, in all large urban centers of the world the presence of tap water supply service has become a necessary requirement for survival.

Water was the root of man's civilization, ancient civilizations sprang up only where abundant water supply were available. Examples of such civilization are those which flourished on the banks of the Nile, the Tigris and Euphrates, the Indus, the Ganges and the Yangtze Kiangs. And large industrial cities such as London, Tokyo, New York, Paris, Cairo, etc. are located wherever abundant fresh water is available (Gebre-Emanuel 1977:17). The main reasons for this is that, urban centers need relatively larger volume of potable water daily in order to accomplish their functions effectively.

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Nowadays, urban centers are growing fast in terms of areal expansion, population and commercial, institutional and industrial activities. In relation to the future expansion of urban centers Chatterjee has argued that " The urban portion of the earth's surface continues to increase. By the end of the century it is likely that 60 per cent of the world's population will live in urban centers. In highly industrialized areas, such as United Kingdom, more than 15 per cent of the total land area will be covered by towns and cities" (1976:57). Thus, the growths of urban centers in terms of population is sure to increase the demand for more water along with other basic services.

The effect of high growth rate of urban population on municipal water supply in Manila is well studied by Feilizar. He has observed that " In metropolitan Manila in 1939 and 1990 the total population of the city were 910,000 and 8, 891, 986 and the water supplied for the indicated population were 300,000,000 and 2,620,000,000 liters per day respectively"(1991:47). This shows that in Manila city, as a result of population growth, within a difference of 41 years the daily water consumption has increased by about 2,315,000,000 liters per day.

Domestic water consumption increases rapidly with the growth of urban population as is also indicated by Lloyed that: " The rapid concentration of population in large urban centers and the rising standards of living is placing constantly growing demands on water on domestic use"(1966:6). The reason is that the volume of water used per person per day for urban dwellers is significantly higher than the rural community as Feachem

states in his study of tropical developing countries (1977:96).

The volume of water used ranges from a daily mean consumption per person of a little over a liter to above 25 liters for rural consumption with out tap connections or stand pipe. For city or village dwellers who uses public stand pipes the consumption is about 10 - 15 liters per person daily, 15 - 19 liters for those with only a single tap in their household and 30 - 300 liters for those with multiple tap in the houses.

~~Thus, nowadays the problem of fresh water supply in urban centers is not only a result of shortages of potable water in the sources but also due to growth of urban population and urbanization. To this effect World Resource Institute (1990:173) has stated that:" Many fresh water problems of the 21<sup>st</sup> century will arise from an increased demand for water generated by population growth, urbanization, industrialization and irrigation. Also Rosegrant emphasized that:" the problems of water shortages in Saudi Arabia is the result of increasing urbanization and industrialization and a great demand per capita, rather than a shortage of the sources" (1996:190).~~

#### **3.3.2.2 Household income, Household size and Level of Education**

For an acceptable living condition, a minimum volume of potable water consumption is set for domestic use. To maintain good health, the minimum per capita domestic consumption of water is generally considered to be around 100 liters per day as is indicated by Engelman and Leroy 1993 in (Rosegrant, 1996:39). But the level of consumption of water in urban communities vary

from region to region because of multitudes of factors already mentioned earlier.

Amongst the families whose standard of livings are higher, the per capita per day water demand will increase (Chatterjee, 1984:5). To highlight the variation Overman expressed his view as follows.

In the so called developing countries as little as 12 liters of fresh water is sometimes sufficient as a daily supply for each person, while in London domestic water consumption exceeds 151 liters per head per day, in United States 250 liters per day per head (1968:18).

Presently, a very small proportion of population has high consumption of water per day per person while the daily per head consumption of the majority of population is less than the recommended minimum per capita requirement, as is reported by the World Resource Institute that:

Only about 4 per cent of the population uses as much as 300 - 400 liters per day per person, and two third of the population, concentrated in Africa and Asia uses less than 50 liters per person per day (1990: 173).

Income and material wealth are known to determine the volume of water use. The volume of water used by urban people of tropical developing countries is a direct function of income and material wealth as only such people have access to large amount of safe water (Feachem, 1977:96). In general, all these researchers have discovered that domestic water use tends to increase with living standards and income of people.

The other socio-economic factor inviting attention in relation to household water consumption rate are household sizes and level of education attained by the household heads etc. The total consumption per household is sure to increase but per head consumption is reduced, as is evidenced by various studies like that of White et al 1972 in (Mekonen 1983), where he stated that per capita water consumption was found to decrease with greater density of housing and with households having larger number of children.

The total water consumption by a given household as well as per capita per day water consumption are also related to the level of education attained in the household as is pointed out by White, et. al 1972 in (Mekonen 1983) that, " for piped consumption educational level were directly related to per capita and total water use".

According to the findings of Tesfaye (1984), in Addis Ababa, the per capita water consumption of a household is positively correlated with the income, accessibility to the tap water, and water using appliances of the households and total water consumption of a household increases with an increase in household size. In addition to this Yimer's (1992) study of household water consumption in Nazareth has shown a negative association between household per capita water consumption and income. The reason is that people in the low income group usually sell water from their private water connection to neighboring households having no private water connection. All such cases are recorded as the consumption by that household. Steady rise in daily per capita water use with an increase in the number of water using appliances is however, recorded .

## CHAPTER FOUR

### RESULTS AND DISCUSSIONS

#### 4.1 THE EXISTING WATER SOURCES AND DISTRIBUTION SYSTEM

##### 4.1.1 WATER SOURCES

As explained earlier the sources of raw water for urban communities may vary between urban center to urban center because of the specific local conditions. Thus, most of the urban centres are supplying potable water for their dwellers from springs, rivers, dams, lakes, ground water, etc. Likewise, Gondar town's potable water sources are springs, stream and ground water. concerning the detail the discussion is given below.

Piped water supply system in Gondar town was first introduced by the Italians in the late 1930's. The town Began to use piped water supply from Korebreb stream, about 12 kms. North of Gondar (Figure 7).

This source of water is supplemented by water from three springs that is, the Chury, the Atari and the Hug (Figure 7). These springs are of small capacity and have no flow in the dry season. The water flows through 3.5 inch supply mains to 80 m<sup>3</sup> reservoir at Genet Mountain and subsequently through an 87 mm supply mains to the town by gravity. The flow of water in supply pipe line was 6 liters per second in 1981 (WSSA,

1982) which at present is 4 to 5 liters per second (Amhara Development Association, 1994).

The other sources of raw water for the town are springs, namely Gondar Georgis, Kahai Eyesus and Fetch Fachit springs. These are small seasonal springs which bring water in to the water supply system by gravity. The flow had been useful in the past. But considering the present needs of the town and the seasonal nature of these springs they are not considered as significant sources. The flow of these springs is not more than 5 liters per second (WSSA, 1982, EWRA, 1980).

In addition to these, ground water is the most significant potable water source for the town. In order to use the ground water for the community of the town a number of boreholes had been drilled in Kahai, Angereb and Shinta well fields (Figure 6).

The Kahai well field consists of borehole EWRA No. 5, which was drilled in this valley by EWRA in 1967 (Figure 7). The pump, raising mains and distribution system were constructed by Yugoslavian company in 1968. The water is pumped from the borehole to the two distribution reservoirs with 100 m<sup>3</sup> and 160 m<sup>3</sup> capacity subsequently and directly distributed to the hospital and kebele 16. The other part is pumped to the reservoir at piassa. Its yield is 4 liters per second (WSSA, 1991, 1982, ADA, 1994).

Four wells were also drilled under Ethio-Chines program(c<sub>1</sub> to c<sub>4</sub>) in 1974 in Kahai Valley (Figure 7). Water is pumped from the boreholes into a 116 m<sup>3</sup> distribution reservoir and

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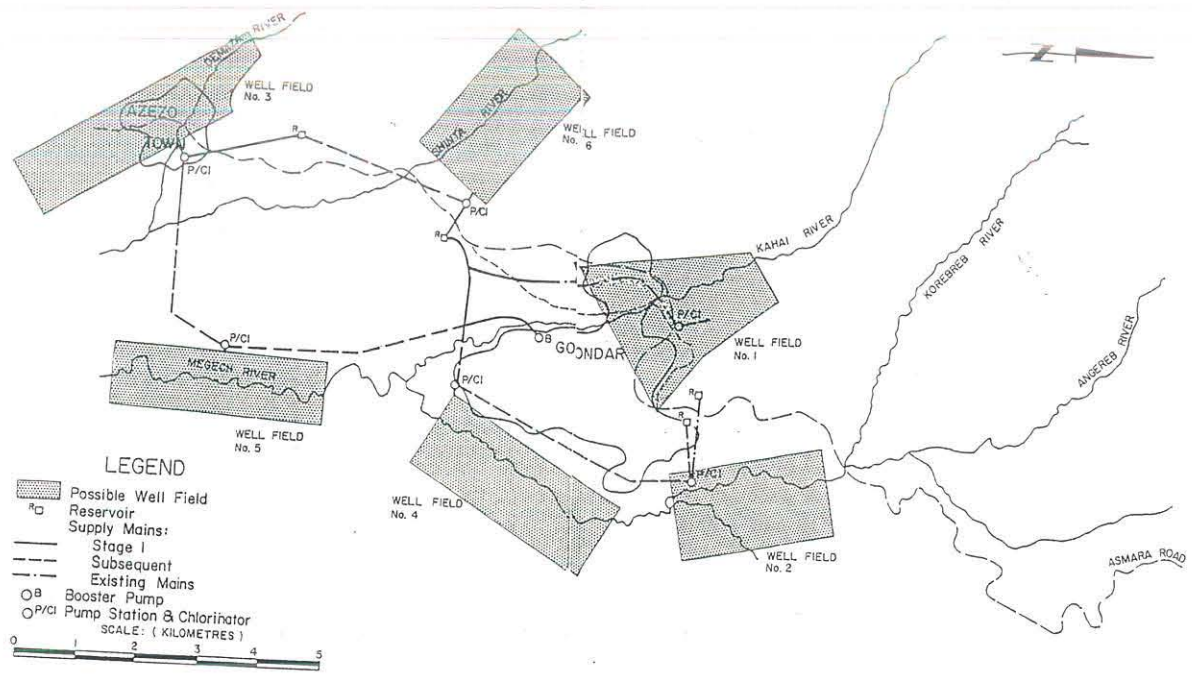
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subsequently to 600 m<sup>3</sup> reservoir. Since its installation the yield from this well field appears to have decreased significantly. Now the yield from these boreholes is 5 to 10 liters per second (WSSA, 1982: 3.3, A.D.A, 1994).



GONDAR  
GROUND WATER WELL  
FIELDS AND MAINS

Figure 6

Source: WSSA, Feasibility Study For Water Supply Gondar Final Report, 1982:6.32

There are six bore holes in Angereb valley (Figure 7). Five of them (A1-A5) were drilled in 1975 E.C. (old Angereb bore holes) and the other one (A6) was drilled by the Chinese experts in 1985 E.C. (new Angereb borehole). The water from these bore holes is pumped by surface pumps to the first reservoir (25 m<sup>3</sup>) and then to the second transferring reservoirs. Then, from old and new Angereb bore holes the water is pumped to Genet Mountain reservoir (300 m<sup>3</sup>) and to 600 m<sup>3</sup> reservoir (near Gondar Municipality Garage) respectively, from where it is finally distributed to the society. The total yield of old Angereb bore holes is 10 liters per second whereas, it is 30 liters per second for new Angereb bore hole. The Chinese experts have also drilled two boreholes in Shinta valley in 1985 E.C. The water from these boreholes is pumped to the connection with the other Chinese system and it makes the total yield of Chinese system 12 liters per second. (WSSA, 1982, ADA 1994 and Figure 6 and 7).

TABLE 8

Average Water Production of sources (liters/second)

Systems	Well field	Yield
Korebreb System		4.0
Yugoslavia System	Kahai	4.0
Chinese System	Kahai and Shinta	12.0
Gondar Geworgis and Aleket System		4.0
Old Angereb System	Angereb	10.0
New Angereb System	Angereb	30.0
Total		64.0

Source: Amhara Development Association, 1994

#### 4.1.2 The distribution Net-Work

Urban community needs ample amount of potable water within a reasonable distance from their residence. Thus, in order to supply urban dwellers with sufficient amount of water around their residence, effective water distribution new-work is a necessary requirement. But physical and socio-economic factors effect the equitable distribution of pipe lines in urban centres. As a result some parts of urban centres have dense net-work structure where as others have sparse.

Gondar town water distribution net-work had been installed in different years by different organizations. These installations had been under taken by the Italians, Yugoslavians, Chinese as well as the Municipality of the town; each one is supplying water mainly to different parts of the town.

The first and the oldest distribution net-work is the Korebreb distribution net-work which was installed in 1930's by the Italians. This net-work covers the oldest part of the town which is now the most developed and densely populated area of the town. The net-work extends from the reservoir located at the Genet Mountain to Kebeles 01, 02, 03, 04, 06, 09, 11, 12 and 13 (figure 8). As this distribution net-work is very old most researchers agree that leakage of water in the system is very high.

The distribution net-work constructed by the Yugoslavians in 1968 is the second oldest net-work next to Korebreb system. This system helps to distribute water from Kahai valley

borehole, which was drilled by EWRA in 1967, mainly to Kebele 03, 09, 10, 11 and 16 (figure 8).

The other net-work is Chinese distribution net-work which was intalled in 1977 in order to distribute water from the Kahai valley to the town dwellers. This net-work covered most of the Eastern part of the town (Kebele 01, 02, 03, 05, and 13) and Kebele 06, 08, 09, 12, 16 and 17 (Figure 8).

The other net-work is constructed from Gondar Georgis and Kahai Jesus and Fech Fuchit springs in order to cover mainly Kebele 15, 14 and 17 (Figure 8).

In addition to these the municipality of Gondar installed pipe line in order to distribute water mainly to Kebele 02, 08, 15, 16 and 18. There is also pipe line from Qusquam spring to the hospital in order to serve the hospital community (figure 8).



In general, from figure 8 it is clear that the present pipe line net-work is not evenly distributed spatially in the built up areas of the town. This can be clearly seen by taking into consideration water taps per 10,000 m<sup>2</sup> of area and population pressure per water taps in the 17 *kebeles*. Thus, at present on an average about 8 taps are serving an area of 10,000 m<sup>2</sup>. But the numbers of taps per 10,000 m<sup>2</sup> vary from *Kebele* to *Kebele* so that, some *Kebeles* have above the average where as others have below. For example the Western peripheral *Kebeles* of the town (*Kebele* 10, 14, 15 and 16) and the Southern (08) have only one to seven water taps per 10,000 m<sup>2</sup> of area which is below the average. But the oldest (central), the northern parts of the town and other *Kebeles* have about 9 to 18 water taps per 10,000 m<sup>2</sup>.

Similarly, the population pressure on water taps also vary significantly between different *Kebeles*. An average one water tap is giving service to as many as 22 people in the town. But in some *Kebeles* such as *Kebele* 05, 06, 08, 09, 10, 11, 16 and 15 one water tap is serving for more than 22 people going up to about 66 persons (*Kebele* 08) where as, for the others it is giving service for less than 21 people, the lowest pressure being in *Kebele* 17 (13.57).

From figure 9 and the above discussion it is clear that the present pipe line net-work of the town is not equitably distributed. That is, it is densely distributed mainly in the central and Northern part of the town where as, it is sparsely distributed in the peripheral built up areas of the town.

Thus, currently about 54% of population, spread over above 65% of the area of the city have population pressure per tap above the average. The pipe lines in large part of the peripheral built up areas of the town are beyond the reach of people. As a result people living in these areas greatly suffer from absence of tap water around their residences and they usually travel for long distances in search of tap water.

#### 4.1.3 Household Water Supply System

Urban dwellers collect water for their daily household needs from tap, river, stream, well, spring, etc. The households who are depending on tap water supply service for their domestic use, are supplied either with the help of private meter connection (house connection or yard connection) or public stand pipes (public fountains).

People use such different kinds of meter connections because of various socio-economic and physical factors but mainly the economic factors. Urban dwellers know that households with private meter connections have favourable condition for having ample amount of tap water than those who do not have this facility and the water fee per cubic meter is lower than public fountain and water sellers. For example in Gondar the water fee per cubic meter for private meter connection is only birr 1.50 but it is birr 0.05 per Jerican (20 liters) i.e. birr 2.50 per cubic meter for public fountain users and birr 0.10 to birr 0.20 per Jerican (20 liters) that is, birr 5.00 to birr 10.00 from the water sellers. But in most of the urban centres like Gondar households having meter connection

are few in number as compared to the households without such facilities.

TABLE 10

Water Sources for Household use of Sample Kebeles- Gondar

Ser. No.	Water Sources	Households	
		NO	%
1	Pipe	267	87.0
2	Well	2	0.6
3	Spring	19	6.2
4	River	1	0.3
5	Pipe & Spring	18	5.8
	Total	307	100.0

Source: Field Survey 1998.

According to the sample survey result of the study, the communities of Gondar town are fetching water from different water sources for their domestic purposes. That is, from taps, spring, well, river and alternatively from pipe and spring. At present the large majority (87.0 per cent) of the households are tap water users where as 7.1 per cent are non-tap water users and 5.8 per cent of the households use both tap water and spring water inter changably (Table 10).

The source of water for household use vary from kebele to kebele. 100%, 98.4%, 86.4% and 52.9% use tap water for their household use in kebele 06, 03, 08 and 15 respectively. The

household purposes serving 18,066 households in 17 Kebeles of the town. This shows that only the minority (25.8 percent) of the households have this facility in the form of house or yard connections. Thus, the majority (74.2 percent) of the households do not have this facility.

The sample survey result shows that only 24.7 percent of the total sample households have private meter connection where as the majority (about 58.0 percent) of the households are using neighbour's water taps. The others 2.9 percent and 7.2 percent are users of shared yard connection and public fountains respectively (Table 11).

Out of the households having private meter connections insignificant number i.e. 1.5 percent and 0.8 percent are having water tanker and water using fixture respectively and only 3.0 percent of the households responded that they were selling water from their private meter connection.

There are various reasons for not having meter connections. From amongst these the most significant one is financial problem. That is the cost of private meter connection installation is much higher which most of the households in the community under consideration could not afford. In addition to this the house ownership status, absence of pipe line net-work around their locality, bureaucracy, etc. could be the other reasons for not having private meter connections.

According to the result of the sample survey, out of the total households investigated (307) 222 (72.3 percent) do not have either private or shared meter connection. Out of these 222

households the large majority (69.4 percent) responded that they could not have this facility because of financial problems. The others 10.4, 10.4, 4.9 and 0.9 percent of households are not having private meter connections because of house ownership status, absence of pipe line net work around their residence, bureaucracy and terrain respectively. Only 4.0 percent responded that they don't need meter connections of their own.

#### 4.1.4 Problems of Household Water Supply System

Problems related to household water supply system are numerous and they vary from one urban center to the other. But, in general, the main problems related to this and affecting the household water consumption are physical distance of the housing units from the water point, short duration of water supply, inconvenient time of water supply, queuing for long time, high cost of water, water supply interruptions, delay in the repair of broken water pipes etc.

Amongst these problems of urban water supply, frequent interruptions of water supply is the main problem in Gondar town followed by high water fee and distance of the water point from the housing units. Thus, according to the sample survey results of the study, out of households using tap water (285) as many as 276 (96.8 percent) responded that there was problem in the water supply system during last year. Out of 276 respondents, 214 (77.5 percent) responded that the main problem of their water supply system was the frequent interruption. The others 7.6 and 5.4 percent responded that their main problem concerning potable water is high tap water

*kebeles*, the picture is more varied, as in *kebele* 03, about 35 and 30 percent respondents expressed the duration of interruptions as one and two weeks respectively, while about 55 percent respondents of *kebele* 06 indicated the duration as one week and 76 percent of the respondents of *kebele* 08 as two weeks. In *kebele* 15 the duration of one week was expressed by about 49 percent of respondents (Table 13).

During this time people were moving in search of water to other *Kebeles*, rivers, springs and wells. Thus, in general about 60 percent of the households moved to other *Kebeles* and 24.3 percent of the households are forced to collect water from non-tap water sources (river, spring and well). The others 15.2 and 0.7 percent are collecting their domestic water form tap and spring, and from water vendors respectively (Table 13 and 14).

TABLE 13

Duration of Tap Water Interruption

<i>Kebele</i>	1-3 days		4-7 days		8-15 days		16-30 days		1-2 months	
	No.	%	No.	%	NO.	%	No.	%	No.	%
03	20	16.9	41	34.7	39	30.0	4	3.4	14	11.9
06	14	20.3	38	55.1	11	15.9	3	4.3	3	4.3
08	-	-	7	18.4	29	76.3	-	-	2	5.3
15	10	19.6	25	49.0	6	11.8	4	7.8	6	11.8
Total	44	15.9	111	40.2	85	30.8	11	4.0	25	9.0

Source: Field Survey 1998.

TABLE 14

## Source of Water During Tap Water Interruption

<i>Kebele</i>	Tap Water from other <i>Kebele</i>	Public Stand pipe	Water Vendor	River Spring Well	Tap and Spring
03	80	-	-	8	30
06	55	-	-	2	12
08	-	-	2	36	-
15	30	-	-	21	-
Total	165	-	2	67	42

Source: Field Survey 1998.

The analysis of dependence on other sources during interruption on *kebele* level (sample *kebeles*) reveals that about 68, 80 and 59 percent of the respondent of *kebele* 03, 06 and 15 respectively were involved in collecting water from neighbouring *kebeles* while about 95 percent of the respondents of *kebele* 08 used the rivers, springs and wells as sources of water during interruptions. The main reason is that, the built up area of *kebele* 15 is an isolated one, which is found at far off distance from the built up area of neighbourhood *kebeles* (06, 07 and 09) in lower ground. It is also in the proximity of Kahai and Angereb Rivers. Thus, dwellers prefer to fetch water from these nearby rivers instead of climbing up for a longer distance to other *kebeles* during tap water interruptions.

## 4.2 Factors Influencing Household Water Consumption Patterns<sup>4</sup>

In urban communities various socio-economic and physical factors have significant relationships with household and per capita water consumption patterns. The impact of these factors on water consumption had been studied by a number of researchers in various urban centres as is indicated in the preceding chapters.

Here an attempt have been made to asses the impact of some of such factors that have significant influence on the level of households and per capita water consumption of the communities of Gondar. In order to identify the relationships between these variables and the dependent variables ( $y_1$ ) i.e. mean monthly consumption of household and ( $y_2$ ) mean per capita water consumption, the independent variables are sub-divided into two broad categories such as socio-economic and housing related variables.

Socio-economic variables are household size ( $x_1$ ), household monthly income ( $x_2$ ), educational status of the household heads ( $x_3$ ), occupation of the household heads ( $x_4$ ), source of water for household uses ( $x_7$ ) and distance of housing units from the water point ( $x_8$ ).

The second category i.e. housing related variables include number of rooms occupied by the household ( $x_5$ ) and type of floor of the house ( $x_6$ ). To asses the influence of these independent variables on the dependent variables ( $y_1$  and  $y_2$ )

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the researcher used simple correlation, multiple regression and coefficient of variance.

#### 4.2.1 Socio-Economic Variables

Household size ( $x_1$ ) is one of the significant variable that affects household water consumption rate. As is evidenced by various studies the rate of water consumption of households increases with the size but the per capita water consumption decreases.

In order to assess the relationship between household size and the level of water consumption of the study area the sample households were divided into five groups according to size (Table 15). The result of the study shows that the grand mean monthly household water consumption is about 2636.6 liters where as per capita water consumption is 15.6 liters/day (Table 15).

Like that of the findings of other researchers the results of the sample survey here also show that monthly household water consumption increases with an increase in household size. That is, for households with four and less family members the mean monthly water consumption is 1680 liters which rises to 3708.4 liters per households for eight and above number of family members. But the per capita water consumption shows a decreasing trend for these groups of households, which is about 17.4 liters for households with four and less family members whereas, it is about 14 liters for eight and above (Table 15).

One notable result is the uneven consumption patterns even within a particular group of family size. The general

coefficient of variation of monthly water consumption per household is 126.61 percent while, in the household size categories it varies from 80.55 percent for size of 8 and above, and reaches to 154.55 percent for the category with household size of 7. Appreciable variations are also indicated in per capita water consumption within the household categories. General coefficient of variation for  $y_2$  is 98.61 percent which ranges from 57.77 percent for household size 7 to 116.8% for the category less than or equal to 4 (Appendix F).

These relationships are also exhibited by correlation coefficients between  $y_1$ ;  $x_1$  and  $y_2$ ;  $x_1$  which are 0.2806 and -0.0677 respectively indicating that  $y_1$  will increase with every increase in  $x_1$  while  $y_2$  decreases with increase in  $x_2$ . But in both cases the relationship is not strong. As is clear from values of the coefficient of determination of about 0.0787 and 0.00458 respectively for  $y_1$  versus  $x_1$  and  $y_2$  versus  $x_1$  only 7.9% of the variation in household monthly water consumption is due to household size which in case of the variation in per capita per day water consumption ( $y_2$ ) explains only 0.5%. The remaining 92.1% and 99.5% of the variations are due to other factors (Appendix E).

When tested at 95% confidence limit the T value of 0.000 and 0.237 for  $y_1$  versus  $x_1$  and  $y_2$  versus  $x_2$  respectively (Appendix E) the r value for relationship between household size and mean monthly water consumption is significant while it is insignificant for household size and per capita water consumption. Thus, mean monthly household water consumption shows an increasing trend as household size increase where as mean per capita water consumption shows a decreasing pattern as

household size increases. Therefore hypothesis one that states household water consumption is positively correlated with household size where as, per capita water consumption is an inverse function with household size is accepted.

TABLE 15

Mean Monthly Household Water Consumption (MMHWC) and Mean per capita Water Consumption by Household Size (in liters).

Class No.	Household Class	No.	%	MMHWC	MPCWC
1	≤ 4	106	34.5	1679.9	17.4
2	5	57	18.6	2119.6	14.1
3	6	48	15.6	2938.9	16.0
4	7	37	12.1	4072.3	14.8
5	≥ 8	59	19.2	3708.4	14.0
Total/mean		307	100.0	2636.0	15.6

Source: Field Survey 1998.

Household monthly income ( $x_2$ ) is the other independent variable which is supposed to affect the per household and per capita water consumption. Since, in urban areas, water is not supplied freely and to have meter connection it needs relatively very high amount of money for installation, the well to do families should have reasonably good access to tap water as compared to poor urban dwellers.

To identify the impact of income on the level of water consumption the sample households are grouped in to five income groups. The grand mean of household monthly water consumption is 2636.6 liters. Households with the income level of Birr

75.00 and less consume on an average lesser water than the grand mean whereas, the average consumption per household per month is higher than the grand mean for all the income levels greater than Birr 75.00 with a maximum of 3121.7 liters for the income group of 250-500 per month (Table 16).

Thus, it shows that with an increase in household income there exists an increase in the monthly household water consumption except for households whose monthly income is Birr 501.00 and above. The reason for the decline of consumption for this large income group is that, these households use their tap water for their own household uses only. But the people from low income group are selling water from their taps and are engaged in business activities such as bear, tea, bread selling, etc., so their monthly water consumption is higher.

The grand mean for per capita water consumption is 15.6 liters which is very low as compared to other towns of the world. Mean per capita water consumption shows an increasing trend with only exception of group with income 121-250 birr per month for which the mean per capita consumption is 19.2 liters which is the highest amongst all the groups of households (Table 16).

TABLE 16

Mean Monthly Household Water Consumption and Mean per Capita Consumption by Income Group (in liters).

Ser. No.	Income Group	No. of Household	%	MMHWC	MPCWC
1	≤ 75	62	20.2	1460.3	13.0
2	76 - 120	62	20.2	2676.2	14.5
3	121 - 250	61	19.9	2972.7	19.2
4	251 - 500	68	22.1	3121.7	15.5
5	≥ 501	54	17.6	2950.9	16.0
Total/ Mean		307	100.0	2636.0	15.6

Source: Field Survey 1998.

The correlation coefficient ( $r$ ) for  $y_1$  and  $x_2$  is 0.1196 which is significant at 95% confidence level ( $t = 0.036$ ). Thus  $y_1$  and  $x_2$  are statistically significant but have weak positive relationship. Concerning the relationship between  $y_2$  and  $x_2$  the coefficient of correlation ( $r$ ) is 0.0520 with a value of  $t = 0.364$  at 95% showing that  $y_2$  and  $x_2$  are statistically insignificant although they have a weak positive relationship (Appendix E).

In addition to this the coefficient of determination which are about 0.0143 and 0.0027 for  $y_1$  and  $x_2$ , and  $y_2$  and  $x_2$  respectively show that about 1.4 percent of the variation in monthly water consumption and 0.3 percent of the variation in per capita water consumption is due to income level of the households. Thus in Gondar town mean monthly household water consumption and per capita water consumption increase with an

increase in household income but the variations are very insignificantly attributable to it. There fore hypothesis two that state per capita per day and mean monthly household water consumption is positively correlated with households monthly income is accepted.

The variation of water consumption within income groups can be assess by applying coefficient of variation. The general coefficient of variation of monthly household water consumption is 126.61%. In these income groups it varies from 53.25% for income group of Birr 501.00 and above to 233.82% for the category whose monthly income is Birr 76.00 to 121.00. The variations also exist in per capita water consumption. For this the general coefficient of variation is 98.61% but it ranges from 43.18% for income group Birr 501.00 and above to 146.97% for category of income group Birr 121.00-250.00 (Appendix F).

Educational level of household heads ( $x_3$ ) is expected to have direct relationship with water consumption rate of the households. Because education is highly related with income and with the assumption that people with higher educational status may use more water for their domestic purposes.

In order to asses the relationship between water consumption and educational level of the households, the sample survey households are grouped into five educational status (Table 17).

As for per capita per day consumption is concerned, the pattern appears to be irregular and contrary to the expectations, because the highest per capita consumption (48.4 liters) is recorded by the group whose household heads are in

the second group followed by household heads who are 12th grade and above and the minimum consumption (14.2 liters) is for households whose household heads are 7th to 12th grade (Table 17).

Similarly the monthly consumption per household is also highest (6563.0 liters) for household heads who are in the second group followed by 6th grade and less (3847 liters). Here the minimum consumption per family is 2107.8 liters, consumed by illiterate group (Table 17).

From the table it is not possible to identify the trend of water consumption but from the computation of correlation coefficient ( $r$ ) which is 0.0680 and -0.0273 for  $y_1$  versus  $x_3$  and  $y_2$  versus  $x_3$  respectively, it is observed that monthly household water consumption has feeble positive relationship with educational status of the household heads and the per capita water consumption has an inverse relationship (Appendix E).

It is clear that none of these relationships are statistically significant at 95% level of significance as the t-values are 0.235 and 0.634 for the variables  $y_1$  versus  $x_3$  and  $y_2$  versus  $x_3$  respectively. Thus with increase in educational level of the household heads there is slight increase in monthly water consumption and slight decrease in per capita consumption (Appendix E).

This may be because the households with higher educational status are mostly government employees and use their water taps for their own purpose. But others with low educational status

may sell water from their taps and are also engaged in business activities like that of selling tela, tea, bread, etc. It makes their per capita water consumption higher than the households with higher educational status.

The coefficient of determination for  $y_1$  versus  $x_3$  and  $y_2$  versus  $x_3$  are 0.46 percent and 0.07 percent. That is only 0.46 percent of the variation in monthly water consumption can be related with educational status of the household heads and only 0.07 percent variation in per capita water consumption is related to educational status. None of these values can be considered as having pronounced effect on rates of water consumption.

There is high variation in water consumption within educational status category. The general coefficient of variation of monthly household water consumption is 126.61%. In different educational categories it varies from 67.28% to 154.57% for households whose heads having educational status of 12th grade and above, and read and write respectively. The general coefficient of variation for per capita water consumption is 98.61% and the variation ranges from 48.66% to 141.71% for those households whose heads educational status is 12th grade and above and read and write respectively (Appendix F).

Monthly household and per capita water consumption have irregular trend with educational status of the household heads. But in general hypothesis two that "monthly household water consumption is positively correlated with educational status of the household heads" is accepted whereas "per capita water

TABLE 18

Mean Monthly Household Water Consumption and Mean per Capita Consumption in liters by Occupation.

Ser. No.	Occupation	No.	%	MMHWC	MPCWC
1	Government Employee	152	49.5	2890.3	15.3
2	Business	78	25.4	3253.5	21.0
3	Daily Laborers	24	7.8	1624.2	10.2
4	Weavers	22	7.2	1404.5	9.9
5	House Wife	26	8.5	1544.0	12.7
6	Peasant	5	1.6	1260.0	8.8
Total/Mean		307	100.0	2636.0	15.6

Source: Field Survey 1998.

It is evident from table 18 that only business men and government employees are showing monthly water consumption per household greater than the general mean of 2636.6 liters per household and also the highest monthly water consumption rate is observed for business men followed by government employees.

The lowest consumption(1260.0 liters) is exhibited by the peasants (Table 18).

Almost similar trend is observed in case of per capita water consumption. But only business men consume more than the general average of 15.6 liters per capita per day (21.0 liters per capita per day). They are followed by government employees (15.3 liters per day) the lowest consumption(8.8 litres) is given by the peasants (Table 18).

In addition to this the correlation coefficient for  $y_1$  versus  $x_4$  and  $y_2$  versus  $x_4$  are -0.1668 and -0.1145 indicating that monthly household as well as per capita per head water consumption have inverse relationships with occupational status of the household heads. Both the relationship are significant at 95% confidence level as t-values are 0.003 and 0.045 (Appendix E).

The variability in the monthly water consumption of the households is higher (coefficient of variation 133.45%) within government employees followed by business men (coefficient of variation 106.54%) and it is lower for weavers (coefficient of variation 48.76%). As for per capita water consumption is concerned, the variability is more amongst business community (coefficient of variation 114.72%) followed by government employees (coefficient of variation 77.6%) and the coefficient of variation is lowest for weavers (37.46%) (Appendix F). But the proportion of variation in monthly and per capita per day water consumption explained by occupation is only 2.78% and 1.3% respectively which are too low (Appendix F). Thus, hypothesis three that states per capita per day and monthly household water consumption varies significantly with the type of occupation of the household heads is accepted.

Type of water sources for household use ( $x_7$ ) in urban communities vary from urban center to urban center. In urban communities where there is tap water supply service, as well, researchers argued that household water consumption is higher for tap water users. The data pertaining to sample survey also

reveals that only the users of pipe water have higher monthly household and per capita per day water consumption than the general average of 2636.56 and 15.6 liters respectively (Table 19).

TABLE 19

Mean Monthly Household Water Consumption and Mean per Capita Consumption by Source of Water (in liters).

Ser. No.	Source of Water	No	%	MMHWC	MPCWC
1	Pipe	267	87.0	2756.6	16.0
2	Well	2	0.7	1500.0	7.0
3	Spring	19	6.2	1284.0	11.0
4	River	1	0.3	900.0	3.8
5	Pipe cum spring	18	5.9	2514.8	15.4
Total/Mean		307	100.0	2636.0	15.6

Source: Field Survey 1998.

Out of the total households in the sample survey the largest (87.0%) are tap water users followed by spring water users (6.2%), and tap cum spring water users (5.9%) (Table 19).

The coefficient of correlation ( $r$ ) for  $y_1$  versus  $x_7$ , and  $y_2$  versus  $x_7$ , are -0.0636 and -0.0443 respectively which are very weak and as expected the types of sources show inverse relationships with monthly and per capita household water consumptions. Even these values for  $r$  are not significant

statistically at 95% confidence level as is evident with t values of 0.267 and 0.440 respectively (Appendix E).

The variation in the monthly water consumption pattern in households is higher (coefficient of variation 125.76%) within pipe water users followed by spring and tap water users (coefficient of variation 121.5%). Concerning per capita water use the variation is higher for pipe water users (coefficient of variation 100.25%) followed by spring and tap water users (Appendix F).

---

The pattern of household water consumption shows a decreasing trend except for spring cum tap water users. Thus, hypothesis three that "per capita per day and households' monthly water consumption vary with the variation of the source of water" is accepted.

The last but not the least significant factor is the physical distance of the housing units from the water point ( $x_8$ ). As it is clear from discussion in chapter three water consumption has inverse relationship with physical distance of the water point from the housing units ( $x_8$ ). This can be indirectly assessed, by taking in to consideration the types of water connections (water sources for household uses).

TABLE 20

Mean Monthly Household Water Consumption and Mean per Capita Consumption and Distance from the Water point (in liters).

Ser. No.	Source of Water	No	%	MMHWC	MPCWC
1	Tap inside the House	7	2.3	5879.7	28.6
2	yard Connection for Private Use	71	23.1	4895.8	24.8
3	yard Connection for shared	9	2.9	3430.9	17.0
4	Neighbor's Meter Connection	177	57.7	1890.0	12.6
5	Public Stand Pipes	21	6.8	1283.3	9.7
6	Non-tap Water	22	7.2	1286.4	11.0
Total/Mean		307	100.0	2636.0	15.6

Source: Field Survey 1998.

It is evident from table 20 that the families and people depending on the first three categories of sources consume more water per household in a month as well as per capita per day than the city's average of 2636.6 and 15.6 liters respectively while others depending on the last three types of sources consume below the averages (Table 20).

The inverse relationship can also confirmed by the values of correlation coefficients ( $r$ ) which are -0.2246 and -0.2085 between  $y_1$  and  $x_8$  and  $y_2$  and  $x_8$  respectively and are statistically significant at 95% confidence limit as  $t$  values are 0.000 for both. The relationships are weaker in general. Distance factor is about to explain 5.0 and 4.3 percent of

TABLE 21

Mean Monthly Household Water Consumption and Mean per Capita Consumption (in liters) with Number of rooms.

Ser. No.	No. of Rooms	No. of Household	%	MMHWC	MPCWC
1	1	113	36.8	1935.3	12.1
2	2	90	29.3	2684.4	17.3
3	3	65	21.2	3104.0	17.3
4	4	22	7.2	3179.9	17.4
5	5 and above	17	5.5	4554.4	21.3
Total/Mean		307	100.0	2636.6	15.6

Source: Field Survey 1998.

From table 21 it is clear that about 37 percent of sample households possess only one room and it is they whose consumption of water per month per household and per capita (1935.3 liters and 12.1 liters respectively) are lower than the general mean of the city (2636.6 and 15.6 liters respectively).

As expected the highest consumption (4554.4 liters) per month per household and 21.3 liters per capita per day is recorded by the households occupying five rooms or more. But this category of households constitute only 5.5 percent of the total sample (Table 21).

The correlation coefficients ( $r$ ) which are 0.1952 and 0.1584 for monthly and per capita water consumption respectively show positive relationships with number of occupied rooms ( $x_5$ ). The  $t$ -values (0.001 and 0.005) at 95% confidence level for mean

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4	4	22	7.2	3179.9	17.4
5	5 and above	17	5.5	4554.4	21.3
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As expected the highest consumption (4554.4 liters) per month per household and 21.3 liters per capita per day is recorded by the households occupying five rooms or more. But this category of households constitute only 5.5 percent of the total sample (Table 21).

The correlation coefficients ( $r$ ) which are 0.1952 and 0.1584 for monthly and per capita water consumption respectively show positive relationships with number of occupied rooms ( $x_5$ ). The  $t$ -values (0.001 and 0.005) at 95% confidence level for mean

monthly and per capita water consumptions show that the relationships are statistically significant (Appendix E).

Thus, households monthly water consumption as well as per capita water consumption show an increasing trend and therefore hypothesis three that "per capita per day and household monthly water consumption is positively correlated with number of rooms that the household occupies" is accepted.

The coefficient of variation of households monthly water consumption and per capita per day water consumption within different categories of number of rooms occupied range from 71.83% to 120.29% and 51.08% to 135.47% for households possessing four rooms and one room and for households possessing four rooms and two rooms respectively.

Type of floors ( $x_6$ ) vary from household to household. In order to identify the relationship between water consumption and type of floors the households were divided into three groups as households with earthen, cement and wooden floors. Households with earthen floor constitute the largest proportion (78.2%), followed by cement floors (20.2%) and an insignificant proportion (1.6%) by wooden floor (Table 22).

TABLE 22

Mean Monthly Household Water Consumption and Mean per Capita Consumption and Floor Type (in liters).

Ser. No.	Type of Floor	No	%	MMHWC	MPCWC
1	Earthen	240	78.2	2534.0	15.2
2	Cement	62	20.2	3080.4	17.3
3	Wooden	5	1.6	2056.0	12.8
Total/Mean		307	100.0	2636.0	15.6

Source: Field Survey 1998.

The highest mean monthly and mean per capita water consumption (3080.5 and 17.32 liters respectively) is shown by the households with cement floor followed by those with earthen and wooden floors (Table 22).

Very weak positive relationship is indicated by the coefficient of correlation which are 0.0461 and 0.0347 for mean monthly per household ( $y_1$ ) and per capita per day ( $y_2$ ) water consumption with type of floor but not significant statistically at 95% level of confidence as t-value are 0.421 and 0.545 respectively. Therefore, hypothesis three that "per capita per day and mean monthly household water consumption varies significantly with the type of floor" is accepted.

Variations within the categories are also significant as the coefficient of variation in monthly household and per capita per day water consumption vary from 36.38% to 143.66% and 31.80% to 109.61% for wooden and earthen cement respectively.

Concludingly it is observed that the dependent variable  $y_1$  has statistically significant relationships with the independent variables  $x_1$ ,  $x_2$ ,  $x_4$ ,  $x_5$ , and  $x_8$ . Thus, in Gondar the determinant variables for the variation in mean monthly

household water consumption patterns are household size, monthly income, occupation of the household heads, number of rooms that the household occupied and the physical distance of the housing units from the water point.

For the second dependent variable  $y_2$  (mean per capita per day water consumption) statistically significant relations exist with  $x_4$ ,  $x_5$ , and  $x_8$  that is occupation of the household heads, number of rooms that the households occupy and the physical distance of the housing units from the water point respectively are the main statistically significant determinant factors for the rate of per capita water consumption.

In addition to the computed results of correlation coefficients ( $r$ ), multiple regression analysis also shows that some independent variables are highly affecting the rate of water consumption than the others. The 8 independent variables considered produced a multiple correlation coefficient of 0.394 with  $y_1$  which means that only about 13% of variation in monthly water consumption of the households can be associated to these variables. When put to stepwise regression analysis, only  $x_1$ ,  $x_8$  and  $x_4$  (household size, distance from the housing units to the water point and occupation of the household heads) could emerge as significant predicators together explaining about 12.4% of the total variation. As a result, the regression equation is  $y_1 = 2800.6 - 359x_1 - 227x_4 - 510.8x_8$ . This shows that as household size increases by one family member the mean monthly water consumption of the household increase by 359 liters per month. Occupation and physical distance of the

housing unit from the water point have inverse relationships with monthly water consumption.

For the dependent variable  $y_2$  versus the eight independent variables the computed value of multiple correlation is 0.3178 which indicates that only about 8% of the total variations in per capita per day water consumption is explained by the independent variables. The stepwise regression analysis produced  $x_3$ ,  $x_4$  and  $x_1$  as important predictors in that order which together explain about 6% of the variations in per capita water consumption. Thus, the regression equation is  $y_2 = 30.6 - 0.8x_1 - 1.2x_4 - .25x_3$ . This shows that in Gondar town as household size, occupational status of the household heads and distance of the housing units from the water point increase the mean per capita water consumption decreases.

#### 4.2.3 Spatial and Temporal Variation in Consumption

TABLE 23

Mean Monthly Household Water Consumption and Mean per Capita Consumption (in liters) by Kebele.

Ser. No.	Kebele	No. of Households	%	MMHWC	MPCWC
1	03	124	40.4	2168.7	13.7
2	06	71	23.1	3292.4	19.7
3	08	43	14.0	2364.4	10.7
4	15	69	22.5	2972.1	18.1
Total/Mean		307	100.0	2636.6	15.6

Source: Field Survey 1998.

Apart from the above findings the inter *kebele* variations in the households' monthly water consumptions are also observed (Table 23). The highest mean monthly consumption per household (3292.4 liters) is seen for *Kebele* 06. The reason may be that this *Kebele* is found around the main market center. Thus, most of the households living in this *Kebele* are engaged in business activities such as selling of bear, tea, bread, etc. Because of this they consume more water than households not engaged in such activities. The second highest consumption is for *Kebele* 15 (2972.1 liters). The reason is that their source of tap water is springs like Gondar Georgis and Kahai Jesus which distribute water to this *Kebele* by gravity method. Further, this *Kebele* (15) is found in the lower altitude zone as compared to others. Thus tap water is available with good pressure. Also this *Kebele* is found near Kahai river so that water is available from river and spring during tap water interruptions. Thus mean, monthly household water consumption is higher. In general it shows that there is a variation in consumption between different *kebeles* of the town because of socio-economic and physical factors. (Table 23).

To assess the temporal patterns of household water consumption in Gondar town the researcher randomly selected five households that have meter connection in two *kebeles* (*Kebele* 06 and *Kebele*

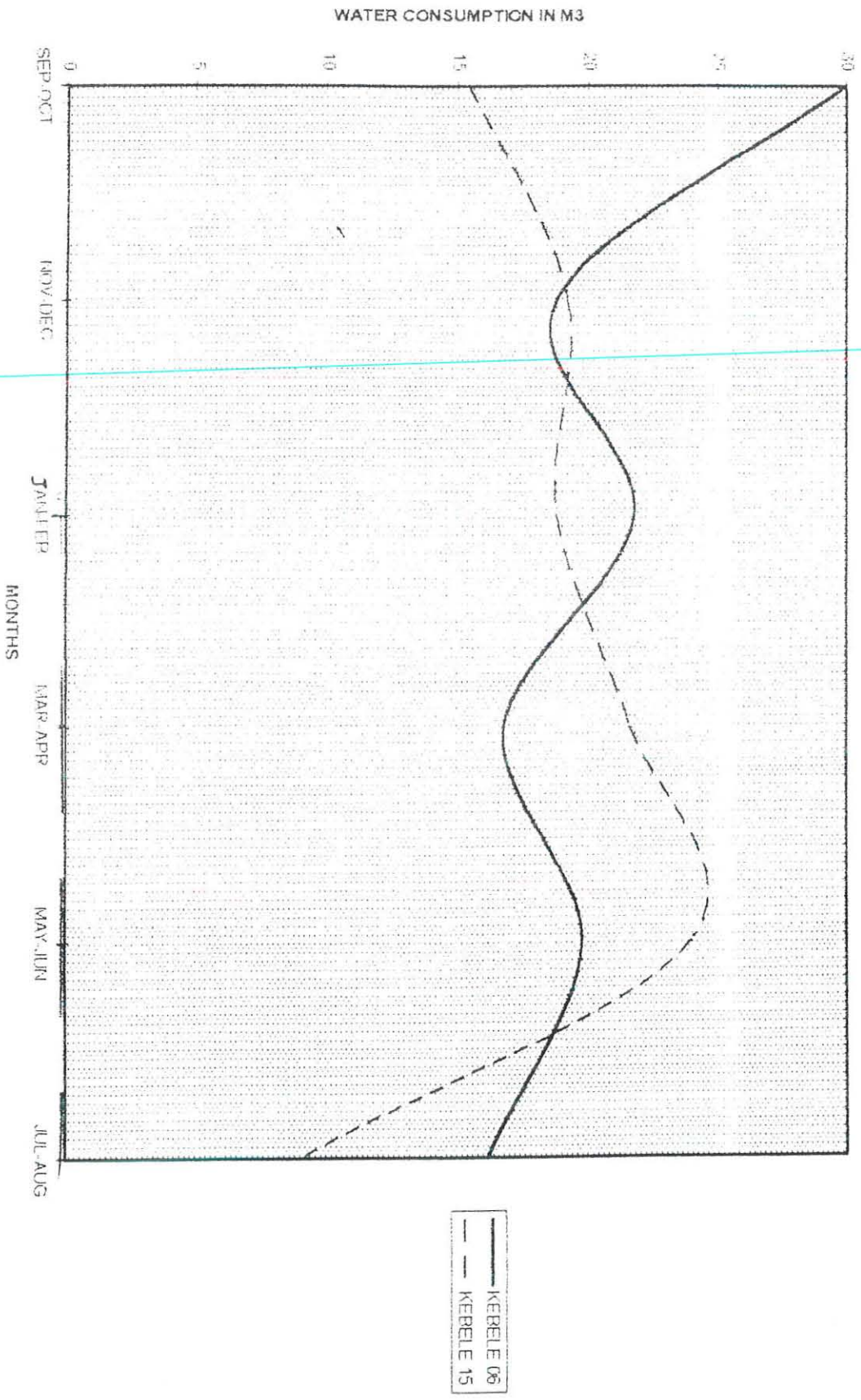
15). The selection of households with meter connection was done in order to get exact amount of water consumption from the water bills.

The selection of the two *kebeles* (06 and 15) was guided by their altitudinal location i.e. *Kebele* 06 from relatively higher ground and *Kebele* 15 from relatively lower ground. Then, the average water consumption for each *Kebele* per two months was computed, because Gondar Water Supply Service collects water fee at the interval of two months.

In relatively wet season that is months of July, August, September and October the average water consumption of households is higher for the dwellers of *Kebele* 06 than what it is for the dwellers of *Kebele* 15. This shows that during these months tap water is available in the supply system. But the average household water consumption of the dwellers of *Kebele* 15 remains greater than that of the dwellers of *Kebele* 06 from March to June. These months are the hotter/drier months of the year in Gondar (Figure 3) when tap water interruption exist. The reason is that *Kebele* 15 is found in the lower ground and mainly the sources of water for this *Kebele* are the Gondar Georgis and Kahai Jesus springs from where water is distributed by gravity distribution system. Thus, it is clear that during

the dry months of the year when there is acute tap water shortage in the water supply system there exists the variation of water consumption from *Kebele* to *Kebele* (Figure 9).

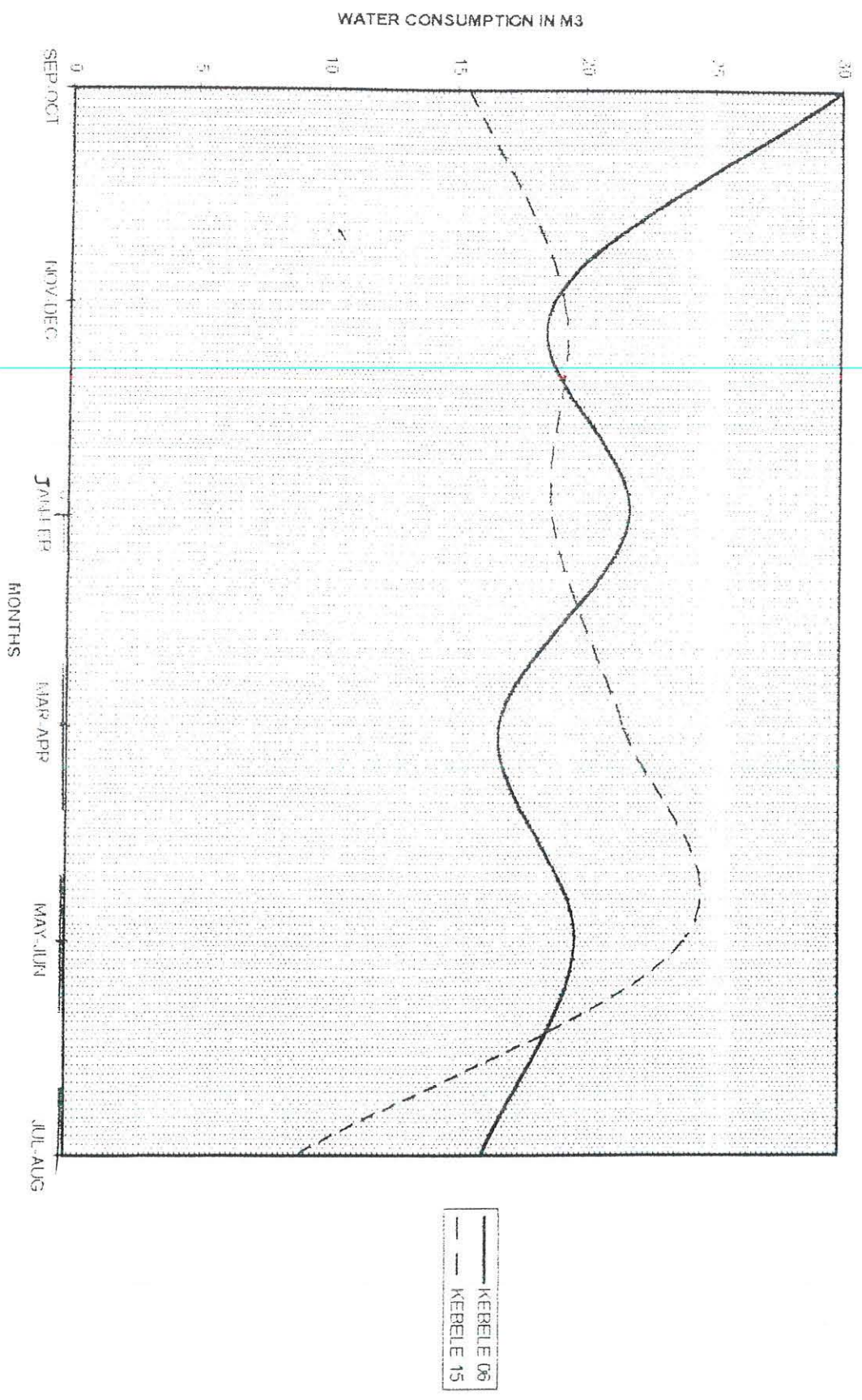
TWO BROTHERS TOTAL WATER CONSUMPTION OF 5 RANDOMLY SELECTED HOUSEHOLDS EACH FROM KEBELES 06 AND 15 WHO HAVE METER CONNECTION (in cubic meter)



Source: Field Survey 1998

Figure 9

TWO MONTHS TOTAL WATER CONSUMPTION OF RANDOMLY SELECTED HOUSEHOLDS EACH FROM KEBELES 06 AND 15 WHO HAVE METER CONNECTION (in cubic meter)



Source: Field Survey 1998

Figure 9

## CAPTER FIVE

### SUMMARY AND RECOMMENDATIONS

#### 5.1 Summary

Water is the most vital element for human survival on this planet. But access to safe drinking water varies from community to community because of socio-economic and physical factors. As a result, nowadays, a number of people in the world do not have reasonable access to adequate amount of potable water.

One of the major reasons for this shortage may be that, supply of fresh water is reduced by pollution and or climatic changes. Others include the population growth, industrial growth and expansion, rising living standards and expansion of urbanization. As a result shortage of potable water is becoming a major challenge for socio- economic and industrial development of many countries urban centers in the world.

Like most of the urban centres of developing countries Gondar town has been experiencing the problem of potable water supply in adequate quantity since its establishment (1635/36). Even if the modern water supply system was installed since the late 1930's and expanded its service by drilling a number of new bore holes, still the demand of water for the community is not satisfied. But no detailed study is conducted on the town's water supply and distribution system and consumption patterns of the community. Thus, the major goal of this study is to identify the rate of household water consumption patterns. To

accomplish the task, primary as well as secondary data were collected.

Water is distributed to the community with the help of house connections, yard connections, neighbor's tap connections and public stand pipes. In relation to this, it is observed that in the central and northern parts of the town pipe line network is densely distributed where as it is sparsely distributed in other built up areas of the town. This adversely affects the rate of household water consumption of the community.

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Primary data collected from the sample households through questionnaire have been analyzed using simple correlation, coefficient of variation and multiple regression techniques. To analyses data the dependent variables are mean monthly household water consumption ( $Y_1$ ) and mean per capita water consumption ( $Y_2$ ) versus where as the independent variables are household size ( $X_1$ ), household monthly income ( $X_2$ ), educational states of the household heads ( $X_3$ ), occupation of the household head ( $X_4$ ), number of rooms occupied by the for household ( $X_5$ ), type of floor of the house ( $X_6$ ) source of water for household use ( $X_7$ ) and the distance of the housing units from the water point ( $X_8$ ).

By simple correlation techniques it was found that mean monthly water consumption is statistically significant with  $X_1$ ,  $X_2$ ,  $X_4$ ,  $X_5$  and  $X_8$  and mean per capita water consumption is statistically significant with  $X_4$ ,  $X_5$  and  $X_8$  at 95% confidence level. Thus, the pattern of household monthly water consumption increase as household size, household monthly income, educational level of the household heads and number of rooms

that the household occupies increases. Where as, it decreases as sources of water for household uses and the distance of the housing units from the water point increases. The pattern of per capita water consumption also increases as household monthly income and number of rooms increase. Where as, it decreases as household size, educational level of the household heads, source of water and the distance of the housing units from the water point increases.

In the case of multiple regression analysis  $X_1$ ,  $X_4$  and  $X_8$  emerged as the best predictor of consumption of the households. While, for per capita water consumption  $X_1$ ,  $X_4$  and  $X_8$  emerged as best predictors.

In addition, there is inter *Kebele* variation in household water consumption patterns. The grand mean of per capita water consumption for all sample *Kebeles* is 15.6 liters /day. The mean per capita water consumption of *Kebele* 06 and 15 is 19.7 and 18.1 liters per day respectively (Table 23) which are more than the grand mean. Where as the average per capita per day water consumption is lesser than the grand mean for other *Kebeles*. There is also temporal variation in of water consumption between *Kebeles* (Figure 9). Thus all socio-economic and physical factors do not have equal impact on household water consumption patterns. Instead some variables have strong impact where as, others have insignificant influence on household consumption patterns.

## 5.2 RECOMMENDATIONS

From the preceding chapters it is clear that the yield of the water source and pipe line network are not capable enough to satisfy the needs of the community. As a result, the mean per capita water consumption in Gondar is much fewer than the corresponding figures for different countries. In addition, the result of the study shows that there is inter Kebele variation in household water consumption. This and related factors invite farther research on such topics and help to recommend ways and means of improving water supply system. Thus, the following measures should be taken in order to improve water consumption rate of the community of the town.

1. One of the significant problems of Gondar water supply system is its frequent interruption. The main causes for these interruptions are inadequate amount of water in the supply system, power failure breakages of the pipe lines. The distribution net-work of pipe line of the town is in the form of branching patterns. Thus, breakage in the pipe line means absence of water for the dwellers behind the breakage. And there will be high water loss during pipe line breakage. Thus, reparation of broken pipe line as quickly as possible could give immediate solution to the problem and helps to protect the water losses.
2. During tap water interruption GWSS in collaboration with other organization and the people should provide potable water for the community by using water tanker.

3. Potable water shortage is a historical phenomenon for Gondar. So it can be better to orient the community to adjust their needs and uses wisely according to the availability of tap water during different seasons of the year.
4. People living near Kahai River use spring water for household use. Thus, it is better to develop the springs as an alternative source at the time of water interruption.

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5. One of the causes for low per capita water consumption rate is high price of tap water from the water sellers. Thus, Gondar water supply service has to install additional public stands pipes.
6. The relatively dense pipe line net-work at present remain in central and northern parts of the town. Thus, this inversely affects equitable distribution of tap water through out the built-up areas of the town. Therefore more pipe line net-works should extend to the peripheral built up area of the town.
7. During dry seasons it is natural that pressure of water in the supply systems reduced considerably. Thus always affects supply in higher parts. During this period the supply should be regulated by shift system.
8. The final solution to the problem of water supply system of the town is the fast completion of Angereb Dam Project.

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**APPENDIX - A MONTHLY MEAN MAXIMUM TEMPRATURE - Gondar**

<b>Year</b>	<b>Jan</b>	<b>Feb</b>	<b>Mar</b>	<b>April</b>	<b>May</b>	<b>June</b>	<b>July</b>	<b>Aug</b>	<b>Sep</b>	<b>Oct</b>	<b>Nov</b>	<b>Dec</b>
1988	28.0	27.5	30.7	30.7	28.5	24.9	21.1	22.0	23.8	25.0	26.1	26.3
1989	26.7	27.4	27.5	27.8	25.5	23.3	22.7	22.6	24.0	25.5	27.1	26.0
1990	27.0	27.5	29.0	29.7	29.9	26.8	22.5	23.0	x	26.5	27.4	27.7
1991	28.1	x	x	x	x	x	x	x	x	x	26.9	27.3
1992	27.1	28.1	31.0	30.1	29.3	27.0	23.0	21.5	24.0	24.6	25.3	26.3
1993	26.6	27.1	29.5	27.9	27.4	24.4	22.7	23.6	24.2	25.6	27.1	27.8
1994	28.8	29.3	29.9	30.7	28.9	24.8	22.0	22.2	24.8	27.3	27.4	28.2
1995	28.6	29.0	29.4	29.7	29.0	26.8	22.5	22.9	25.6	27.6	28.3	27.7
1996	27.8	29.8	29.5	29.1	26.6	25.9	23.3	23.0	25.4	27.1	27.0	26.8
1997	27.3	29.3	29.8	29.2	26.9	25.0	23.2	24.3	27.0			

**Source:** National Meteorological Service Agency.

**APPENDIX - B MONTHLY MEAN MINIMUM TEMPRATURE - Gondar**

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1988	10.0	11.1	15.3	15.3	15.0	14.0	13.0	12.9	13.1	12.4	10.9	10.7
1989	8.8	10.0	11.7	12.8	12.9	11.3	11.4	10.9	11.1	11.0	11.0	13.5
1990	11.3	11.5	13.3	14.3	14.5	13.6	11.8	11.2	x	10.8	10.7	13.9
1991	12.9	x	x	x	x	x	x	x	x	x	12.3	12.0
1992	12.0	12.0	16.0	16.4	16.4	15.0	13.4	13.9	13.4	14.0	12.9	11.7
1993	11.1	14.1	15.2	15.2	15.7	14.5	13.9	13.5	13.5	14.0	12.9	13.0
1994	13.4	13.6	14.2	17.1	16.0	14.8	14.1	13.8	13.8	13.9	13.4	12.3
1995	13.3	14.0	14.5	16.7	16.3	15.1	14.4	14.1	13.6	13.5	13.5	13.3
1996	12.3	14.9	15.4	16.0	15.7	14.3	13.9	13.7	13.7	13.0	13.1	12.3
1997	11.9	13.8	15.4	15.5	15.0	14.5	14.2	14.6				

**Source:** National Meteorological Service Agency.

**APPENDIX - B MONTHLY MEAN MINIMUM TEMPRATURE - Gondar**

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1988	10.0	11.1	15.3	15.3	15.0	14.0	13.0	12.9	13.1	12.4	10.9	10.7
1989	8.8	10.0	11.7	12.8	12.9	11.3	11.4	10.9	11.1	11.0	11.0	13.5
1990	11.3	11.5	13.3	14.3	14.5	13.6	11.8	11.2	x	10.8	10.7	13.9
1991	12.9	x	x	x	x	x	x	x	x	x	12.3	12.0
1992	12.0	12.0	16.0	16.4	16.4	15.0	13.4	13.9	13.4	14.0	12.9	11.7
1993	11.1	14.1	15.2	15.2	15.7	14.5	13.9	13.5	13.5	14.0	12.9	13.0
1994	13.4	13.6	14.2	17.1	16.0	14.8	14.1	13.8	13.8	13.9	13.4	12.3
1995	13.3	14.0	14.5	16.7	16.3	15.1	14.4	14.1	13.6	13.5	13.5	13.3
1996	12.3	14.9	15.4	16.0	15.7	14.3	13.9	13.7	13.7	13.0	13.1	12.3
1997	11.9	13.8	15.4	15.5	15.0	14.5	14.2	14.6				

Source: National Meteorological Service Agency.

**APPENDIX - C MONTHLY TOTA RAINFALL - Gondar**

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1986	0.0	0.0	6.9	29.6	10.5	155.1	283.4	269.4	85.7	79.3	20.2	3.2
1987	12.8	0.0	2.1	36.5	210.2	177.5	222.6	195.2	116.1	90.6	17.4	3.7
1988	0.0	32.6	0.0	12.2	62.5	190.5	306.6	304.1	92.1	83.3	7.7	0.7
1989	0.0	1.4	38.7	32.4	59.7	208.4	269.1	279.7	102.1	34.5	7.0	X
1990	4.2	0.0	6.5	29.7	13.0	59.4	359.1	235.2	X	1.4	1.2	0.0
1992	0.0	0.0	2.7	51.7	80.7	86.8	249.5	219.2	117.6	79.6	11.9	21.6
1993	0.0	3.5	30.8	78.5	104.2	166.6	305.4	201.9	136.6	86.7	36.8	0.5
1994	0.0	1.0	0.0	7.8	84.5	156.0	289.4	265.9	120.0	38.0	20.0	12.8
1995	0.0	0.0	34.5	23.9	99.3	105.9	283.0	307.4	91.8	11.9	0.9	19.8
1996	0.0	4.4	22.2	83.6	183.8	194.7	249.3	83.6	75.8	67.7	23.2	0.4
1997	0.0	1.8	28.2	42.8	124.2	184.8	239.7	230.4	33.1			

Source: National Meteorological Service Agency.

APPENDIX - D SAMPLE KEBELE'S TOTAL HOUSEHOLD SIZE AND SAMPLE SIZE

Kebele	Total Household Size		Sample size (12%) From Kebele List
	From CSA, 1995	From Kebele List	
03	1272	1030	124
06	860	591	71
08	391	364	44
15	682	573	69
Total	3205	2558	308

Appendix - E Correlation Coefficients

	Independent Variables							
	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>	X <sub>7</sub>	X <sub>8</sub>
MMHWC(Y <sub>1</sub> )	.2806	.1196	.0680	-.1668	.1952	.0461	-.0636	-.2246
P=	.000*	.036*	.235	.003*	.001*	.421	.267	.000*
Number of cases	307	307	307	307	307	307	307	307
MPCWC(1/2)	-	.0520	-	-.1145	.1584	.0347	-.0443	-.2085
P=	.0667		.0273					
	.237	.364	.634	.045*	.005*	.545	.440	.000*
Number of cases	307	307	307	307	307	307	307	307

\* Statistically Significant at 95 % Confidence Level.

## Appendix -F

The Results of Analysis of Coefficients of Variance for Mean Monthly Household Water Consumption (MMHWC) and Mean per Capita Water Consumption (MPCWC).

Variables	Group	Coefficient of variance(%)	
		MMHWC	MPCWC
Household Size( $X_1$ )	<= 4	123.46	116.80
	5	80.55	79.85
	6	101.13	99.08
	7	154.55	57.77
	8	80.55	77.49
	Total/Mean	126.61	98.60
Household Income( $X_2$ )	<= 75	123.99	71.57
	76 - 120	233.82	65.71
	121 - 250	127.36	146.97
	251 - 500	88.95	64.99
	>= 500	53.25	43.18
	Total/Mean	126.60	98.61
Educational Status( $X_3$ )	Illiterate	103.63	79.22
	Read and Write	154.57	141.71
	6th grade and less	173.12	71.31
	7th to 12th grade	84.69	60.49
	above 12th grade	67.28	48.66
	Total/Mean	126.61	98.61
Occupation( $X_4$ )	Gov. Employee	133.45	77.60
	Business	106.54	114.72
	Daily Labourers	86.88	42.70
	Weavers	48.76	37.46
	House Wife	82.72	64.87
	Peasant	54.29	47.28
	Total/Mean	126.61	98.61
Source of Water( $X_7$ )	Pipe	125.76	100.25
	Well	84.85	6.06
	Spring	56.71	48.81
	River Pipe & Spring	121.59	83.62
	Total/Mean	126.61	98.61
Distance( $X_8$ )	Tap inside House	80.90	52.24
	Yard Connection for Private use	119.87	63.58
	Yard Connection for Shared	61.20	111.13
	Neighbor's Meter Connection	55.13	45.75
	Public Foundation	44.76	46.03
	Non-tap Water	57.29	52.24
	Total/Mean	126.61	98.61

Number of Rooms( $X_5$ )	1	129.57	56.01
	2	120.29	135.47
	3	88.40	76.75
	4	71.83	51.08
	5 and above	76.83	67.75
	Total/Mean	126.61	98.61
Floor Type( $X_6$ )	Earthen	143.66	109.61
	Wooden	62.19	55.11
	Cement	36.39	31.80
	Total/Mean	126.61	98.61
Kebele	03	26.81	47.50
	06	109.98	128.63
	08	251.30	45.51
	15	108.91	90.85
	Total/Mean	126.61	96.81

**APPENDIX - G MONTHLY HOUSEHOLD WATER CONSUMPTION (in m<sup>3</sup>)  
OF FIVE RANDOMLY SELECTED HOUSEHOLDS OF KEBELE 15  
AND 06 WHO HAVE WATER CONNECTION**

Kebele 15

Ser. No.	M	O	N	T	H	
	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-June	July-Aug
1	2	2	4	16	4	2
2	15	18	35	12	37	10
3	35	31	25	36	31	6
4	21	41	19	33	33	22
5	4	4	11	11	15	6
Total	77	96	94	108	120	46
Average	15.4	19.2	18.8	21.6	24.0	9.0

Kebele 06

Ser. No.	M O N T H S					
	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-June	July-Aug
1	13	6	5	10	3	2
2	55	12	26	23	25	25.5
3	5	4	5	3	6	4.5
4	13	20	9	9	25	8
5	64	52	64	39	40	41
Total	150	94	109	84	99	81
Average	30	18.8	21.8	16.8	19.8	16.2

QUESTIONNAIRE

Household water consumption sample survey - Gondar town

Part 1- Socio-economic characteristics.

1. Name \_\_\_\_\_ age \_\_\_\_\_ sex \_\_\_\_\_ of the  
household head

2. Marital status: 1. Married \_\_\_\_\_ 3. Widow/widower \_\_\_\_\_  
2. Unmarried \_\_\_\_\_ 4. Remarried \_\_\_\_\_

3. Address: Town \_\_\_\_\_ Kebele \_\_\_\_\_ House no. \_\_\_\_\_

4. Religion: 1. Christian \_\_\_\_\_ 3. Others, specify \_\_\_\_\_  
2. Muslim \_\_\_\_\_

5. Household size: 1. Adult male \_\_\_\_\_ female \_\_\_\_\_  
2. Children male \_\_\_\_\_ female \_\_\_\_\_

6. Monthly total household income (in Birr)  
1. Household head \_\_\_\_\_ 2. Others \_\_\_\_\_  
3. Total \_\_\_\_\_

7. Educational status of  
1. Household head \_\_\_\_\_  
2. Others \_\_\_\_\_

8. Type of occupation

1. Household head \_\_\_\_\_
2. Others \_\_\_\_\_

9. House ownership status:

1. Private \_\_\_\_\_
2. Rented \_\_\_\_\_

10. If rented , rented from

1. Kebele \_\_\_\_\_
2. ARHA \_\_\_\_\_
3. Cotenant \_\_\_\_\_
4. Others, specify \_\_\_\_\_

11. State the number of rooms \_\_\_\_\_

1. Covered space \_\_\_\_\_
2. Open space \_\_\_\_\_

12. Type of house

1. Villa \_\_\_\_\_
2. Studio apartment \_\_\_\_\_
3. One room apartment \_\_\_\_\_
4. Two room apartment \_\_\_\_\_
5. Three room apartment \_\_\_\_\_
6. Four room apartment \_\_\_\_\_
7. Five and above room  
apartment \_\_\_\_\_
8. Others, specify \_\_\_\_\_

13. Type of floor:

1. Earthen \_\_\_\_\_
2. Cement \_\_\_\_\_
3. Wooden \_\_\_\_\_
4. Plastic tile \_\_\_\_\_
5. Others, specify \_\_\_\_\_

14. Type of wall \_\_\_\_\_

15. Type of roof \_\_\_\_\_

16. Is there kitchen garden in your compound?

1. Yes \_\_\_\_\_ 2.No \_\_\_\_\_

17. Do you have domestic animals living in the compound?

1. Yes \_\_\_\_\_ 2.No \_\_\_\_\_

18 If yes, indicate the number \_\_\_\_\_

19. DO you have automobile/s?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

20. If yes, indicate the number and type \_\_\_\_\_

**Part 2: Household water supply and consumption.**

21. What is/are the source/s of water for household uses?

1. Pipe water \_\_\_\_\_ 4. River \_\_\_\_\_  
2. Well \_\_\_\_\_ 5. Rain water \_\_\_\_\_  
3. spring \_\_\_\_\_ 6. Others, specify \_\_\_\_\_

22. If you use pipe water, what is the type of connection?

1. Meter connection \_\_\_\_\_  
2. Public stand pipe \_\_\_\_\_

23. If you use piped water, what is the location of the water tap?

1. Inside the house \_\_\_\_\_  
2. Inside the compound \_\_\_\_\_

3. Outside the compound(neighbors)\_\_\_\_\_
4. Public stand pipe\_\_\_\_\_
5. Others, specify\_\_\_\_\_

24. If you have meter connection, how are you using it?

1. Privately \_\_\_\_\_
2. Sharing with your neighbors\_\_\_\_\_
3. Sharing with other households on contractual bases\_\_
4. Others, Specify\_\_\_\_\_

25. If you use your meter connection shared with others

1. How many households are sharing water from your tap?
2. What is their total household size? \_\_\_\_\_
3. What is their total monthly income?\_\_\_\_\_

26. If you share your meter connection with other household/s on a contractual basis, what is their amounts of water consumptionpermonth? (in liters/ barrel/pot)\_\_\_\_\_

27. Do you sell water from your meter connection?

1. Yes\_\_\_\_\_
- 2.No \_\_\_\_\_

28. Do you have water well in addition to pipe water of your own?

1. Yes \_\_\_\_\_
2. no \_\_\_\_\_

29. If yes, for which purpose/s you usually use well water?

1. Kitchen garden \_\_\_\_\_

2. For washing cars \_\_\_\_\_
3. For washing cars \_\_\_\_\_
4. For bathing \_\_\_\_\_
5. For watering animal \_\_\_\_\_
6. For all purposes during tap water interruption \_\_\_\_\_
7. Others, specify \_\_\_\_\_

30. Do you have private water tanker?

1. Yes \_\_\_\_\_
2. No \_\_\_\_\_

31. If yes, what is its capacity (in liters) ? \_\_\_\_\_

32. Do you have water using fixtures?

1. Yes \_\_\_\_\_
2. No \_\_\_\_\_

33. If yes,

1. Number of bathrooms \_\_\_\_\_
2. Number of wash basins \_\_\_\_\_
3. Number of flush toilets \_\_\_\_\_
4. Number of kitchens with complete water supply services \_\_\_\_\_

34. If you fetch water from your neighbor's connection, how do you get it?

1. Freely \_\_\_\_\_
2. On cash payment \_\_\_\_\_
3. On monthly contractual basis \_\_\_\_\_
4. Sharing the charges equally \_\_\_\_\_
5. Others, specify \_\_\_\_\_

35. If you fetch water from public stand pipes, mention the distance ( round trip) from your home and the time taken?

1. Distance \_\_\_\_\_ Km \_\_\_\_\_ meters
2. Time \_\_\_\_\_ hours \_\_\_\_\_ minutes

36. How much time do you spent at queuing at the public stand pipe?

1. Less than 10 minutes\_\_\_\_\_
2. 10 to 20 minutes \_\_\_\_\_
3. 20 to 30 minutes\_\_\_\_\_
4. More than an hour\_\_\_\_\_
5. Others, specify\_\_\_\_\_

37. If you use source/s other than pipe water, mention the round trip distance and time taken from your home.

1. Distance \_\_\_\_\_Km \_\_\_\_\_ meters
2. Time \_\_\_\_\_ hours \_\_\_\_\_ minutes

38. How many times do you fetch water daily? \_\_\_\_\_

39. If you use source/s of water other than pipe water, what are the main reasons to do so?

1. High price of tap water\_\_\_\_\_
2. Physical distance of tap water point form your house\_
3. High interruption of tap water supply \_\_\_\_\_
4. Others, Specify

40. How do you transport water from the public stand pipes and other sources?

1. By carrying\_\_\_\_\_
2. By rolling barrel\_\_\_\_\_
3. Using donkeys\_\_\_\_\_
4. Human load\_\_\_\_\_
4. Others, specify\_\_\_\_\_

41. State the reasons as to why you don't have private meter connection.

1. You don't like to have it\_\_\_\_\_
2. Shortages of meter\_\_\_\_\_
3. Shortages of pipes\_\_\_\_\_
4. Bureaucracy\_\_\_\_\_
5. House ownership\_\_\_\_\_
6. Financial problems\_\_\_\_\_
7. You are new comer for the locality\_\_\_\_\_
8. Others, specify\_\_\_\_\_

42. Do you use the same source/s of water throughout the year?

1. Yes\_\_\_\_\_
2. No\_\_\_\_\_

43. If no, which source/s of water do you use during

1. Bega season \_\_\_\_\_
2. Kiremt season\_\_\_\_\_

44. If you use source/s other than pipe water in Bega season, what are the main reasons?

1. Inadequacy of tap water\_\_\_\_\_
2. Frequent tap water interruption\_\_\_\_\_
3. Others, specify\_\_\_\_\_

45. If you use source/s other than pipe water in Kiremt season, what are the main reasons?

1. High cost of tap water\_\_\_\_\_
2. Distance of tap water point from your house \_\_\_\_\_
3. Others, specify\_\_\_\_\_

46. Do you use the same source/s of water supply for different household purposes?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

47. If no, indicate the type of water source/s you usually use for the following purposes.

1. Drinking and cooking \_\_\_\_\_
2. Clothes washing \_\_\_\_\_
3. Animal watering \_\_\_\_\_
4. Floor washing \_\_\_\_\_
5. Gardening \_\_\_\_\_
6. Car washing \_\_\_\_\_
7. Bathing \_\_\_\_\_
8. Others, specify \_\_\_\_\_

48. What is/are the main reason/s for using different sources of water for different household purposes?

1. In order to reduce tap water charge \_\_\_\_\_
2. Inadequacy of tap water supply \_\_\_\_\_
3. Frequent interruption of tap water \_\_\_\_\_
4. Distance factor \_\_\_\_\_
5. Others, specify \_\_\_\_\_

49. Where do you usually wash your clothes?

1. Inside the compound \_\_\_\_\_
2. Near by the public stand pipes \_\_\_\_\_
3. on the river side \_\_\_\_\_
4. Others, specify \_\_\_\_\_

50. Where do the members of your family usually taking bath?

1. Inside the house \_\_\_\_\_
2. At public shower \_\_\_\_\_
3. In the river \_\_\_\_\_
4. Others, specify \_\_\_\_\_

51. What is the frequency of bathing of the household members?

- |                             |                            |
|-----------------------------|----------------------------|
| 1. Once in two days _____   | 4. Once in a week _____    |
| 2. Once in three days _____ | 5. Once in two weeks _____ |
| 3. Once in five days _____  | 6. Others, specify _____   |

52. state the amount of your monthly water consumption (in liters barrels/pots)/ please show your water consumption bill for the period from September 1989 to August 1998 E. C.

Months of the year	amount (liters)	Cost in Birr	Month of the year	amount (liters)	Cost in Birr
September			March		
October			April		
November			May		
December			June		
January			July		
February			August		

Grand total \_\_\_\_\_

Average monthly consumption \_\_\_\_\_

53. Are there problems to your household water supply system?

- |              |             |
|--------------|-------------|
| 1. Yes _____ | 2. No _____ |
|--------------|-------------|

54. If yes mark them in order to importance.

1. Physical distance of the water point \_\_\_\_\_
2. The daily water supply time is very short \_\_\_\_\_
3. The daily water supply time is inconvenient \_\_\_\_\_

4. Queuing for long time to fetch water in public stand pipes\_\_\_\_\_
  5. High tap water fee\_\_\_\_\_
  6. An expected water interruption\_\_\_\_\_
  7. Problems of repairing water pipes\_\_\_\_\_
  8. Others, specify\_\_\_\_\_
55. If you are tap water user (private or public), had there been any water interruption during the year?
1. Yes\_\_\_\_\_
  2. No\_\_\_\_\_
56. If yes, in which season of the year?
1. In Bega season\_\_\_\_\_
  2. In Kiremt season\_\_\_\_\_
57. Frequency of interruption in pipe water supply
1. Daily\_\_\_\_\_
  2. Weekly\_\_\_\_\_
  3. Monthly\_\_\_\_\_
  4. Seasonably\_\_\_\_\_
58. In which month/s of the year do you face high water interruptions? \_\_\_\_\_
59. If your answer to question no. 47 is yes, what was the duration of interruption?
1. For a week \_\_\_\_\_
  2. For eight to fifteen days\_\_\_\_\_
  3. For sixteen to thirty days\_\_\_\_\_
  4. For one to two months\_\_\_\_\_
  5. For more than two months\_\_
  6. Others, specify\_\_\_\_\_
60. From where do you fetch water during tap water interruption?
1. Tap water from Kebele\_\_\_\_\_

2. Public stand pipes from Kebele \_\_\_\_\_
3. Buying from water vender \_\_\_\_\_
4. From other water sources \_\_\_ spring \_\_\_ river \_\_\_ well \_\_\_\_\_
5. Others, specify \_\_\_\_\_

61. During the time of tap water interruption which member/s of the household is/are highly responsible to fetch water?

1. The male household head \_\_\_\_\_
2. The female household head \_\_\_\_\_
3. The male children \_\_\_\_\_
4. The female children \_\_\_\_\_
5. The maid servant \_\_\_\_\_
6. Both the female household head and the children \_\_\_\_\_
7. Others, specify \_\_\_\_\_

62. At what time of the day are you going to fetch water during tap water interruptions?

1. During the day \_\_\_\_\_. From \_\_\_\_\_ to \_\_\_\_\_ hour.
2. During the night \_\_\_\_\_. From \_\_\_\_\_ to \_\_\_\_\_ hour.

63. What is the approximate round trip distance of the water point that you walk in order to fetch water during tap water interruptions? And how much time it takes?

1. Distance \_\_\_\_\_ Km \_\_\_\_\_ meters.
2. Time \_\_\_\_\_ hour \_\_\_\_\_ minutes.

64. How much water does the household use per day during tap water interruptions?

1. \_\_\_\_\_ liters or \_\_\_\_\_ barrels \_\_\_\_\_ or \_\_\_\_\_ pots.
2. Others, specify \_\_\_\_\_

65. What are the main problems faced by the household during tap water interruptions?

1. Walking for long distance \_\_\_\_\_
2. Walking for long hours \_\_\_\_\_
3. High water cost \_\_\_\_\_
4. Long waiting hours \_\_\_\_\_
5. Tiredness of carrying water \_\_\_\_\_
6. Others, specify \_\_\_\_\_

66. Do you know the main reasons for these water interruptions?

1. Yes \_\_\_\_\_
2. No \_\_\_\_\_

67. If yes what are the main reasons?

1. Lack of water management \_\_\_\_\_
2. Power cut \_\_\_\_\_
3. Shortage of water at the sources \_\_\_\_\_
4. Lack of effective water distribution system \_\_\_\_\_
5. Lack of maintenance \_\_\_\_\_
6. Others, specify \_\_\_\_\_

68. Is there any water conservation measure taken by Gondar WSSA and Gondar municipality before the interruption comes?

1. Yes \_\_\_\_\_
2. No \_\_\_\_\_

69. If yes, what are the measures they usually take?

1. Voluntary measures such as \_\_\_\_\_
2. Compulsory measures such as \_\_\_\_\_

70. When there is acute shortages of tap water in the water supply system, do these organizations tried to alleviate the problem on time?

1. Yes \_\_\_\_\_
2. No \_\_\_\_\_

71. If yes,

1. By distributing the existing water in shift system \_\_\_\_\_
2. Distributing water by using water tanker \_\_\_\_\_
3. Others, specify \_\_\_\_\_

72. Do you think the measures taken by these organizations are satisfactory?

1. Yes \_\_\_\_\_
2. No \_\_\_\_\_

73. If no, what are the shortcomings of these measures?

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74. What are your short term and long term recommendations in order to alleviate these seasonal acute shortages of tap water?

1. State your short term recommendations \_\_\_\_\_  
\_\_\_\_\_
2. State your long term recommendations \_\_\_\_\_  
\_\_\_\_\_

DECLARATION.

I, the undersigned, declare that this thesis is my work and that all sources of material used for this thesis have been duly acknowledged.

Name: Mequenent Ejigu

Signature:  \_\_\_\_\_

Place and date of submission

College of Social Science, Addis Ababa

University June 1998.