POTENTIALS FOR WATER CONSERVATION IN DHAKA CITY

A Thesis

by

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DECLARATION

It is hereby declared that except for the contents where specific references have been made to the work of others, the studies contained in this thesis are the result of investigation carried out by the author. No part of this thesis has been submitted to any other University or other educational establishment for a degree, diploma or other qualification (Except for publication).

December, 2010 Md. Shibly Anwar

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ABSTRACT

Water crisis becomes an enormous problem in recent time in Dhaka (Capital of Bangladesh) city where overpopulation and industrialization are alarmingly depleting the groundwater level .It is predicted that Dhaka will be the fourth largest city by the year 2015 with an estimated population of 21.1 million. At present the total water supply in Dhaka is about 1800 MLD where as the total demand is 2400 MLD. In the face of increasing water scarcities, the first and foremost priority should be given to the reduction in water consumption. Taking measures from authority and consumer to conserve water will not only meet the water demand and reduce waste load on sewerage line but also saves the money for the water provider, consumer and the city as a whole.

A survey was conducted among 100 families at Dhaka city to estimate where and how much water people require in daily life. Basically the survey was made in apartment buildings of Dhaka city. Slum areas were not considered. Primary data was collected through questionnaire survey and discussion with people of different areas in Dhaka city. Another survey was made to determine the attitude and preferences of people on water conservation option. In this study the deficit of water supply of the city was calculated. The water supply for the tube-wells of different zones and the different surface water treatment plants has been collected. Most of the information has been collected from different official records and report obtained from DWASA and informal discussion with DWASA staff. Population data has been collected and analyzed to projects the present and future water crisis.

The study shows separately how much water people require in different activities (like bathing, drinking, toilet, faucets, washing, cooking etc).The study also suggests, depending on the habit and system, there is a possibility of savings of water, savings of money and electricity from the reduction in people's daily water use. According to the study about 30% (9 GPCD) of the household's water can be saved by installing the water efficient plumbing fixture with habitual change. An analysis is made for a model apartment building of 60 people. From an apartment building of 60 people the study shows that with 15% reduction from daily water uses, approximately 375 gallons (1700 Liter) of water can be saved each day. The cost of this savings will be equivalent to 111 US$ per year at present water tariff and the corresponding energy savings will be 180 KWh per year. This amount is equivalent to 576 US$ of DWASA vehicle water and 6.6 Million Taka (96000 US$) of bottled water.

The study also shows that the water requirement for household level is higher as compared to many other cities in the Asia. System loss in main distribution system, non metered connection, lower water tariff and ignorance on the valuation of water are the major barriers for the conservation practices in Dhaka city.

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ADB	Development Bank
BWDB	Bangladesh Water Development Board
DTWs	Deep Tube Wells
DPHE	Department of Public Health Engineering
DWASA	Dhaka Water and Sewerage Authority
EPA	Environmental Protection Agency
GPF	Gallon per Flush
GPM	Gallon per minute
GPL	Gallon per Load
GWI	Global Water Intelligence's
GWL	Ground Water Level
GW	Ground Water
GPCD	Liter per Capita per Day
IRIN	Integrated Regional Information Networks
IWM	Institute of Water Modeling
KWH	Kilowatt hour
LPCD	Liter per Capita per Day
MLD	Million Liters per Day
NSU	National Utility Service
OECD	Organization for Economic Cooperation and Development
SWTP	Saidabad Water Treatment Plant
WWC	World Water Council

UNITS

1 Gallon= 4.55 Liters

1 MLD= 10^6 Liter per Day

1 m^3= 10^3 Liter

1 US$= 69.4 Taka

1 GPCD= 4.55 LPCD

CHAPTER ONE
INTRODUCTION

1.1 General

As Bangladesh is a riverine country, water management was never thought to be a problem in the country. However, due to population and economic growth, water demand for industrial, domestic and commercial purposes are increasing, while the functioning and quality of watersheds are deteriorating (Khondokar, 2006). Urban areas of Bangladesh depend on deep tube-wells for supply of potable water. But due to rapid decline in recharge area over the local groundwater basins and excessive withdrawal rate, water levels is falling in many parts of the country. In Dhaka the capital of Bangladesh, groundwater level has fallen by more than 20 meters in the last decade from 1995-2005 alone (Okubo et al, 2008). Also discharge of untreated and semi-treated wastewater from City Corporation and industrial sources is causing serious water pollution for the adjacent river of the city. This puts added pressure on the government to keep City Rivers clean or to spend more money for water treatment.

Water crisis becomes an enormous problem in recent time in Dhaka city where overpopulation and industrialization are alarmingly. It is predicted that Dhaka will be the fourth largest city by the year 2015 with an estimated population of 21.1 million (BBS, 2001). The total water production is about 1800 MLD where as the total demand is 2275 MLD (DWASA, 2009). That means there is a total deficit of 475 MLD which is equivalent to the water demand of 2.0 million people.

In the face of increasing water scarcities, the first and foremost priority should be given to the reduction in water consumption. Taking measures from authority and consumer to conserve water not only meet the water demand and reduce waste load on sewerage line but also saves the money for the water provider, consumer and the city as a whole. There is a strong imperative for adoption of conservative use of water with some recycling technologies such as reuse of reclaimed water, rain water harvesting etc. At the same time existing water supply system needs to be improved for the adequate supply of water in the City.

1.2 Importance of the Study

Water is the most important resource to sustain life. Water resources are challenged in Dhaka today due to pollution and overuse of the local resources. This study shows how to conserve this precious resource in various situations from the home environment. The study explains the following importance

(i) Explain the importance of water in the Dhaka city and the reasons for its sustainable conservation and management.

(ii) Explain the importance of water conservation and methods to save water at the home and workplace.

(iii) Explain the importance of wastewater reuse and recycling option in daily household.

1.3 Objective of the Study

(i) To estimate the amount of water people require in different household activities (like bathing, drinking, toilet, faucets, washing, cooking etc).

(ii) To investigate the possible conservative use of supplied water in daily household life.

(iii)To perform the benefit analyses and energy conservation by saving water.

(iv)To determine the possible volumetric reduction in water demands on conventional water supplies.

The quantitative assessment will show the potential for water saving. The study will enhance information on the possible cost savings from consumers and authority point of view. This assessment will provide several approaches that can help to mitigate the present water crisis in Dhaka city. The outcome of the study is to highlight the potential for saving supplied drinking water and its contribution in meeting the water shortage in Dhaka city.

1.4 Organization of the Thesis

The present study has been presented in five chapters as follows:

Chapter 1 provides a general introduction with importance and objective of the study. Chapter 2 describes literature review on water supply, demand, scarcity in Dhaka city and also describes related literature review on conservative use of water and reuse of reclaimed water.

Chapter 3 presents methodology and data collection.

Chapter 4 describes the result of the analysis's and discussion on result.

Chapter 5 draws the conclusion of the study as well as provides the recommendation for future work.

CHAPTER TWO

LITERATURE REVIEW

2.1 Information of Dhaka City Area

Dhaka the capital, centrally located in Bangladesh, in the southern part of the district of Dhaka. It is situated between latitudes 24º40´ N to 24º54´ N and longitudes 90º20´ E to 90º30´ E .The city has developed on the higher elevated Pleistocene terrace land or older Alluvium of the central part of Bangladesh. In addition, a substantial portion of the adjoining low-lying areas have recently been brought under the structured zones of the city due to the accelerated rate of the urban growth in Dhaka.

Dhaka starts with a general profile of the city highlighting its geography and population characteristics. The urbanization of Bangladesh is interlinked with the intense development of Dhaka City which has developed as a politico-administrative centre, having gained and then lost its position through the political development of the country. Due to the concentration of both domestic and foreign investment, Dhaka has experienced massive migration from the rural population of Bangladesh in recent decades. But a critical downside to this has been the dramatic rise in population concentration. In addition, the state of Dhaka's infrastructure is inadequate and unable to keep up with growing urban pressures. Significant portions of the city's population are living in slums and squatter settlements and are experiencing extremely low living standards, low productivity and unemployment.

The study area includes Dhaka city corporation area, part of the urban extension to the north, the Dhaka –Narayangong- Demra (DND) and the city Narayangonganj. Acoording to DWASA the study area covered by the river Buriganga in the south; the Balu and the Shitalakhya rivers in the east; Tongi Khal in the north, the Turag River in the west and Daleshwari River in south. The Peripheral Rivers of Dhaka City is shown in the Figure 2.1

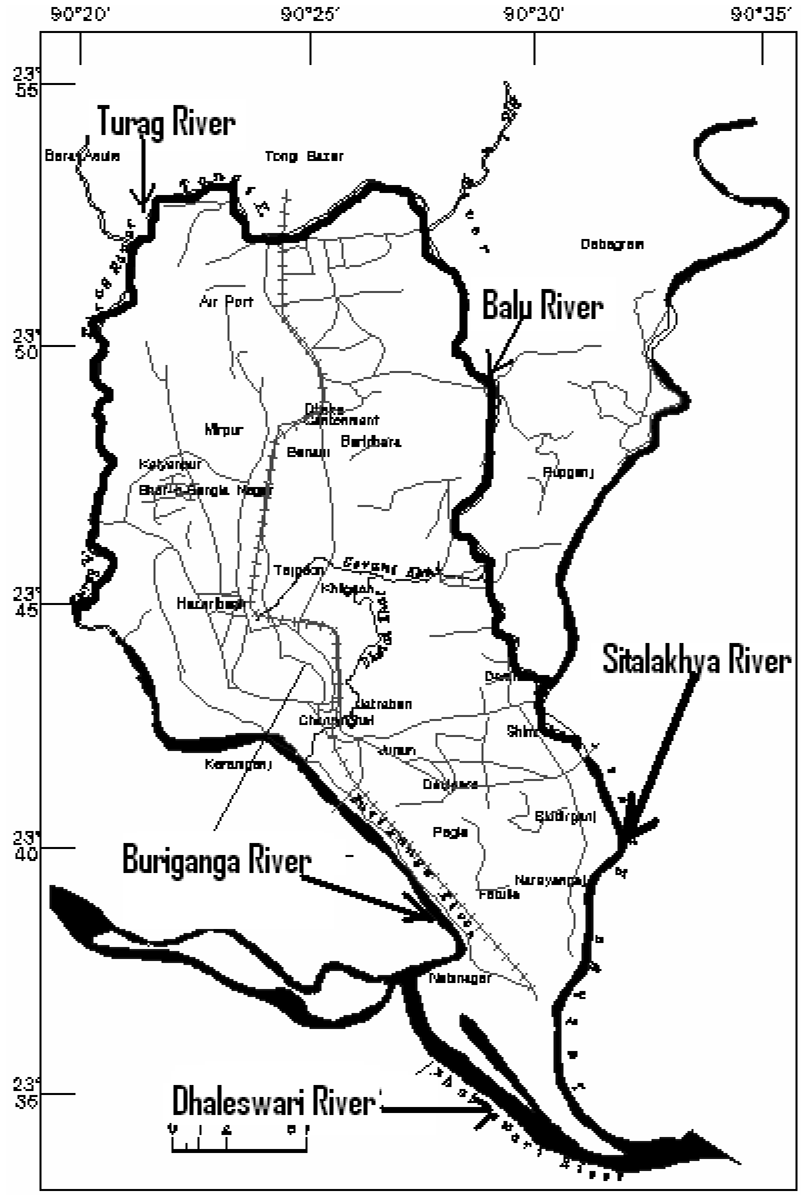

Fig. 2.1 Peripheral Rivers of Dhaka

2.2 History of Water Supply in Dhaka City

The first water supply system was introduced in Dhaka by the British in 1888 at Chandnighat. The Chandnighat plant treats water from the Buriganga River and it has a capacity of supplying 39 MLD of water officially. The first deep-water pump was installed in Dhaka in 1949. Till the end of 1960s, the water supply in Dhaka was almost surface-water system based. Dhaka WASA (Water and Sewerage Authority, Dhaka) was formed in 1963, being separated from the Department of Public Health Engineering (DPHE), with the aim of giving better water service to its city dwellers.

In the mid-1990s, DWASA supplied about 428 MLD where as the demand was estimated 728 MLD. In 1997, the peak shortage was 490 MLD, which came down to 470 MLD in 1999. With the commissioning of the Sayedabad water treatment plant (SWTP), the situation has improved slightly in recent years. The dependence on groundwater for domestic, industrial, and commercial water supply in the city area was more than 95 per cent prior to the commissioning of SWTP.

From so many years since the first operation, the old Chandnighat treatment plant is unable to treat according to its normal capacity. Moreover, the sources of water for the plant, the city part of the Buriganga River, have become biologically and hydrologically dead because of ongoing water pollution caused by industrial and domestic sources (Alam, 2003). The conventional treatment plant, which uses only lime and chlorine for treatment, cannot neutralize the existing pollutants in river water, many of which may cause serious health hazards.

DWASA inherited only 33 deep pumps from DPHE. But, to meet the steady increasing demand of the city dwellers, DWASA kept on installing deep-water pumps on a crisis by crisis basis without having any long-term vision.

2.3 Sources and Problems Associated with Water Supply

Public water supply refers to water withdrawn by public and private water suppliers and delivered to users. Public water suppliers provide water to domestic, commercial, and industrial users, to facilities generating thermoelectric power, for public use, and occasionally for irrigation. In Dhaka city the water-use activities in the public water-supply category include water withdrawal from ground and surface water.

2.3.1 Ground water

Urban areas in Bangladesh especially in Dhaka already depend on deep tube-wells for the supply of potable water. Conventionally 95% of water supplied by DWASA is groundwater, which is cheaper, and hygienically safer compared to surface water.

2.3.2 Surface water

Before 1997 ground water was the key source for the potable water. But at that time it was become very difficult to fulfill the requirement of water demand by ground water due to rapid increase of population as well as industrialization. Dhaka may rely on the perennial rivers around the Dhaka city for the surface water. These are Buriganga, Shitalakhya, Turag and also Tongi Khal for the surface water. The three small rivers Turag, Balu and Tongi Khal are mainly connected with the big rivers Buriganga and Shitalakhya the perennial river around the Dhaka city (Figure 2.1)

2.3.3 Ground water declination

With the ever increasing demand of a growing population and a developing industrial sectors, groundwater source has been rapidly becoming inadequate to meet the demand and progressive draw down of the groundwater table has been taking place at an alarming rate in recent years. The analysis of records of the groundwater level was observed by BWDB (Bangladesh Water Development Board) for the year 1995 to 1999, (Table 2.1), indicates that the rate of annual decline of groundwater level in Green Road area was 2.70 m, 2.41 m and 2.52 m respectively for the year 1997, 1998 and 1999. At New Shewrapara, the annual decline of groundwater level was 2.86 m in 1997, 2.06 m in 1998 and 1.01 m in 1999. At Lalbagh, the annual decline of groundwater level was 0.80 m in 1997 and 0.30 m in 1998. The analysis of the hydrographs of the observed groundwater level indicates that after 1991, the decline of the groundwater up to 1998 in 7 years varied from 6.0 m to 12.0 m within the city area and the average yearly decline of groundwater level varied from 1.00 m to 2.50 m. Hydrographs of groundwater levels show that at the periphery areas of the city, GWL varied from 0.50 m to 4.0 m in 7 years and the average yearly decline of groundwater level varied from 0.30 m to 0.50 m. Recharge to groundwater at the periphery of the city was more than that of groundwater within the city during floods, and as such, the annual decline of groundwater level was less at the periphery of the city.

Table 2.1 Yearly decline of ground water level in the Dhaka city during 1995- 1999 (Afzal et al., 2000)

Maximum depth to groundwater level during the month										
Location of observation well	Dec ’95	Dec ’96	Difference (m)	Dec ’97	Difference (m)	Dec ’98	Difference (m)	Apr ’99	Difference (m)	Remarks
Lalbagh (DH-110)	21.63	23.6	-1.97	24.4	-0.8	24.7	-0.3			Yearly average decline of GWL 1.02m
Sabujbagh (DH-123)	27.23	28.84	-1.61	31.04	-2.2	32.27	-1.23			Yearly average decline of GWL 1.68m
Green Road (DH-124)	28.17	30.49	-2.32	33.19	-2.7	35.6	-2.41	38.12	-2.52	Yearly average decline of GWL 2.48m
New Shewrapara (Mirpur)	21.63	24.18	-2.55	27.04	-2.86	29.15	-2.06	30.16	-1.01	Yearly average decline of GWL 2.12m
Joarshahara (Cantonment)	19.92	20.43	-0.51	21.93	-1.5	24.25	-2.32	25.6	-1.35	Yearly average decline of GWL 1.42m
Sultangaj (DH-012) Mohammedpur	18.04	18.5	-0.44	20.68	-2.1	21.8	-1.2			Yearly average decline of GWL 1.24m

Difference of the depth to ground water level for the year 1995 and 1996, 1996 and 1997, 1997 and 1998, 1998 and 1999 are shown Table 2.1. And the Average yearly declinations for different places in Dhaka city are shown in Figure 2.2.

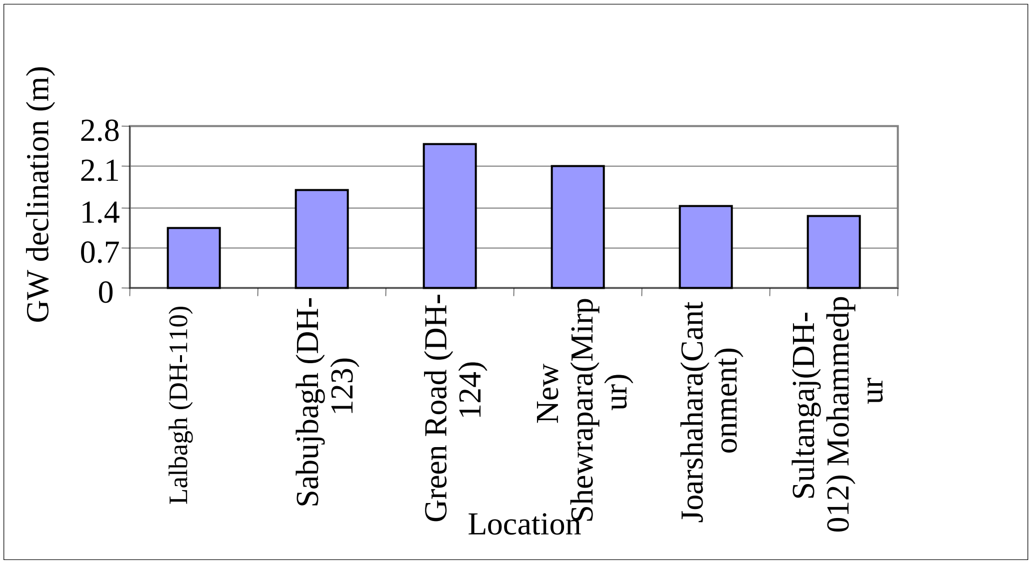

Fig. 2.2 Average ground water declination from year 1995-1999 at different places in Dhaka (Afzal et al., 2000)

The groundwater table is rapidly declining due to large scale abstraction. Therefore, ground water will no longer be a viable option for the source of water in the Dhaka city.

2.3.4 Surface water pollution

The peripheral rivers in Dhaka city have undergone major pollution due to random discharge of domestic waste water and industrial effluent. So the only future water source is the surface water which is also deteriorating. The peripheral rivers are definitely good source of water if pollution controls measures could be implemented. DWASA is working with the support from the World Bank to find ways and means of pollution control in the Dhaka water shed. several studies on the peripheral Rivers of Dhaka city have identified many causes for the river's pollution such as sedimentation at the upstream, encroachment, and disposal of solid wastes, sewage and industrial wastes in the river. The present river pollution scenario with some causes are shown in the Figure 2.3, 2.4, 2.5, 2.6 and 2.7

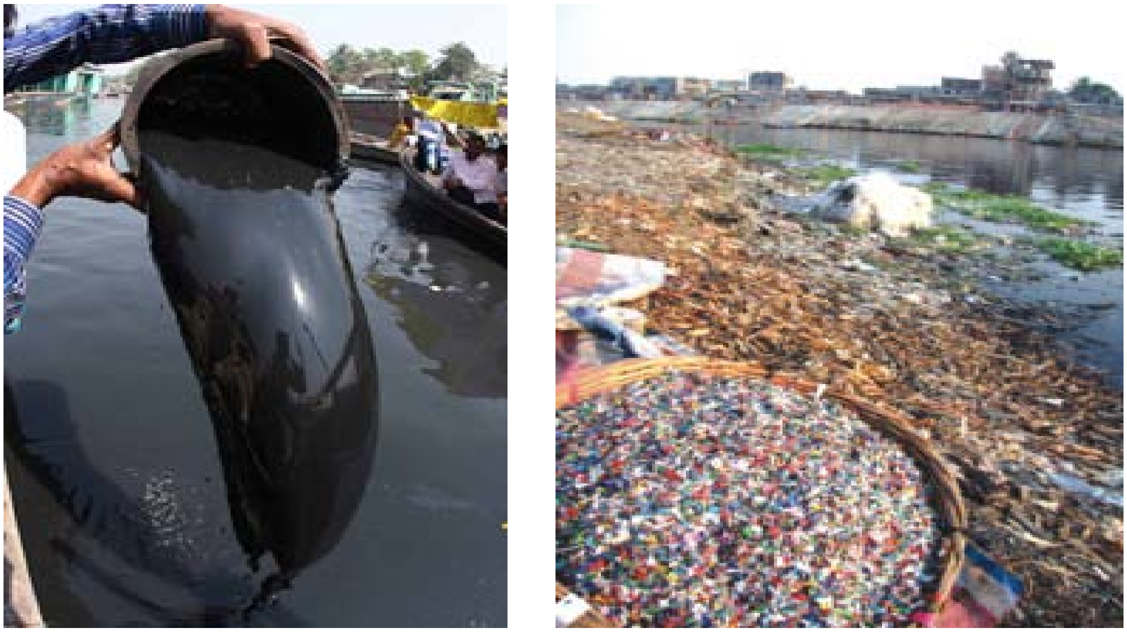

Fig. 2.3 Heavy pollution of the Balu River has turned its water into a thick black sludge (IRIN 14 July 2009) and ignoring any laws; solid wastes are dumped into the river

Fig. 2.4 Both domestic and industrial wastes carried through such canals are polluting the river.

Fig. 2.5 Small dyeing units on the river create environmental degradation. The pitch-black color of water indicates the alarming level of pollution in the Buriganga River.

Fig. 2.6 Shipyards on the riverbank discharge burnt oil and effluents into the river.


Fig. 2.7 The River carries only wastewater

2.4 Population and Water Demand in Dhaka City

Dhaka is the primate city of the country as its share of national urban population was 25% in 1981, 31% in 1991 and 34% in 2001 respectively (BBS, 2001). Dhaka's dominance not only in terms of population, but also in terms of economy, trade, commerce, and administration is obvious. In 1991 among the thirty-four mega cities of the world having a population of more than five million, Dhaka ranked twenty-fifth (BBS, 1997) while in 2000 it ranked eleventh and it is predicted to be the world's fourth largest city by the year 2015 with an estimated population of 21.1 million (Lizin, 2002). The increase in population means the increase in water demand. A study has been made (Unnayan Shamannay, 2001-2003) based on DWASA report to find out the water demand, supply and deficit in Dhaka city with the increasing number of population. The Table 2.2 shows the population, water demand, supply and deficit of water in different years at Dhaka city. The Table 2.2 showed that the per capita water consumption was approximately 33 GPCD.

Table 2.2 Demand, supply and deficit of water in Dhaka city

Year	Population (Lakhs)	Demand of water (Crore liter)	Supply of water (Crore liter)	Deficit of water (Crore liter)
1963	8.48	15	13	3
1970	14.64	26	18	8
1980	30.31	55	30	25
1990	55.56	100	51	49
1996	72.5	130	81	49
1997	75	135	87	48
1998	80	140	93	47
1999	97.94	144	107	37
2000	102.43	150	113	37
2001	107.12	160	122	38
2002	112.03	168	130	38
2003	117.16	176	150	26

(Unnayan Shamannay, 2002-2003 and DWASA, 2003)

2.5 Water Tariffs of Dhaka City

In Dhaka city water and sanitation tariffs, which are almost always billed together, can take many different forms (DWASA). Where meters are installed, tariffs are typically volumetric (per usage), sometimes combined with a small monthly fixed charge. In the absence of meters, flat or fixed rates - which are independent of actual consumption - are being charged (Madrasha, Mosque, temples, Relief camp, Community). In Dhaka city, tariffs are usually the same for different categories of users and for different levels of consumption.

In Dhaka city, Government is providing cross-subsidies with the intent to make water more affordable for residential low-volume users that are assumed to be poor. For example, industrial and commercial users are charged higher tariffs than public or residential users. The water tariff growth is shown in the Figure 2.8 (Table A1).

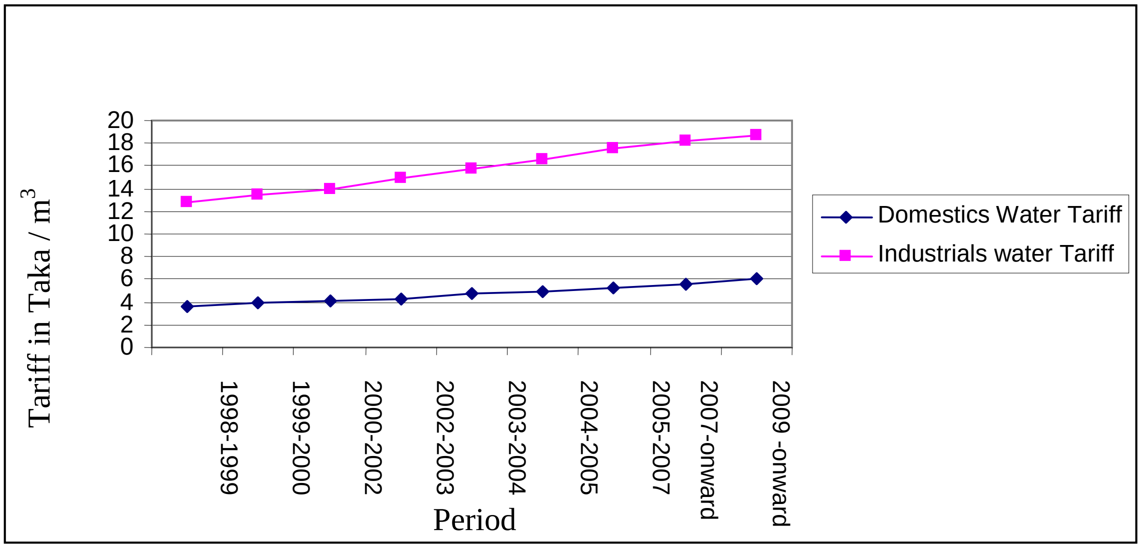

Fig. 2.8 Water tariff in different years (Taka / m^3). (DWASA, 2009)

2.6 Water Tariffs of Different Countries in the World

According to the study (NSU, 2005-2006) the average water and sewerage tariff in 14 mainly OECD countries excluding VAT varied between US$ 0.66 per cubic meter in the United States and the equivalent of US$ 2.25 per cubic meter in Denmark. However, it should be noted that water consumption in the US is much higher than in Europe. Therefore, residential water bills may be very similar, even if the tariff per unit of consumption tends to be higher in Europe than in the US. A typical family on the US East Coast paid between US$30 and US$70 per month for water and sewer services in 2005 (DC WASA, 2005). In developing countries tariffs are usually much further from covering costs. Residential water bills for a typical consumption of 15 cubic meters per month vary between less than US$ 1 and US$ 12 per month (World Bank, 2006).

Table 2.4 shows the water and sewer tariff and house hold water consumption per person in different countries in the world. Table 2.3 shows per capita water consumption of different cities in Asia. A comparison has been made between the water tariffs and per capita consumption of the different cities with that of Dhaka city. The comparison will show in the Result and discussion chapter.

Table 2.3 Average per capita water consumption and Tariffs of different cities in Asia (ADB, 2004)

City	Per capita water consumption (LPCD)	Tariffs (US$/$m^3$)
Chengdu	138	0.14
Colombo	119	0.22
Delhi	110	0.07
Ho ChiMinh	167	0.18
Hong Kong	187	0.35
Jakarta	77	0.29
Karachi	197	0.07
Kathmandu	68	0.09
Kuala Lumpur	132	0.3
Manila	127	0.14
Osaka	263	1.37
Phnom Penh	104	0.24
Seoul	205	0.49
Shanghai	251	0.1
Tashkent	328	0.01
Ulaanbaatar	278	0.19
Vientiane	110	0.04

Table 2.4 Average tariffs ($/$m^3$) and water usages in some major countries (GWI, 2009)

Country	**Combined Tariff in $/$m^3$**	**Water Tariff in $/$m^3$**	**Sewerage Tariff in $/$m^3$**	**Domestics Uses LPCD**
Denmark	8.83	8.83	0	114
Germany	4.87	3.12	1.75	151
France	4.24	3.58	0.66	232
United States	2.45	1.03	1.42	616
Spain	2.33	1.22	1.11	342
Japan	2.14	1.19	0.95	373
Portugal	1.85	1.31	0.54	308
Turkey	1.67	1.28	0.39	238
Italy	1.15	0.59	0.56	483
South Korea	0.65	0.49	0.16	552
Mexico	0.58	0.48	0.1	300

Figure 2.9 shows that the higher the water prices lower the water consumption for domestic's purposes. Thus the water use efficiency is directly proportional to the prices charged for water servicing. Rising prices lead to increasing attention to water use characteristics, and, over the long run, to more conservative use of water. In other words, rising prices generate powerful incentives for increasing water conservation.

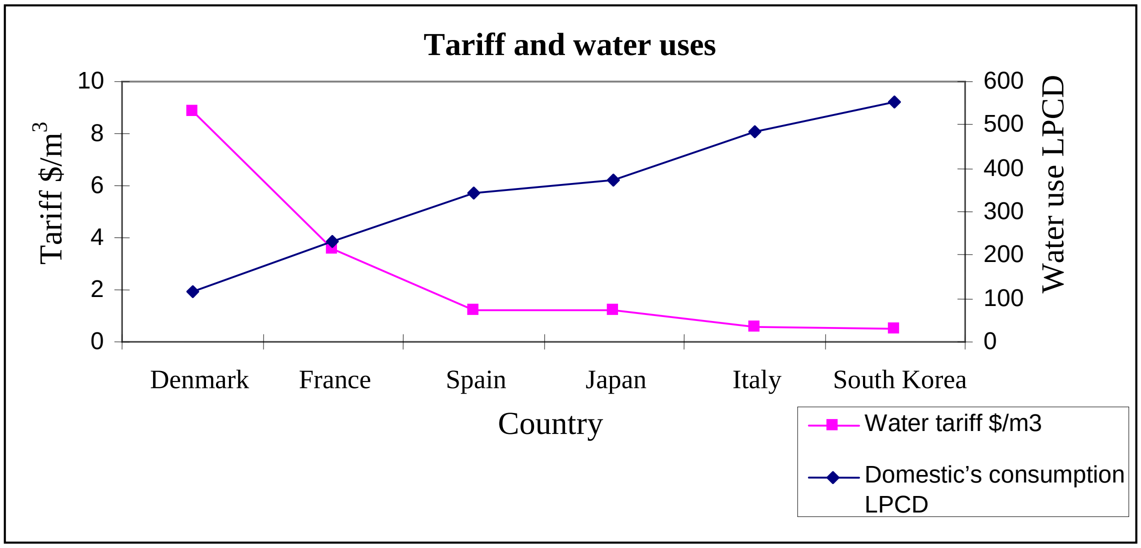

Fig. 2.9 Tariffs and domestics water uses of the different countries in the world

2.7 Present Water Crisis Situation in Dhaka City

During every dry season from (March to June) Dhaka City dwellers suffer from an acute water crisis. In many parts of the city people get sticky and straw colored water from the DWASA supply line. Such contaminated water, which causes many water-born diseases, is a public health disaster.

The city's northern parts are the most affected. People living in Gulshan, Niketan, Mirpur, Mohammadpur, Shyamoli, Dhanmondi, Jhigatola, Panthopath and others are facing an acute water crisis. Meanwhile, apart from the actual shortage of water that everyone is facing, people living in the middle part of Dhaka and in Old Dhaka such as Rampura, Madhubagh, Paltan, Karwan Bazar, Malibagh, Wari, Lalbagh and others have to bear with an added menace - water that is sticky and foul smelling. It's not that DWASA isn't trying to ease the crisis but so far all it has been able to achieve is the fury of most of Dhaka's 12 million residents (Paul, 2009) who have to live day after day with little or no water. It's not just the middle income groups and poor who are suffering; an acute water crisis is making life in the pushiest areas a living hell.

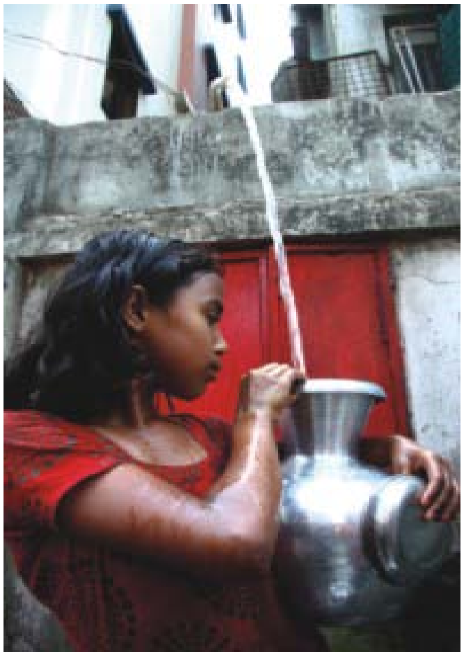

Fig. 2.10 People are flocking to collect water wherever available.

Sometimes for the two months residents of some apartment building have been collectively buy water from DWASA. The share of water that the people get each day is too little to lead their normal household activities. Some times after completing their daily chores they have to go to some relatives' house to take a shower. Long lines of parched residents waiting with buckets or other containers in front of a DWASA truck has become a too familiar scene for Dhaka dwellers who has to wait at least for two hours in a long queue to collect water from the DWASA lorry (Figure 2.11). The situation deteriorates further when DWASA officials of Zones sometimes refuse to sell emergency water.

Fig. 2.11 waiting with containers in front of a DWASA lorry - a familiar scene in many parts of the city

Moreover the cost of vehicle supplied water is more than the supplied normal rate. This is not affordable for every resident in the city. In crisis moment people will not get water even though they want to pay more money for that. As DWASA have not enough vehicles support to supply the water to its excess people.

Similar ordeals occur in most parts of the city. People get a little water only for 15 to 20 minutes after midnight. But some people mostly the residents of the apartments store their huge reservoirs with powerful illegal lift pumps. As a result general people don't get water normally. People even spend sleepless nights collecting a little water from the supply line to be used the following day.

2.8 Basic Water Requirements for Human Activities

People need water for drinking as well as other purpose such as bathing, toilet, hand washing (faucets), dish washing and laundry. Beside this other domestics areas for water demand are in car washing, gardening, building construction and other developments works. Usually water in a society is also used for other purposes rather than domestic uses such as industrial use, commercial use, public uses, and livestock etc. Many studies have been made to find out the basic or minimum water requirements for a human being to fulfill their domestic's needs.

A "minimum" must also be defined for providing sanitation services. There is a direct link between the provision of clean water, adequate sanitation services, and improved health. Basic water requirement for sanitation is not identified. A minimum of 20 liters per person per day was recommended to account for the maximum benefits of combining waste disposal and related hygiene, and to permit for cultural and societal preferences (Gleick, 1996: Esrey and Habicht, 1986). Table 2.5 shows the minimum water requirement for different types of toilet recommended by different studies

Table 2.5 Minimum water requirement for sanitation activities (Kalbermatten et al, 1982 and Yolles, 1993)

Sanitation Technology	**Minimum Water requirement**
Pit latrine	1 to 2 liters/flush
Pour/Flush (PF) toilets	6 to 10 liters/person/day
Vault toilets and cartage	3 to 6 liters/person/day
PF toilets/septic tanks	7.5 liters/person/day

Beside the sanitation requirements, additional domestic water is used for showering or bathing. A review of a range of studies in North America and Europe suggests average (not minimum) water use in industrialized nations for bathing to be about 70 liters per person per day, with a range from 45 to 100 LPCD (Gleick, 1996). Data on water used for bathing in developing countries or in regions with no piped water are not widely available. Some studies suggest that minimum water needed for adequate bathing is on the order of 5 to 15 LPCD and that required for showering is 15 to 25 LPCD

(Kalbermatten et al, 1982). There are many other human uses of water in domestic level. The recommended basic need for water in domestic purpose is shown in Table 2.6

Table 2.6 Recommended basic water requirements for human needs in domestic's level (Gleick, 1996)

Purpose	**Recommended Minimum (LPCD)**
Drinking Water	5 (1.1 GPCD)
Sanitation Services	20 (4.4 GPCD)
Bathing	15 (3.3 GPCD)
Cooking and Kitchen	10 (2.2 GPCD)
Total Recommended Basic Water Requirement	50 (11GPCD)

Note: 1 GPCD= 4.55 Liter

Moreover the water required for each of these activities varies with climatic conditions, lifestyle, culture, tradition, diet, technology and so on. The factors influencing the water consumption in a community are described in below:

Climatic Condition: Seasonal variation in public water supply can be as important a factor as the total volume used over a year. When the climate has little variation over a year, seasonal variations in use generally are minimal. But in areas of strong climatic seasonal variation, the volume of use during the summer months can be an order of magnitude or higher than the volume of use during the winter months.

Water user type in a community: The water requirement is greatly influenced by the population in a community in age groups, sex, socio-economic conditions, profession, and religious practices.

Quality of water: Good quality water has the higher demand for all domestic purposes rather than bad quality water.

Water Rates and metering: High cost of water tariff makes people more conservative in water use. Same as metered consumers use less amount of water than non- metered consumers.

Toilet Type: The quantity of water needed for toilet purpose depend on type of toilet. The water requirement is minimal for traditional pit latrine and water requirement increase for flashing system latrines.

The per capita water requirement is greatly influenced by various user types such as age group, religion, sex, socio- economic condition, profession etc. Per capita consumption for all these type of user is not identical. Water use greatly influenced by the occupation of uses. In the rural area of Bangladesh the water requirement for various house hold purposes has been estimated as follow

Table 2.7 water requirement in house hold activities ((Ahmed and Rahman, 2000)

Item	**Water requirement LPCD**
Drinking	4-5
Washing Cloth	8-10
Washing Utensils	6-8
Cooking	6-8
Bathing	14-20
Toilet Use & Hand wash	10-12
Others	9-14
Total 67 LPCD or 15 GPCD (1Gallon=4.55 Liter)	

Usually in city area more water is used for some other purpose rather than rural area. Beside this industrial and commercial organization exert a significant demand on water supply.

2.9 Conservative Use of Water

There is a worsening trend in water supply in Dhaka city. Water conservation represents one of the most important pro-ecological activities to be modeled and developed for a sustainable way of life on this planet (Corral-Verdugo et al., 2002). According to experts, the problem of scarcity and poor quality of water for human consumption is one of the main environmental challenges to be faced by humanity in the 21st century (Brown and Flavin, 1999).Conservative use of water refers to reducing the usages of water and recycling for different purpose such as cleaning, toilet flushing, manufacturing and agricultural irrigation.

2.9.1 Definition of water conservation

Water conservation can be defined as:

i) Any beneficial reduction in water loss, use or waste. (EPA, 2010)

ii) A reduction in water use accomplished by implementation of water conservation or water efficiency measures; or,

iii) Improved water management practices that reduce or enhance the beneficial use of water (Vickers, 2001, Geerts and Raes, 2009). A water conservation measure is an action, behavioral change, device, technology, or improved design or process implemented to reduce water loss, waste, or use. Water efficiency is a tool of water conservation. That results in more efficient water use and thus reduces water demand. The value and cost-effectiveness of a water efficiency measure must be evaluated in relation to its effects on the use and cost of other natural resources (e.g. energy or chemicals) [Vickers, A., 2001].

2.9.2 Definition of water use efficiency

Water use efficiency includes any measure that reduces the amount of water used per unit of any given activity, consistent with the maintenance or enhancement of water quality (Chamak and Riza, 2005).Water efficiency can be defined as:

i) The accomplishment of a function, task, process, or result with the minimal amount of water feasible (Vickers, 2001).

ii) An indicator of the relationship between the amount of water required for a particular purpose and the amount of water used or delivered (Vickers, 2001).

iii) Water use efficiency is closely related to, and in several cases overlaps, other basic concepts of current environmental resource management (Kanber et al, 2004). The best established of these related concepts, perhaps, is water conservation. The latter term has received many definitions in the past, but perhaps the definition used by Baumann et al. (1979) is most useful, namely, that water conservation is any socially beneficial reduction in water use or water loss. Put in this manner, water use efficiency is of central importance to conservation. At the same time, the conservation definition suggests that efficiency measures should, in addition to reducing water use per unit of activity, make sense economically and socially (Gleick et al., 2003).

Finally, for the sustainable development of the present water resources, conservative use of water can play an effective function. Thus the present inhabitants should keep in mind the conservative use of water for that the future generations have sufficient water to meet their demand. Improving the efficiency of resource use comprises one means of meeting sustainable development goals.

2.9.3 Objective of water conservation

i) To ensure availability for future generations, the withdrawal of fresh water from an ecosystem should not exceed its natural replacement rate (Daniel, 2009)

ii) To save the energy. Water pumping, delivery, and wastewater treatment facilities consume a significant amount of energy. In some regions of the world like example, California (California Energy Commission, 2005) over 15% of total electricity consumption is devoted to water management.

iii) To minimizing human water use helps to preserve fresh water habitats for local wildlife and migrating waterfowl, as well as reducing the need to build new dams and other water diversion infrastructure (Rubenstein, 2008).

2.9.4 Importance of water conservation

The importance of efficiency in water use or water conservation clearly varies across regions and nations, as well as through time. According to the Second UN World Water Development Report, 2006, if present levels of consumption continue, two-thirds of the global population will live in areas of water stress by 2025. Increasing human demand for water coupled with the effects of climate change mean that the future of our water supply is not secure. As of now, 2.6 billion people do not have safe drinking water. Added to this, are the changes in climate, population growth and lifestyles. The changes in human lifestyle and activities require more water per capita. This tightens the competition for water amongst agricultural, industrial, and human consumption. (WWC, 2010)

Geographically, for instance, water availability will condition the manner in which use patterns develop. Other things being equal, arid and semi-arid regions require a greater efficiency of water use than humid ones. But simple geographical patterns mask several equally important factors.

Economic conditions will often lead to greater or lesser water use efficiency. Many regions in the world have been assisted in their development through public financing of water development. While the benefits or costs of such projects in efficiency terms are often debatable, the main point here is that economic factors can influence water use efficiency. Further, in some cases, where water developments have supported new settlements in dry areas, industrial processes and technologies that use water more efficiently than elsewhere may develop. An example would be the development of recirculation technologies or process changes.

Social conditions may also be important in examining the conservative use of water resources. The literature reveals many areas where public education has led to conservation and better use of available water supplies.

Reducing the use of water will decrease water pollution, increase energy savings, and create more efficient use of our water resources. Too much water in an on-site sewage treatment system can flush untreated material through before organisms have a chance to break it down. If untreated material gets to the drain field, the material can plug up the soil within the drain field and shorten the life of the septic system.

The foregoing discussion indicates that an examination of water conservation or water efficiency requires a multi-dimensional approach. In addition to the physical elements, social, economic and environmental factors are also important.

2.9.5 Considerable Issue for Water Conservation

In adopting new strategies for water management, a central issue concerns effective evaluative procedures. In the definition of water conservation given earlier, two criteria have suggested that the methods adopted must reduce water use or consumption and must also be socially beneficial in the benefit-cost sense. The following criteria, which is based upon Herrington's work for the Organization for Economic Co-operation and Development (OECD, 1987), examines these and other evaluation criteria that can be used in assessing various water demand management measures.

2.9.5.1 Technical consideration

Any method of increasing water use efficiency should be subjected to a technical evaluation in order to obtain an estimate of the actual reduction in water demand or discharge resulting from using the method. In other words, will the proposed modification, in fact, reduce water usage.

Technical evaluations may involve the concept of "engineering efficiency", which basically measures the ratio between water pumped into a system and water delivered to consumers or end users. However, economic and environmental factors may also be involved. "Thus technical effectiveness may in one sense be subsumed under the economic and environmental criteria. But it is probably still worth separating out the technical criterion, since a proposed measure may sometimes be abandoned without proceeding to the economic calculations" (OECD, 1987). In addition, consumer acceptance and political factors may comprise other factors for consideration in a technical analysis.

2.9.5.2 Economic consideration

From the policy viewpoint, where water development costs and competition for available capital are rising, the concept of engineering efficiency is limited by its inability to address the value of any specific use of water (e.g. for in-house residential use) in relation to alternative uses for the same water (e.g. lawn watering or industrial use). An exclusive emphasis on improving the engineering efficiency of a given water use, therefore, may lead to unproductive expenditures if the value of that use is less than the value of some other use of the same water.

The second part of the water conservation definition given earlier highlights a second type of efficiency concept. When prices reflect the value of resources used in production and demanded by consumers, an "economically efficient" allocation of resources is said to occur. Economic or allocative efficiency addresses the value of scarce resources available to society. Thus, concern with the economic efficiency of water use creates a concern about net values of water in alternative uses and whether existing institutions are flexible enough to permit the allocation of existing supplies in such a way that society as a whole derives maximum value from those supplies. The achievement of economic efficiency would form a rational prerequisite for the development of new supplies. In practical terms, increasing the economic efficiency with which existing water is allocated can mean increased incomes and jobs, as well as improvements in the quality of life. The achievement of economic efficiency in resource use is a major economic policy aim, for it means that the economy is approaching maximum productivity in the context of available resources.

2.9.5.3 Financial consideration

Financial analysis is conducted principally on the basis of cash flows. From a financial point of view, a particular project would be considered feasible only if the rate of return of the project in terms of the investment exceeded or equaled the opportunity cost of the capital as reflected by interest rates. Financial appraisals must have a positive net present value, that is, the present value of all future cash flows. The rate of return should be greater than the cost of the capital.

2.9.5.4 Social / Political / Institutional consideration

Social/political/institutional appraisals focus on the balance between various sectors in society, with resource allocations going to the most powerful group. In the water demand context, this type of evaluation might tend to discourage such measures as higher water pricing. For example, a recent study of municipal water pricing (Tate, 1989) found that "political acceptability" was probably the most important criterion in setting water rates.

One important issue in evaluating efficient water use relates to the equity implied by a prospective action. Equity concerns the achievement of a desirable distribution of income among the participants in society. The equity of any management action is difficult to address because no single criterion has been developed to assess the degree to which a given action is equitable. What can be shown, however, is how existing practices are inequitable and how demand management moves toward achieving greater equity. The fact that many municipalities practice flat-rate water pricing is instructive in this regard.

On the surface, and certainly at the political level, flat rates appear to epitomize equity. Each residential customer, for example, pays the same amount for water. This stance, however, completely ignores the fact that some customers may use significantly more water than others and, therefore, place heavier burdens on the system. Industrial usage, priced the same way, is subsidized to an even greater extent. The large water users determine the size of the water system required in the municipality, and thus systems tend to be oversized (and more costly) just to meet the needs of a few. Thus an apparently equitable system is actually inequitable. The same type of reasoning can be applied to other aspects of water use, for example, indiscriminate waste discharge into watercourses. In a sense, many of the points made in this section reiterate the earlier discussions. However, it is important to bear in mind that steps taken toward improving water use efficiency must be formally evaluated against multiple criteria.

2.9.6 Water Conservation Practices

Water users can be divided into two basic groups: system users (such as residential users, industries, and farmers) and system operators (such as municipalities, state and local governments, and privately owned suppliers). These users can choose from among many different water uses efficiency practices, which fall into two categories:

1. Engineering practices**:** practices based on modifications in plumbing, fixtures, or water supply operating procedures
2. Behavioral practices: practices based on changing water use habits

The practices have been evaluated by many researchers, and there is a growing body of literature that presents the results of many studies related to water use efficiency.

2.9.6.1 Practices for residential user

The use of water saving devices is effective in reducing the water conservation (Geller et al, 1983). The following sections present examples of conservation and water use efficiency practices that can benefit residential users. Both engineering and behavioral practices are described.

2.9.6.1.1 Engineering practices

Plumbing

An engineering practice for individual residential water users is the installation of indoor plumbing fixtures that save water or the replacement of existing plumbing equipment with equipment that uses less water. Low-flow plumbing fixtures and retrofit programs are permanent, one-time conservation measures that can be implemented automatically with little or no additional cost over their life times (Jensen, 1991). In some cases, people can even save the resident money over the long term.

The City of Corpus Christi, for example, has estimated that an average three-member household can reduce its water use by 54,000 gallons annually and can lower water bills by about $60 per year if water-efficient plumbing fixtures are used (Jensen, 1991).

Low-flush toilets

Residential demands account for about three-fourths of the total urban water demand. Indoor use accounts for roughly 60 percent of all residential use, and of this, toilets (at 3.5 gallons per flush) use nearly 40 percent. Toilets, showers, and faucets combined represent two-thirds of all indoor water use. The average American uses about 9,000 gallons of water to flush 230 gallons of waste down the toilet per year (Jensen, 1991). In new construction and building rehabilitation or remodeling there is a great potential to reduce water consumption by installing low-flush toilets.

Water-efficient toilets have evolved over the past 30 years, with much of the pioneering work occurring in the early 1970s. Many innovations have been introduced, including toilets with two flush volumes (one for liquid and one for solid wastes) and models that incorporate water pressure in the service line to flush. The ultra-low flush models of today retain the basic design of the gravity-flush toilet. They look similar to conventional models, but use 1.33 Gallon (1.6 US gallons) of water per flush versus the 2.5-4.25 (Mayer et al., 1999) gal per flush (3–5 US gallons) of older models as shown in Figure 2.12. These low-flush toilets are required in new construction (William and Bryan, 2008).

Fig. 2.12 Low-flush toilets, like the 1.33 (US1.6 gpf) model pictured below, are required in all new construction

Toilet flushing with basin or upper flat bathroom water delivered to lower flat toilet flashing (Jeppesen, 1996). One may recycle grey water at home by putting a bucket in the shower or sink or fitting the basin at the upper portion of the toilet flashing and using that water to flush the toilet as shown in Figure 2.13. Poor quality grey water is not a problem if it is used to flush toilets, because the water goes into the sewer or septic system where it would have gone had it not been reused . Figure 2.13 shows such type of toilet configuration with basin in the upper portion. This practice will save water about 6 GPCD from the daily household requirements.

Fig. 2.13 The cistern of this toilet is filled by grey water from the sink above it.

Toilet displacement devices

Plastic containers (such as plastic milk jugs) can be filled with water or pebbles and placed in a toilet tank to reduce the amount of water used per flush. By placing one to three such containers in the tank (making sure that they do not interfere with the flushing mechanisms or the flow of water), more than l gallon of water can be saved per flush. A toilet dam, which holds back a reservoir of water when the toilet is flushed, can also be used instead of a plastic container to save water. Toilet dams result in a savings of 1 to 2 gallons of water per flush (USEPA, l991b).

Air-Assisted toilet

Air-assisted toilets, which require compressed air for waste removal, have been used for many years where minimal water use or waste flow reduction is at a premium. Airplane toilet facilities are a prime example (Figure 2.14). Use of these toilets in homes is less widespread because of the need for air lines, a compressor, and the higher initial costs of air-assisted units. However, domestic use of air-assisted toilets at present water and sewer rates can be cost-effective. Increased education and marketing efforts may result in wider adoption of these highly efficient toilets. Water use per flush is only 0.5 gallons, roughly one-third of the volume of the low-flush toilets. With proper maintenance, air-assisted models remain serviceable for many years and more than return their significantly higher costs. Installing air-assisted toilets is more involved, but not difficult. A small, ¼-horsepower compressor, with an air line to each toilet, must be located in your home's garage, basement, or utility closet. Approximately 20 flushes may be made before the compressor cycles on; noise is not usually an issue. More than one toilet can be operated with the same compressor. Air-assisted toilets use only 0.5 gallons per flush. (William and Bryan, 2008)

Fig. 2.14 Air-assisted toilet

Low-flow showerheads

Showers account for about 20 percent of total indoor water use. By replacing standard showerheads with low gallon-per-minute heads, which cost less than $5 each, a family of four can save approximately 20,000 gallons of water per year (Jensen, 1991). Although individual preferences determine optimal shower flow rates, properly designed low-flow showerheads are available to provide the quality of service found in higher-volume models.

Conventional showerheads typically deliver 2.5-4.15 (3–5 US) (Mayer et al., 1999). gallons of water per minute. Conservation is accomplished by restricting water's flow rate through the showerhead. Showerheads with reduced flows as low as 1.67 (2 US gallons) gallons per minute (gpm) (Figure 2.15), at normal household water pressure, have been designed to give an acceptable shower and reduce water use. (William and Bryan, 2008) They can be sensitive to low water pressure and sudden changes in temperature; consequently, proper pressure-balanced mixing valves are necessary. Exiting water temperatures normally need to be slightly higher because the smaller droplets cool quickly. Slightly hotter water does not negate the substantial energy savings achieved by low-flow showerheads.

Fig. 2.15 Low volume shower head

Faucet aerators

Faucet aerators, which break the flowing water into fine droplets and entrain air while maintaining wetting effectiveness, are inexpensive devices that can be installed in sinks to reduce water use. Aerators can be easily installed and can reduce the water use at a faucet by as much as 60 percent while still maintaining a strong flow. More efficient kitchen and bathroom faucets that use only 2 gallons of water per minute--unlike standard faucets, which use 3 to 5 gallons per minute--are also available (Jensen, 1991).

Most faucets deliver 2.5-4.15 (3–5 US) gallons of water per minute. Like showerheads, restricting a faucet's flow rate can save water. Where faucets are operated continuously, as in washing operations, significant savings are possible. Residential, low-volume faucets typically produce 1.25-2.1gpm (1.5–2.5 US gpm) (Figure 2.16) (William and Bryan, 2008). In institutional settings, flow-restricted faucets with spray heads that turn off automatically are increasingly used. When combined with point-of-use water heating, significant energy savings are possible in addition to reduced water use. Maintenance is required to prevent water loss from malfunctioning units

Fig. 2.16 Low volume faucets

Automatic Dishwashers

Automatic dishwashers have relieved people of this unpleasant mealtime chore; however, they use large amounts of water. If dishwashers are fully loaded for each use, water can be saved. Newer, more efficient models may use as little as 3.75 gpl (4.5 US gpl). However, old dishwashers require 5-5.8 gpl (6-7 US gpl) (William and Bryan, 2008).

Pressure reduction

Because flow rate is related to pressure, the maximum water flow from a fixture operating on a fixed setting can be reduced if the water pressure is reduced. For example, a reduction in pressure from 100 pounds per square inch to 50 psi at an outlet can result in a water flow reduction of about one-third (Brown and Caldwell, 1984).

Homeowners can reduce the water pressure in a home by installing pressure-reducing valves. The use of such valves might be one way to decrease water consumption in homes that are served by municipal water systems. For homes served by wells, reducing the system pressure can save both water and energy. Many water use fixtures in a home, however, such as washing machines and toilets, operate on a controlled amount of water, so a reduction in water pressure would have little effect on water use at those locations.

A reduction in water pressure can save water in other ways: it can reduce the likelihood of leaking water pipes, leaking water heaters, and dripping faucets. It can also help reduce dishwasher and washing machine noise and breakdowns in a plumbing system. A study in Denver, Colorado, illustrates the effect of water pressure on water savings. Water use in homes was compared among different water pressure zones throughout the city. Elevation of a home with respect to the elevation of a pumping station and the proximity of the home to the pumping station determine the pressure of water delivered to each home. Homes with high water pressure were compared to homes with low water pressure. An annual water savings of about 6 percent was shown for homes that received water service at lower pressures when compared to homes that received water services at higher pressures.

2.9.6.1.2 Behavioral practices

Behavioral practices involve changing water use habits so that water is used more efficiently, thus reducing the overall water consumption in a home. These practices require a change in behavior, not modifications in the existing plumbing or fixtures in a home. People's abilities for saving water are indicators of conservation competency, a factor directly influencing water conservation behavior (Corral-Verdugo, 2002). Behavioral practices for residential water users can be applied both indoors in the kitchen, bathroom, and laundry room and outdoors.

In the kitchen, for example, 10 to 20 gallons of water a day can be saved by running the dishwasher only when it is full. If dishes are washed by hand, water can be saved by filling the sink or a dishpan with water rather than running the water continuously. An open conventional faucet lets about 5 gallons of water flow every 2 minutes (Florida Commission, 1990).

Water can be saved in the bathroom by turning off the faucet while brushing teeth or shaving. Water can be saved by taking short showers rather than long showers or baths and turning the water off while soaping. This water savings can be increased even further by installing low-flow showerheads, as discussed earlier. Toilets should be used only to carry away sanitary waste. Households with lead-based solder in pipes that flush the first several gallons of water should collect this water for alternative non potable uses (e.g., plant watering).

Water can be saved in the laundry room by adjusting water levels in the washing machine to match the size of the load. If the washing machine does not have a variable load control, water can be saved by running the machine only when it is full. If washing is done by hand, the water should not be left running. A laundry tub should be filled with water, and the wash and rinse water should be reused as much as possible.

Outdoor water use can be reduced by watering the lawn early in the morning or late in the evening and on cooler days, when possible, to reduce evaporation. Allowing the grass to grow slightly taller will reduce water loss by providing more ground shade for the roots and by promoting water retention in the soil. Growing plants that are suited to the area ("indigenous" plants) can save more than 50 percent of the water normally used to care for outdoor plants.

As much as 150 gallons of water can be saved when washing a car by turning the hose off between rinses. The car should be washed on the lawn if possible to reduce runoff.

Additional savings of water can result from sweeping sidewalks and driveways instead of hosing them down. Washing a sidewalk or driveway with a hose uses about 50 gallons of water every 5 minutes (Florida Commission, 1990). If a home has an outdoor pool, water can be saved by covering the pool when it is not in use.

2.9.6.2 Practices for system operator

2.9.6.2.1 Engineering practices

Metering

The measurement of water use with a meter provides essential data for charging fees based on actual customer use. Billing customers based on their actual water use has been found to contribute directly to water conservation. Meters also aid in detecting leaks throughout a water system. In 1977, for example, Boston, Massachusetts, could not account for the use of 50 percent of the water in its municipal water system. After installing meters, the city identified leaks and undertook a vigorous leak detection program (Grisham and Fleming, 1989). Unaccounted-for water dropped to 36 percent after metering and leak detection programs were started.

Sub metering

Sub metering is used in units such as apartments, condominiums, and trailer homes to indicate water use by those individual units; the entire complex of units is metered by the main supplier. Sub metering of water use in apartment or business complexes makes it possible to bill tenants for the water that they actually use rather than for a percentage of the total water use for the complex. Sub metering makes water users more aware of how much water they use and its cost, and tenants who conserve water can benefit from lower water use costs. Sub metering is reported to reduce water usage by 20 to 40 percent (Rathnau, 1991).

Leak detection

One way to detect leaks is to use listening equipment to survey the distribution system, identify leak sounds, and pinpoint the exact locations of hidden underground leaks. As mentioned in the previous section, metering can also be used to help detect leaks in a system.

An effective way to conserve water is to detect and repair leaks in municipal water systems. Repairing leaks controls the loss of water that water agencies have paid to obtain, treat, and pressurize. The early detection of leaks also reduces the chances that leaks will cause major property damage. When water leaks from a system before it reaches the consumer, water agencies lose revenue and incur unnecessary costs. Such costs should provide an incentive for system operators to implement a leak detection program.

Programs for finding and repairing leaks in water mains and laterals (conduits) might be cost-effective in spite of their high initial costs. Leak detection programs have been especially important in cities that have large, old, deteriorating systems (RMI, 1991).

Water pricing

Water prices are the major means of efficient use of water and the prime requirement for the promotion of such use is full-cost prices. In practice, however, water prices seem to be lagging behind full costs in the majority of cities in both developed and developing countries (OECD, 1998; Pearce, 1999; Dalhuisen et al, 2003; Bithas, 2006).The under pricing, non-metering and increasing block rates are the enemy of the water conservation. Low price of water behind full costs induces overuse and misallocation of water. Furthermore, both non-metering and increasing block rates, besides reducing efficiency, inhibit the pursuit of social equity in the long run. It is in this context that the appealing cause of setting prices that lag behind full costs – also known as egalitarian pricing since it presumably ensures sufficient provision of water for low-income households – is evaluated. When prices are appropriately set so as to approach full costs, equity will improve in the long run as well.

Water reuse

Another practice that should be considered by water system operators who operate publicly owned treatment works is the reuse of treated wastewater. Wastewater and grey water (GW) recycling are emerging as integral parts of water demand management, promoting the preservation of high quality fresh water as well as reducing pollutants in the environment and reducing overall supply costs (Odeh, 2003) GW represents the largest potential source of water savings in domestic residence. For example, the reuse of domestic GW for landscape irrigation makes a significant contribution towards the reduction of potable water use. In Arizona, for example, it is documented that an average household can generate about 30,000 to 40,000 gallons of GW per year [Website: http://www.watercasa.org/pubslgraywaterguidelines. html.].

2.10 Reuse of Waste (grey) Water

Historically, domestic grey water reuse was practiced to conserve water. However, social and economic constraints prevented its further development and integration in the urban water systems (Surrendran et al., 1998). This is no longer the case because the water shortage problem is obvious and treatment technology has evolved tremendously. It is likely that new innovations in water management will eventually lead to substantial changes in lifestyle, particularly if the use of water as a transport medium for our domestic waste is reduced or eliminated (Niemczynowicz, 1995). Therefore, the anticipated benefits of reuse and recycling should not be under estimated. The interest in the reuse of water is increasing due to several factors. One is the water shortage due to low amounts of rainfall along with high evaporation rates, which is the case in countries like Australia (Eriksson et al., 2002). The ground water declination and surface water pollution due to rapid urbanization is another reason for water shortage like Dhaka, Bangladesh (DWASA, IWM, and IRIN, 2009). Another reason can be high water demands from the size of the population, which is the case in countries like Japan (Eriksson et al., 2002), Dhaka, Bangladesh (DWASA, 2003, Unnayan Shamannay, 2004). A third reason can be the environmental and economical considerations behind the reuse process. Living in a remote area where wastewater collection or potable water network are not available can be a fourth reason. This is one of the cases where the use of gray water becomes of significant value.

But people should know what types of waste water dispose from the house hold activities and from that waste water which type of water can be reuse. There could be many different types of waste water, which can be classified in different ways. Again such classification may vary from country to country. In general waste water from house hold can be classified depending on the source of generation as black water and grey water.

2.10.1 Black water

The water that comes from toilets and must be flushed straight to the sewer is known as Black water. Black water indicates it contains fecal matter and urine. It is not so easy to recycle for further use and need more complex treatment process to use this type of water. (Hunt, 2007)

2.10.2 Grey water

Gray water is the untreated household wastewater which has not come into contact with toilet wastes. “Gray water includes used water from bathtubs, showers, bathroom, washbasins, and water from clothes washing machines and laundry tubs. It shall not include waste water from kitchen sinks or dishwashers (Alkhatib and Edgerly, 2004). In other words Grey water comprises 50-80% of residential wastewater generated from all of the house's sanitation equipment except for the toilets (Grey water wikipedia August 2010). Some grey water (from kitchen sinks) isn't easily recyclable because of the content of the water. Grey water that is easily recyclable (from bathtubs, showers and bathroom sinks) is relatively clean. Therefore it requires very little treatment before it can be reused for non-potable purposes (Hunt, 2007)

2.10.3 Grey water quantity

Each household produces significant amounts of gray water. Different studies have been conducted to find the quantities of grey water generated from a household. Such a study conducted by the American Water Works Association entitled as “Residential End Uses of Water”. According to them the gray water quantity from a house ranged from 33 to 45 GPCD which averaged at 38 GPCD (Alkhatib and Edgerly, 2004). This number constitutes about 56% of the total indoor use and about 23% of the total water consumption in a household. Other studies have different numbers ranges for grey water quantities. Another report produced by the City of Los Angeles (City of LA, 1992) revealed that if the total available gray water is used in a household, the amount of water savings would be approximately 50 percent. This number was estimated from eight gray water sites in which the potential demand for gray water used ranged from 13 to 65 percent. (Alkhatib and Edgerly, 2004)

2.10.4 Use of reclaimed (grey water) water

Reclaimed water can be used in many purposes: Such as

Urban reuse: Irrigation of park/garden, highway medians beautification maintenance, plays ground like golf courses etc.

Domestic or commercial reuse: Vehicle washing, windows washing, fire protection, dust control, concrete production, toilet flashing etc.

Industrial reuse: Cooling water, boiler make up water, industrial process water.

The reclaimed (Grey Water) water can be reusing more other purpose such as Ground water recharge, Agricultural reuse, Environmental and recreational purpose (To create wetland, recreational and aesthetic impoundments).

2.10.5 Benefits of using reclaimed water

Despite the fact that the earth consists of 70% water, only 2.5% of it is freshwater and only 0.3% of that freshwater is readily available to us (Greeniac24, 2010). According to UNESCO, by 2050 it is probable that 1 in 4 people will live in a country that experiences freshwater shortages. It will become very complex situation if people will not use other water sources except ground and surface water.

Reuse of water, especially domestically, reduces demand on conventional water supplies and pressure on sewage treatment systems, which is very beneficial to local waterways. The potential ecological benefits of conservative use of water includes

1. Lower fresh water extraction from rivers and aquifers
2. Less impact from septic tank and treatment plant infrastructure
4. Reduced energy use and chemical pollution from treatment
5. Groundwater recharge
6. Increased plant growth as greywater may contain detergents with nitrogen and phosphate

2.10.6 International experience of grey water reuse

On the global scene, Japan, the US and Australia maintain the highest profile in GW reuse (Mustow et al., 1997). Other countries involved in active grey water research and applications include Canada, the UK, Germany and Sweden (Asano, 1996 and Waller et al., 1996). On the regulatory and legal arena, grey water reuse has gained a degree of acceptance in the US and Australia. This is evident in the California Pumping Code and in the Australian general guidelines for domestic grey water reuse (Mustow et al., 1997). At the regional level, Saudi Arabia, Cyprus, and Jordan have introduced GW systems to optimize water use. However, guidelines and technical specifications are still underway. It should be noted that each country has a different reason for the adoption of grey water reuse. For example, the Japanese reuse initiative is driven by the demands of a high population density and small land space, while the US, Australian, Saudi Arabian and Jordanian initiatives are a direct response to drought conditions and the unregulated uptake of domestic grey water reuse for garden irrigation. Following successful operation of these systems and achievement of the set criteria, guidelines for service water reuse were then first introduced in Germany in 1995 on a local level by the Berlin Senate Department for Building and Housing. The main use for GW in Germany is for toilet flushing, irrigation and garden plants. In terms of In Tokyo, Japan, the reuse of treated wastewater has been highly promoted. In industrial countries like Germany and Japan, GW is used for toilet flushing. This is justified based on the fact that the cumulative flow balance between the grey water generated and toilet flushing requirements shows a natural affinity at about 30% of the total water use (Jefferson et al., 1999 and Edwards et al, 1995 and Burton, 1997). On the other hand, in Western Australia, five particular methods were being tested by the Institute for Environmental Science at Murdoch University to achieve fully integrated perm culture development (Beder, 1993). Model guidelines for domestic grey water reuse in Australia have also been prepared (Jeppeson, 1996; Anda et al, 1996). These covered hand basin toilets, primary grey water systems (direct subsurface application) and secondary grey water systems (mesh, membrane or sand filtration).

2.10.7 Treatment of grey water

Water from recycling system should fulfill four criteria: hygienic safety, aesthetics, environmental tolerance and technical and economical feasibility (Odeh, 2003). Treatment must be sufficient to ensure proper operation and longevity of the plumbing fixtures. All equipment and components in a gray water system should be certified by the manufacturer for use with waste water. A number of methods of treating gray water are available, although the type of treatment required should be determined by the quality of the incoming gray water, what the end use will be, and the degree of maintenance desired by the system user. In all cases, the treatment must include filtration, disinfection, and dyeing of the treated gray water.

CHAPTER THREE
METHODOLOGY AND DATA COLLOECTION

3.1 General

Determination of the water requirement for domestic purposes through survey questionnaire serves as the contribution of this Study. The main objective of the survey is to estimate the amount of water people require in different household activities (Bathing, drinking, toilet, faucets, washing, cooking etc). Specifically, this chapter aims to describe the methodology and data collection (1) to determine the present water supply condition of Dhaka city, (2) to obtain actual per capita water consumption by activity based on household water usage and (3) to investigate the attitudes and preferences of the residential water users of Dhaka city on water conservation. The Population data has been collected and analyzed to projects the future water crisis.

3.2 Present Water Supply Condition of Dhaka City

Basically the data of present water supply situation of Dhaka city was collected from the Dhaka Water and Sewerage Authority (DWASA). The water supply for the tube-wells of different zones and the different surface water treatment plants has been collected. Most of the information has been collected from different official records and report obtained from DWASA and informal discussion with DWASA staff. Additional information on zone wise water connections system, water distribution system, unaccounted for water, losses in the system were also collected. The aim is to show as possible as the actual quantities of water which are available in Dhaka city. The present water tariffs, DWASA vehicle water supply rate and bottle water rate has been collected from DWASA and bottle water supply dealer to estimate the amount of municipal water charges that can be saved for homeowners by savings the water. The energy consumption data (electricity bill with respect to water production) was collected for some of the Deep Tube Wells (DTWs) of DWASA. The data is to be used in estimating the electricity savings by water conservation practices. Population data has been collected and analyzed to projects the present and future water crisis.

3.2.1 Dhaka water supply

Dhaka Water and Sewerage Authority (DWASA) a government controlled service organization is solely responsible for providing water to the publics, industries, and commercial concern of Dhaka City. It is also responsible for disposal of sewage. DWASA divided the whole area in seven distinct zones for the convenience of water supply. Figure 3.1 shows the seven zones of DWASA.

Fig. 3.1 DWASA Water supply zones (DWASA, 2009)

DWASA's sewerage network covers only parts of the city. In addition some private agencies contribute some amount of water. At a glance water supply and category wise connection system in Dhaka city provided by DWASA is showing in the Table 3.1 and Table A2

Table 3.1 DWASA details (DWASA, 2008)

SL No	Items	Unit	Present DWASA Status
1	Water Line	Km	2533.73
2	Water Connection	Nos	255220
3	Daily Water production	MLD	1974.44
4	Deep Tub Wells in Operation	Nos	485
5	Deep Tube Wells of Other Agencies	Nos	1179
6	Over Head Tank in Operation	Nos	38
7	Water Treatment Plant	Nos	3
8	Public Stand pipes	Nos	1643
9	Sewer Connections	Nos	60158
10	Sewage Lift Station	Nos	29
11	Sewer Line	Km	881.02
12	Sewage Treatment Plant	Nos	1
13	Religious Institutions	Nos	1896
14	System Loss	%	34.82
15	Employee	Nos	3686

3.2.2 Water supply from different sources

As mentioned earlier the water supply in Dhaka city depends on the deep tube wells (DTWs) and surface water treatments plants.

3.2.2.1 Ground water extraction

The Dhaka water supply preliminary based on ground water source as good quality ground was available in an aquifer extending between 50 to 120m. DWASA depends on the DTWs for the extracting and supplying the water to the inhabitants. The different zones have different number of DTWs which are working. In present time, 485 DTWs are under operation in the Dhaka city which is controlled by DWASA. The number of DTWs in operation varies from month to month. Variations in water production from

DTWs are also observed throughout the year. Table A4 shows month-wise & zone- wise no of DTWs in operation. The capacity of different DTWs in different year has been shown in the Table A5, and Table A6 and actual production of the water in the year under the report has been shown in Table A7. Figure 3.2 shows the capacity against actual production of DTWs in MLD in the months of the year under report.

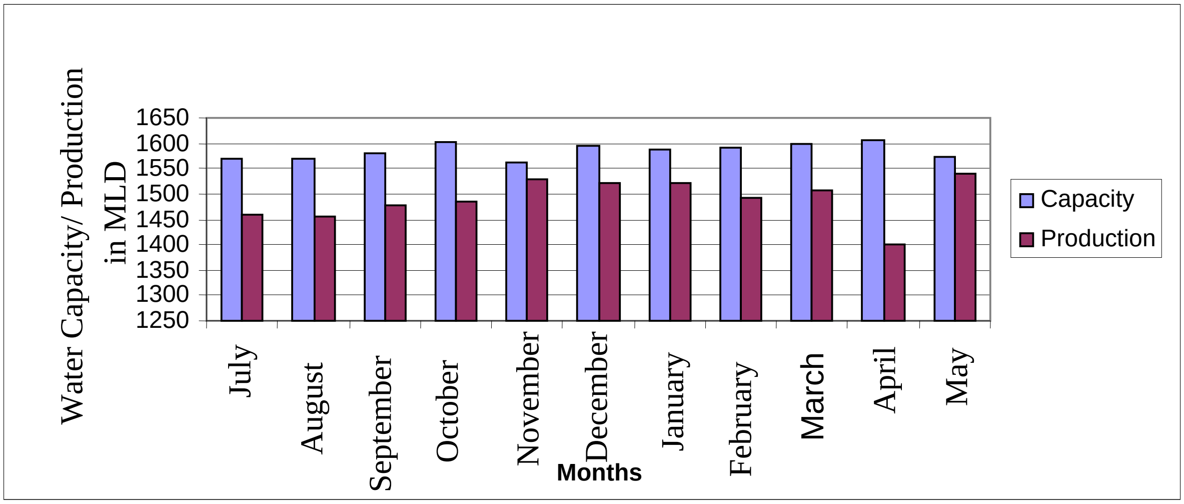

Fig. 3.2 Capacity vs. actual production of deep tube- wells in different month (DWASA, 2008)

3.2.2.2 Surface water supply

There are mainly three surface treatment plants monitored by DWASA for supplying the water in Dhaka City. These are Saidabad, Chandnighat and Narayangonj treatment plant. The Water from the Buriganga and Sitalakhya are performing as the source of water for the treatment plants (Water works).

Saidabad surface water treatment plant: It is the biggest surface water treatment plant of Bangladesh. The construction was started at 1997 .In first phage the plant came under operation on 2002 using the water from the river Sitalakhya. The present production capacity is 225 MLD (DWASA, 2008) but now its actual production varies from 200MLD to 220MLD. With the completion of second and third phages of this plant, the total capacity will increase to 900MLD. This will enable DWASA to adopt a plan for conjunctive use of groundwater and surface water resources.

Dhaka water works (Chandnighat) Constructed 130 years ago, the water works of chandnighat is still producing 39-40 MLD water using the water from Buriganga, although the deterioration in raw water quality has caused operational problems in the recent years

Narayangonj water works west (Godnail): The treatment plant at Narayangonj on Lakhya River has been constructed under Japanese grant aid. The Production Capacity of the plant is 34.07 MLD, but presently it can deliver only about 10-14 MLD of water because the existing distribution network is not sufficient to supply more water.

Narayangonj water works east: The amount of water supply is negligible. But production capacity is 1 MLD. It also uses the water from the river Sitalakhya.

Sonakanda water works: It is a very old water supply plant (1929). Now a day it is out of production

Actual production of all plants varies from month to month in a year. The production capacity and actual production of different water works are shown in the Table A8 and Table A9. The Figure 3.3 shows the comparison between the production capacity and actual production of water works

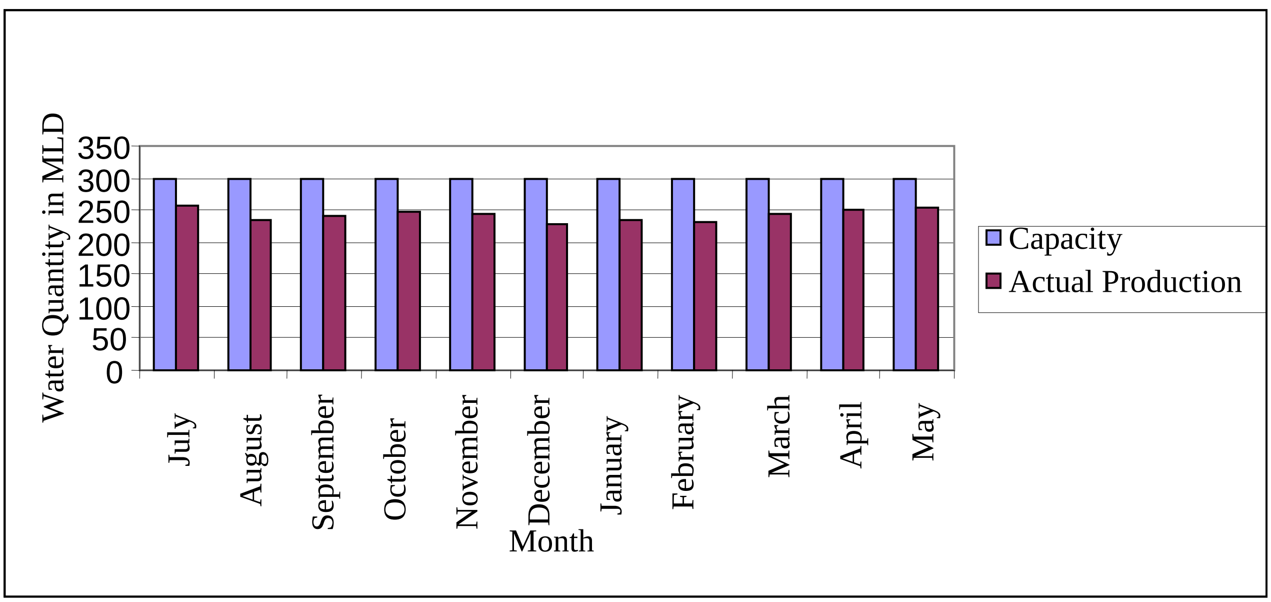

Fig.3.3 Comparison between the production capacity and actual production of water works in different months (DWASA, 2008)

3.2.3 Potential for future water sources in Dhaka City

To cope up with the future water demand DWASA is searching for new water sources and some projects are undertaken by DWASA.

So far DWASA does not seem to have any concrete plan to solve the crisis despite the fact that over the years many donor agencies have urged it to shift to surface water sources instead of its current dependence on groundwater extraction. Surface water pollution has affected the ability of DWASA to draw and treat surface water at Sarulia and Chandnighat.

Danish International Development Agency (Danida) has come up with technology to control the foul smell in water treated at the Saidabad Water Treatment Plant to a minimum level. This 'pre-treatment technology' will be installed as part of the Second Phase project of the plant, which is expected to be functional from 2012.

"The second phase of the SWTP is supplying 225 MLD of additional water daily, which will improve the existing situation. But at the same time the government should take steps to control the ongoing pollution in the Sitalakkhya River. Otherwise, it will be difficult to implement the third phase of the plant, which is expected to produce additional 450 MLD water a day (DWASA, 2009).

DWASA hopes to solve the water problem in the next four years. To meet the water crisis in the Mirpur area a well field in Singair Upazila, Manikganj district has been identified. A total of 300 MLD of water is expected to be abstracted from the field. After getting approval from the Planning Commission, DWASA expects to go to production in three years (DWASA, 2009)

In order to meet the growing water demand in Uttara, North Badda and Gulshan, a surface water treatment plant is under consideration at Khilkhet area, which would add another 500 MLD of water in a day to the supply line. The intake of this treatment plant would be the Meghna River. In fact this is a part of the Asian Development Bank (ADB)'s proposed 'Water Supply and Sector Development Project, This treatment will also create opportunity to improve the existing water quality at the intake point of SWTP at Sarulia (DWASA, 2009). Thus from the above references it has been concluded that the possible future source of water supply in Dhaka city as like Table 3.2

Table 3.2 Future sources of water supply planed by DWASA

Future Source	Expected time to complete	Capacity (MLD)
The second phase of SWTP	Ongoing	225
Third phase of SWTP	-	450
Well field in Singair Upazila, Manikgonj	2014	300
Surface water treatment at Khilkhet	2013	500
Expected future production		1250

(DWASA, 2009)

3.2.4 Water distributions system, connection and system loss

The Water distribution network is unique for Dhaka city, where the largest pipe is 800mm diameter. These networks are usually connected together by a small manifold distribution system, design primarily to convey surplus or standby water resources from one neighborhood unit to another. New transmission and distribution pipes have been installed for the supply of water of SWTP. 1800mm and 1400mm diameter transmission pipe is installed to convey water from this treatment plant to the city (Table A3).

In Dhaka city, tariffs are usually the same for different categories of users and for different levels of consumption. There are some metered connection, some non -metered connection and also some where flat or fixed rate are practiced –which are independent of actual water consumption. The Table A11 shows the metered and non metered connections. It also observed that there are many road side tap connection. People from slam and even household level used to collect this water from road side tap. But no body is paying this water money. DWASA used to treat this as system loss.

In the early nineties system loss in DWASA was 75% of the water produced. Afterwards installation of meter, development in billing system necessary arrangement to detect illegal connections, helped to bring-down system loss below 50%. The system loss is considered as the loss of both physical and non-physical loss. The Table A12 shows various physical and non physical losses as the findings of DWASA and the year wise system loss are shown in Table 3.3

Table 3.3 Year wise system loss for supplied water by DWASA

Year	**DWASA Zone(s)**							
	Zone I (%)	Zone II, (%)	Zone III (%)	Zone IV (%)	Zone V (%)	Zone VI (%)	Zone VII (%)	Total (%)
2002-2003	64.25	73.6	53.36	55.32	36.02	50.29	52.31	54.25
2003-2004	56.45	69.81	40.71	47.61	36.59	44.76	57.82	49.32
2004-2005	47.89	60.05	25.95	32.1	32.77	43.43	65.62	40.59
2005-2006	39.42	48.47	23.52	26.9	25.65	37.99	67.55	34.11
2006-2007	41.51	45.08	23.98	28.13	29.62	35.4	73.89	34.82
2007-2008								

(DWASA, 2008)

3.2.5 Energy cost for water production and present water tariff

Table 3.4 shows the energy cost (electricity cost) per m^3 of water in recent year. Table 3.5 shows the present water tariff charged by DWASA.

A substantial amount of energy (electricity) is expended to pump and treat the water for our use. The electricity bill of different pump station has been collected for a month from DWASA to find out the energy expenditure per m^3 water production from the DTWs. The Table 3.4 shows the electric bill and units for water production in different water pumps at Dhaka city.

Table 3.4 Electricity unit and bill of different water pump station in Dhaka City (DWASA, 2010)

Name of water Pump	**Production M^3/Month**	**Electricity Unit**		**Electric bill in taka (Including PFC charge, Demand charge, VAT)**
		Off peak	Peak	
Mohammadia Housing society	138329	26639	7896	167039
Rafiq Housing	174881	39530	12166	274796
Dhaka Udan	83700	16925	8615	84095
Monsurabad	119334	22368	6504	135344
Tikkapara	120014	22892	8032	164613
Iqbal road	83600	26858	9444	174708

(DWASA, 2010)

Government already increased the water and sewerage tariff 10% for the both domestic and industrial use in the year of 2009-2010.

Table 3.5 Present water and sewer tariff

Type	**Water tariff in Taka per m^3**	**Sewer + water tariff in Taka per m^3**	**Sewer + water tariff in US$ per m^3**
Domestics	6.05	12.8	0.18
Commercial	18.75	37.5	0.54

(Source: DWASA, 2009)

Note: 69.4 taka =1US$

More over the water crisis become very high at month of April, May, and June in Dhaka. Continuity of water supply is taken for granted in most places at Dhaka City, but is a severe problem in many places in this city where sometimes water is only provided for a few hours in every day or a few days in a week. It is estimated that about half of the population of this city (DWASA, 2009) receives water on an intermittent basis at summer season. Somewhere water is supplied by water truck and van and their cost will be like Table 3.6. Some people have the experience to buy the bottle water to meet their water demand in crisis moment. As sometimes they are not getting water from supply line as well as truck or lorry supply is not available to give them support. The vehicle rate of DWASA and bottle water rate for various companies are given in Table 3.6 and Table 3.7 respectively

Table 3.6 Rate for sale of water by DWASA vehicle (in Taka)

Capacity (Gallons)	**Rate (Taka)**	**Rate in US$ (69.4Tk=1US$)**
2200	300	4.3
1800	250	3.6
1200	200	2.9
800	150	2.2
500	125	1.8
250	75	1.1

(DWASA, 2008)

Table 3.7 Bottle water rate of different companies

Name of company	**Bottle capacity in Liter**	**Rate in Taka**	**Bottle water rate Taka/ m^3**
Mum	0.5	12	24000
	1.5	20	13333
	5	60	12000
Fresh	0.5	10	20000
	1	15	15000
	2	22	11000
	3	30	10000
	5	55	11000
Jibon	0.5	10	20000
	1	15	15000
	2	20	10000
Water Jar	20	60	3000

(Purchase rate)

3.2.6 Ground water lowering and DTWs depths

Although ground water in Bangladesh is said to be abundant, a considerable area of the country like Dhaka city faces scarcity of ground water within suction limit in dry season. Due to rapid decline in recharge area over the local groundwater basins and excessive withdrawal rate, water levels is falling in many parts of the city. In Dhaka city, groundwater level has fallen by 20 meters in the last decade alone. Water table is falling by about 2-3m annually (Patro, 2009). The Figure 3.4 forecast the decline of ground water levels in Dhaka city in the different years with reference to Table A13.

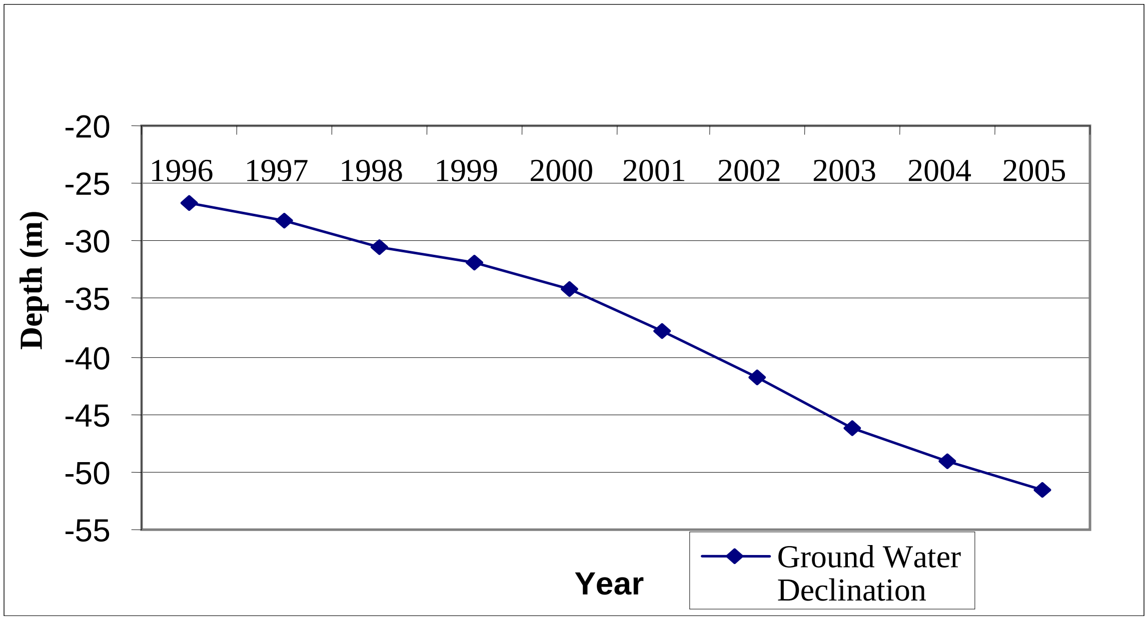

Fig.3.4Ground water declination in Dhaka city

The life span of Tube wells significantly reduced from 14-20 years to less than 5-6 years (Patro, 2009 and DWASA, 2010). Table A16 represents the change in Deep tube wells operation from shallow aquifer to deep aquifer in the recent years.

3.3 Population of Dhaka City

Dhaka is the one of the largest urban populated city in the world. This population has recorded very rapid growth during the last three decades (nearly 7 percent annually), and continues to grow rapidly (at over 5 percent annually). By 2035 Bangladesh will statistically become an urbanized country, with more than 50 percent of its population being urban. This situation may even happen earlier, give certain shifts in the economy and technology-taking place.

In order to estimate the present and future population of Dhaka city, population figures and its growth rate has been considered from different census. The population and its growth rate data from different sources has been collected and are shown in the Table 3.8

Table 3.8 Population and its growth rate of Dhaka City

BBS, 1997,BBS, 2001		**Dhaka WASA, 2004.**		**Average Annual Growth Rate (%)**
Year	Population	Year	Population	
1951	411,279	1970	14.64	1.28
1961	718,766	1980	30.31	5.74
1974	2,068,353	1990	55.56	8.47
1981	3,440,147	2000	102.43	7.53
1991	6,487,459	2001	107.12	6.55
2001	9,912,908	2002	112.03	4.33

Among the different methods the study used least square probable method and arithmetic method for estimating the present and predicting the future population.

3.4 Methodology and Data Collection for Domestic Water Consumption

The exact amount of water a person needs is depends on the people attitude, awareness, habit, the amount of physical exercise, and on the environmental temperature and humidity. For example, during summer people will require more water than winter. An individual's can provide better information for how much water they require rather than a specific, fixed number. People can determine how much water they need in their daily activities. The purpose of the survey is to determine the water requirement in domestic level. Understanding the water saving behaviors of people it is necessary to find out their per activities water requirement in daily life.

3.4.1 Instrument

The studies on people's water consumption in domestic arena are very limited in Bangladesh. In absence of reliable consumption data a survey has been conducted in Dhaka city to recognize where and how much water people require in daily household life. At the time to develop the questionnaire for the survey, the people's water usages behaviors have observed at house. In accordance, peoples water usages areas at their home are determined in the following group: Drinking, bathing, toilet use, faucets use, laundry, dishwashing, indoor washing etc.

Primary data of water usages in family life was collected through questionnaire and discussion with the people. Each micro component for water demand is determined by gathering information on ownership of appliances, frequency of use, and the volume of water per use. The simple questionnaires like (Table A14) will allow tracking the household consumption for indoor water usages. The Environmental Agency (UK) used such type survey method and estimated data were used for water demand forecasting (Otaki et al., 2008).

Also the questionnaires include some questions related to demographic background of respondents. The study discusses details of these measurements in the result and discussion chapter**.**

3.4.2 Samplings and selection of sample area

The field survey was conducted in August 2009 in the area being covered by the services of the DWASA. The study drew sample of 100 families living in different part of Dhaka City. Basically the survey was made in apartment buildings of Dhaka city. Slum areas were not considered as there is no fixed supply and usages of water. Moreover people of slum area have no knowledge about their water usages. This survey was conducted through questionnaire survey and discussion with the people of different socio economic class. Mirpur, Mohammadpur, Dhanmondi, Uttara which is under DWASA Zone 3, Zone 4 and Zone 5 and other some families from different areas (Zone 6) were chosen scattered as the sampling site to make the average per capita water consumption for whole Dhaka city. No families were selected from Zone 1, Zone 2 and Zone 7. The houses were selected depending on co-operative attitude of the respondents. A total number of 70% families were interviewed in these four areas and other 30% families in other part of the city. As the resources available for the conduct of this survey limited, the number of sample or families has been chosen 100.

Mirpur, Mohhammad pur, dhanmondi and uttara area were chosen for several reasons. First the Mohammad pur and Mirpur were selected as these are dense populated and middle economy class people living area rather than Dhanmondi and Uttra. Secondly the other families from other part of Dhaka city have also been chosen to make an over view of per capita water consumption for whole city. The demography of the families discuss in result and discussion chapter.

3.4.3 Data collection

Houses were visited and informed the people about the goals of this study. Their consent for participating in this study was obtained and then they were trained to record water consumption. Within a week, participants conducted the three observations. They wrote down the time for minimum two participants took taking showers, washing dishes, brushing their teeth, and number of flushing the toilet or number of Jug use after each use. After the observations were completed, the questionnaires were administered. The record keeping approach has advantage, it has also disadvantages. A major weakness of these type of survey is that it is be set with problems that may arise from half hearted cooperation from the household, i.e., respondents may not have enough incentive to record and keep track of all water usages in the household by activity. Quantitative assessment has been made from the possible conservation practices in Dhaka city. The sample of survey question to determine the water consumption in house hold is given in the Table A14. Two field survey samples have been attached in the Appendix.

3.5 Survey on Attitude and Preference on Water Conservation

DWASA, water planners as well as different users have to deal with many challenges to meet the up growing water demand in Dhaka city. The traditional response to water demand has been the development of additional water supply. The engineering- oriented solutions given so far to increase supply, led to irreversible environmental deadlocks responsible for the current situation. Little attention has been given to the objective of water conservation through the options that control and modify water demand. Economic incentives, water pricing policies, public participation and awareness, as well as education and information strategies are today powerful demand management tools, (Mylopoulos and Mentes, 2000).

In this context with the water consumption survey another questionnaire survey was conducted among the same 100 families about the attitude and knowledge on water valuation and water conservation. The objective of the survey was to investigate the attitudes and preferences of the residential water users of Dhaka city. The field survey has been conducted to investigate among others the reliability of the utility’s services and infrastructure, the acceptability of various water demand options, the willingness to pay of the consumers and the level of public awareness

3.5.1 Survey questionnaires

The questionnaire covered questions that include issues likes:

• Demographics of the sample (sex, age, education, family size, income etc.)

• Water supply, (reliability of the water supply network and infrastructure)

• Water quality (satisfaction with and reliability of tap water quality, use of additional cleaning devices, use of bottled water etc.)

• Water demand (water consumption levels, classification of residential water uses, use of additional water deposit or pressure devices, and acceptability of alternative water demand management practices)

• Pricing policy (acceptability level of the pricing policy, willingness to pay, efficiency of economic instruments)

• Public awareness

The questionnaires sample is given in the Table A15

CHAPTER FOUR
RESULT AND DISCUSSION

4.1 General

Dhaka had many water resources. There were thousands of ponds, lakes, reservoirs and five big rivers around the Dhaka City. And there was also abundant of groundwater. For this the city dwellers have become accustomed to adequate supplies for all uses. For most of people, water is never more than a few steps away. People only need to open a faucet, press a button, or turn a cap to quench their thirst.

In the present study the rapid population growth, increasing water demand as well as lowering the ground water level with surface water pollution gives more attention on water conservation in Dhaka city. Savings of water at household level not only saves the money for homeowner but also have the impact on energy savings. As well as water conservation practices also minimize the demand of fresh water on the conventional water supply system.

According to this study the water requirement for household level is higher compared to other countries in the world. System loss in main distribution system, lower water tariff and ignorance on the valuation of water are the major barriers for the conservation practices in the Dhaka city.

4.2 Factors Influencing Water Conservation in Dhaka

The main requirement of a water supply system are to provide adequate water required for all domestic purposes and make water easily available to the consumers. DWASA cannot cope up with the water demands of consumers with its existing supply arrangement. The following issues were considered in the present study in order to assess the influence factors for the water conservation in Dhaka city.

- Rapid population growth
- Lower capacity of water supply than demand
- Ground water level lowering
- Non availability of suitable surface water sources
- DWASA service related problem (leakage in distribution system, system loss, non metered connection)

4.3 Rapid Population Trend in Dhaka City

In 1990, approximately the demand was 1000 MLD of water in Dhaka city (Table 2.2). Domestic water consumption has changed dramatically in Dhaka during the last 40 years. In 1970, only 1.4 million people lived in the city and the demand for water was 260 MLD. The current growth rate is 4.33 % per year and calculated recent population is more than 14 million (Table 4.1). If this growth rate continues at the end of the year 2020 the population will be more than 20 million. A significant number of studies have been made to estimate the present population and to predict the future population in Dhaka city. Table 4.1 shows the present and projected population of Dhaka city from this study calculation and from different studies.

Table 4.1 Present and projected population of Dhaka city (Comparison between study calculation and other studies)

Source	Population in 2010 (Million)	Population in 2015 (Million)	Population in 2020 (Million)	Population in 2025 (Million)
Hedayetullah, 2006	13.6	16.6	20.4	24.25
Paul, 2009	12.27	14.93	-	21.16
Rahman and Das, 2003	14	18.7	<20.0	
DWASA population data using author’s projection (least square probable method)	15.9	19.5	23.7	28.4

BBS, 2001 population data using author's projection (Arithmetic Method)	14.5	17.9	22.2	27.4

Actual population of Dhaka city is difficult to assess because of the substantial floating population and slum dweller. Population data obtained from DWASA is high because they consider these floating or movable people as a consumer of water. According to DWASA it would be 10-20% of the total population. The historical and projected population trend is shown in Figure 4.1 considering the growth rate 4.33% from 2002.

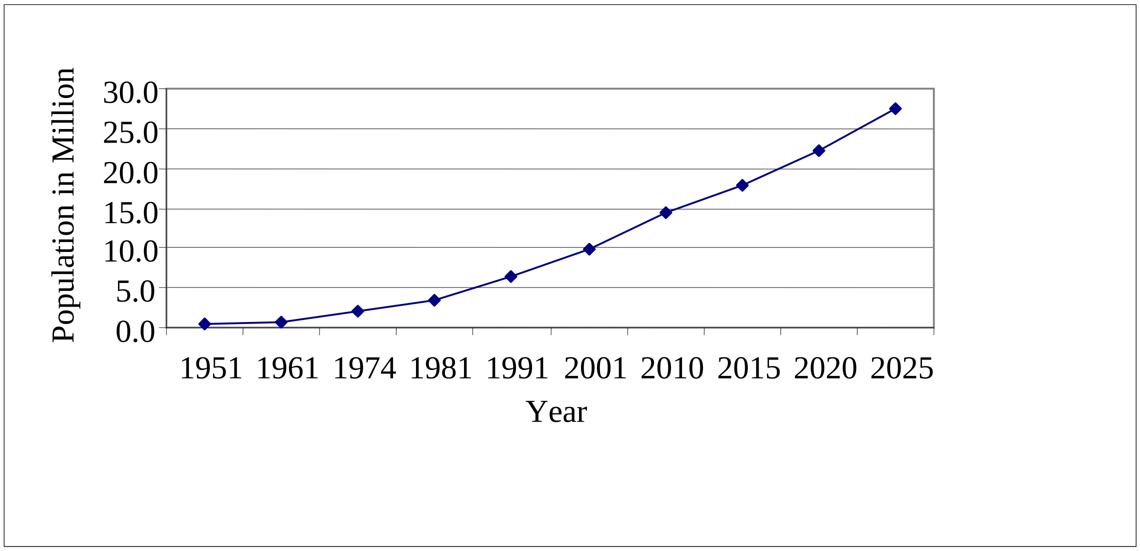

Fig. 4.1 Trends in population in the Dhaka City from 1951 to 2025

Considering the rapid expansion of the city with the high rate of population growth and other infrastructure developments, there would be huge demand for domestic, industrial and commercial water in near future.

4.4 Lower Capacity of Water Supply than Demand

Water demand

In order to estimate the present and future water demand for Dhaka city from the data collection and population estimation two different scenarios with different assumption has been considered in this study. First scenario is considered as large population with lower per capita consumption. Another is less population with higher per capita consumption. Table 4.2 forecast the present and future water demand of the Dhaka city. It is assume that the per capita consumption remains constant.

Table 4.2 Present and future water demand projection

Scenario	**Population in Million**			**Per capita consumption per Day**		**Water demand in MLD**		
	Year 2010	Year 2015	Year 2020	GPCD	LPCD	Year 2010	Year 2015	Year 2020
1	15	19	23	35 (DWASA)	160	2400~2400	3040~3000	3680~3700
2	13	16.5	20	41 (Study survey)	186	2418~2400	3069~3000	3720~3700

Thus in 2010, there are over 14 million residents, the demand become 2400 MLD. While long-term consumption has increased significantly, people have made progress in conserving water in the Dhaka

Water Supply

Currently there are 485 Deep Tub-wells under operation in the Dhaka city which is controlled by DWASA (Table 3.1). So far the maximum water supply by DWASA from ground water by extracting with deep tub wells is 1540 MLD (Table A10). The actual production from the DTWs becomes lowest (1399 MLD) in the month of April –May (Table A7). And DWASA keeps more tube wells in operation at that period to meet the water demand in the city.

Excluding ground water, only suitable water sources exist within the city area treated surface water from water works. Surface water source can supply only 254 MLD (Table A9). Table A10 clearly shows the overwhelming dependence on groundwater supplies that comes from underlying aquifers.

Total water supply is about 1800 MLD where as the total demand is 2400 MLD (Consider the lowest demand among the three scenarios). That means deficit 600 MLD has been observed basically at summer season when the demand is peak. Thus the shortage of water is equivalent to the water requirement of 2.0 million people.

Due to the DWASA supply expansion plans, water needs are expected to increase rapidly in the next few years. In order to help reduce the risk of a future water shortage a new water supply project is being developed, according to which 1250 MLD (Table 3.2) of water will be transferred daily from the nearby Meghna River and from Savar well field. It is expected that the entire future sources (Table 3.2) will go in production within year 2015-2020. Hence at the end of the year 2015 DWASA will be capable to supply 3050 MLD (Present production 1800 MLD+ expected production 1250 MLD) Water. Figure 4.2 shows the overall condition of water demand and supply of DWASA in the past and future.

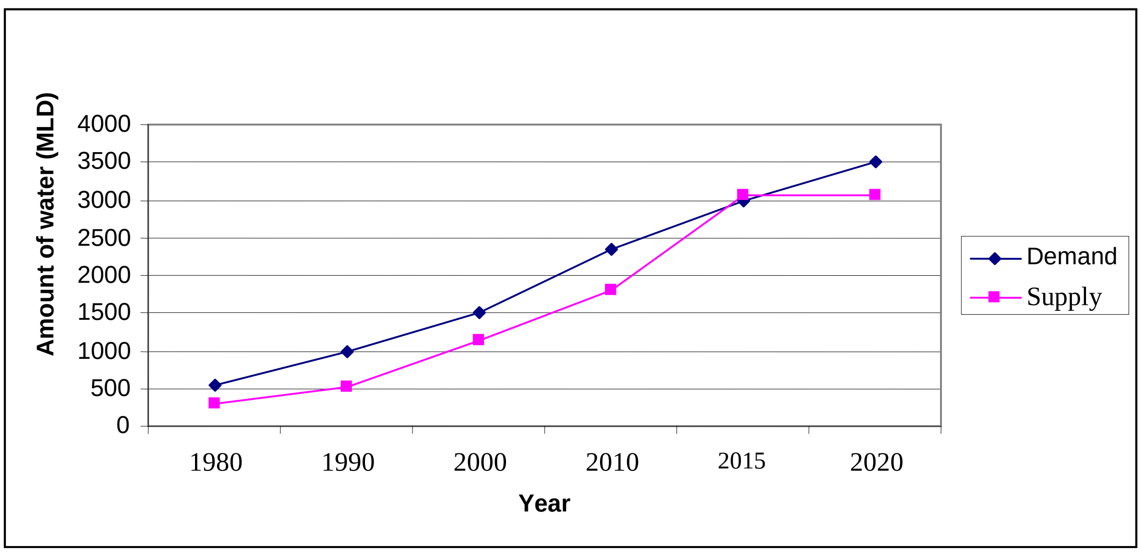

Fig. 4.2 Demand vs. supply for the Dhaka city

Projection Figure 4.2 shows that supply line meets the demand by 2015 but after that there is increasing demand of water. DWASA has no complete plan to make this future project successful. As a result water conservation practices will add some value to mitigate the water scarcity in Dhaka city.

4.5 Ground Water Lowering

(Table A10) 85% of Dhaka city water demand comes from ground water sources. There are 485 Deep Tube Wells (DTW) operated by DWASA and 1179 DTWs by other private agencies (Table 3.1). Excessive use of ground water (1540 MLD) through deep tube wells without any adequate replenishing mechanism has lead to an alarming drop in the piezometric level about 3-4m per year from the year 2000 (Figure 3.4 and Table A13). Before the year 2000 the lowering rate was 1-2m per year (Fig.3.4).

Table 3.16 shows most of the deep tube wells were installed by DWASA in the Dhaka city within the 30m depth in early 1990s. Such areas are going through the water crisis as most of the existing pumps in these areas cannot abstract water properly from the ever-decreasing ground water layer. Already most of the available water of the upper aquifer layer (<100m) has been used up. In 2005 – 2007 DWASA started installing deep aquifer pumps to abstract water from the second layer that was greater than 140m (Table A17). At present time even this is becoming difficult in many areas of the city.

As the Ground water depletion increasing, the deep aquifer expectedly will also reduce its productivity. If the declination of the ground water table is as shown in the Table A13 the entire deep tub wells will need to be abandoned as source of water supply for the city. Total 48 DTWs in deeper aquifer are in operation at different zones (Table A16) and another 50 DTWs have been planned (DWASA, 2010). The Impact of abstraction from deeper aquifer (>200m) is now being monitored. And no further abstraction from upper aquifer (100-200m) will be viable (Paul, 2009)

With the existing system, the natural recharge is not sufficient to meet the demand of excessive rate of abstraction. The rate of natural recharge through rainwater has decreased since the concrete structures are replacing the water bodies. Thus increasing demand for water supply cannot be met as the ground water abstraction is showing strong signs of rapid depletion.

4.6 Non Availability of Surface Water

Apart from ground water, no suitable water sources exist within the city area. Surface water source can supply only 254 MLD against the total demand of 2400 MLD (Table 4.2). In the present the most of the rivers carry only sewage and industrial effluents during the seven months of the dry season (November-May). The literature review shows that incremental water pollution due to the domestic, industrial wastes and encroachment of rivers confines the use of river water. Buriganga, Turag, Balu and some portion of Sitalakhya are not suitable for treatment by conventional methods due to highly polluted water (Literature review).

4.7 Organizational Problem (System loss and unaccounted connection)

There are many other reasons which have the effects on the water conservation policy making in Dhaka city, such as leakage and damage of supply pipes and main distribution lines and illegal connection with connivance or assistance of lower level of stuffs of DWASA. As in present time 34% system loss (Table 3.3) observed according to the DWASA report. Non metering connection (Table A11) and low rate of piped water make people unconscious to save the water which result more wastage of water. Improving the quality of operation and maintenance of the service is an efficient tool for water conservation management.

4.8 Survey Result for Per Capita Water Consumption

This section examines per capita water usage based mainly on data from survey. Per capita water consumption depends on the people attitude, awareness, habit, profession and other factors.

Demographics of the sample

Table 4.3 shows the detail demography of the sample. Most of the respondents were women, as a result of the fact that more women don't work and therefore stay at home during working hours. But in family the men are more than women in percentage. Concerning the educational level, age, family size and number of people having income per residence, house rent per Sq. ft, their distribution confirms the representative of the random sample.

Table 4.3 Demographics of survey (sex, education, age, family size, income and house rent)

(%)	Sex	Education	Age	Family size	Income/ residence	House rent Taka/ Sq.ft
Women	46.37					
Men	53.62					
Secondary level		30				
High school level		10				
Graduate level		60				
0-18 years old			19			
18–40 years old			50			
40–60 years old			24			
>60 years old			7			
Single family				5		
2–4 persons/residence				60		
>5 persons/residence				35		
1–2 persons/residence					88	
3 persons/residence					4	
>4 persons/residence					0	

No income (students)	8
5-6 Taka/Sq.ft	11
7-10 Taka/ Sq.ft	74
11-13 Taka/Sq.ft	15

Average families are living in a 7-10 Taka /Sq. ft house. These families are basically middle income group. Most of this type of families has only one/ two income person. Below this house rent is consider as a low income group. In this group there is some student's bachelor house which indicates that they have no income. On the other hand the people leaving in house which rent is higher than 10 Taka/ sq.ft consider as a high income group.

The column for minimum shows the lowest possible consumption per activity based on the survey. And the last column represents the maximum possible water consumption. Based on survey data minimum, maximum and average water consumption for each household purpose is determined and described in below.

4.8.1 Drinking and cooking

Based on the survey people used maximum 1.5 GPCD and minimum 0.8 GPCD for drinking and cooking purpose

4.8.2 Bathing

Depending on the technology associated with a household activity, bath usage can vary greatly. The water consumption for bath use is expected to depend on temperature. Some people (about 40%) are taking bath 2 times in a day (generally at summer season) where as some are taking bath only single time in a day. Some people use shower for bath but an average people (more than 50%) used bucket (number of bucket or running tap). Those who take bath 2 times in a day, the water requirements for that people become very high. According to survey the estimate for two times bathing requirement of about 18 GPCD-28 GPCD (Table 4.4). In single use cases the water requirements for bath varies from 6 GPCD to 20 GPCD. Based on the survey average limit of water consumption for single bath is 8 GPCD-14 GPCD (Table 4.4)

Table 4.4 Water requirement for Bath (GPCD)

Using shower			Using running tap			Using bucket		
Number of respondents	Maximum (GPCD)	Minimum (GPCD)	Number of respondents	Maximum (GPCD) (single +double)	Minimum (GPCD) (single bath)	Number of respondents	Maximum (GPCD) (single +double)	Minimum (GPCD) (single bath)
4	15	10	3	16	12	5	13.5	9
5	20	10	4	15.4	12	4	18	9
3	17.5	10	2	20	12	5	27	9
1	22	8.8	3	14	10	3	18.2	9.1
4	14	10	4	24	12	3	19.5	13
3	24	12				2	27.3	13.65
2	20	8				3	26	13
1	24	8				3	27.3	9.1
3	28	14				5	13.65	9.1
5	24	10				4	18.2	13.65
2	26	12						
3	12	10						
2	25	10						
1	28	8						
3	16	10						
1	24	20						
3	16	14						

Average for single bath 8-14 GPCD

The most of the respondent about 60% (Figure 4.3) use minimum 8-10 GPCD water for single bath. As the survey was made in summer season most of the respondents take bath two times in a day. More than 50% people use maximum 18-28 GPCD of water for taking the bath in summer season Figure 4.4.

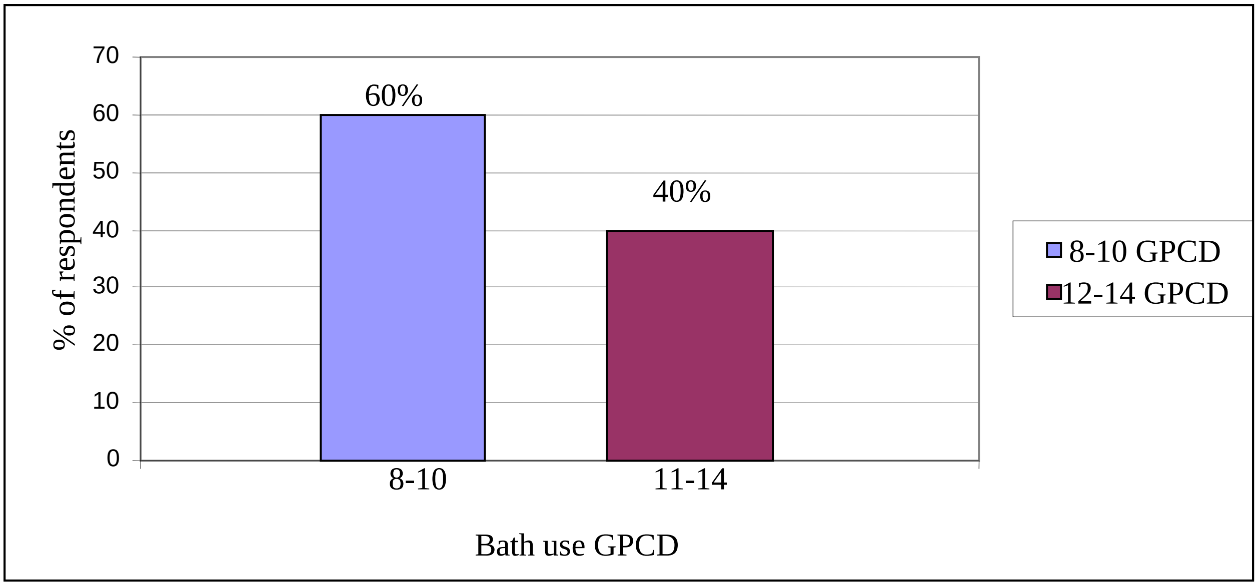

Fig. 4.3 Minimum range for bath use GPCD

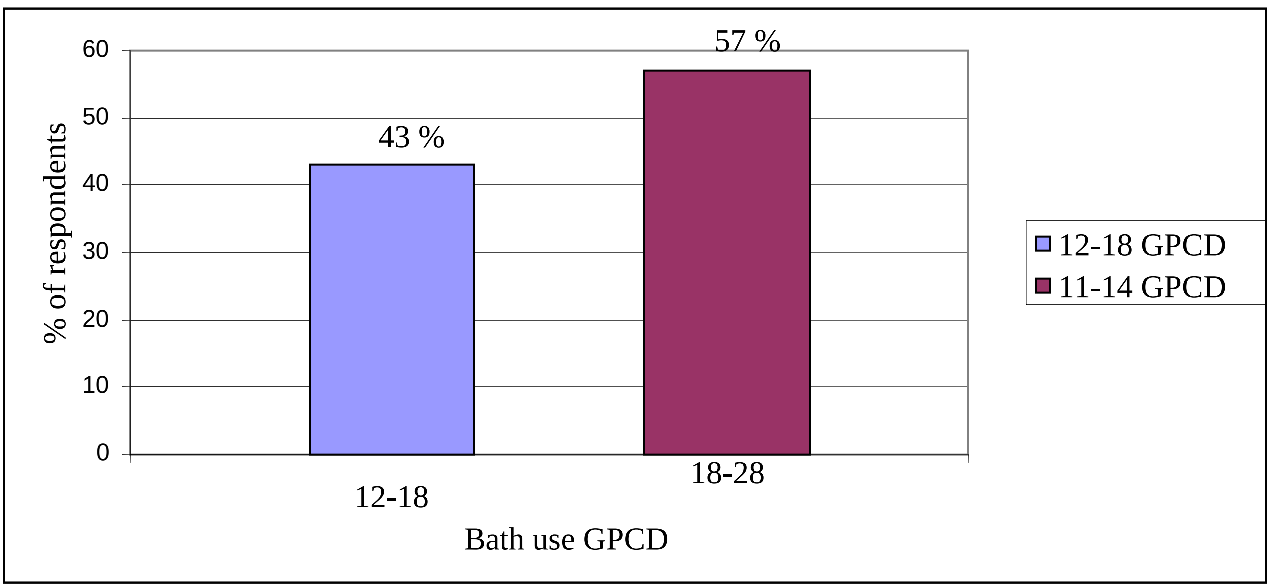

Fig. 4.4 Maximum range for bath use GPCD

4.8.3 Toilets uses

Water requirements for toilets purpose depends on the types of sanitation facilities. Some people use toilets having flashing system (45%) and another have non flushing system (55%). But other some families have flushing toilet but they do not use this as most of the cases it was found, the flushing system is faulty. In non flushing system people used jug for washing. The water consumption is minimal for people using pit latrines than the flushing system toilets. In flushing system toilets water requirements range 7 GPCD to 15 GPCD. But the non flushing system toilets water consumption varies from 4 GPCD to 8 GPCD. Based on the survey average demand of water for toilets use is 4 GPCD to 11 GPCD Table 4.5.

Table 4.5 Water requirement for toilet use (GPCD)

Non toilet flushing			**Toilet flushing**		
Number of respondents	Maximum (GPCD)	Minimum (GPCD)	Number of respondents	Maximum (GPCD)	Minimum (GPCD)
			2	8.8	4.4
3	6.6	3.52	4	10	5
2	10.56	4.4	2	12.5	5
2	7.04	5.28	4	7.5	5
5	8.8	6.6	5	8.8	6.6
2	8.8	3.52	2	11	6.6
4	7.04	2.64	5	12.5	7.5
6	8.8	3.96	3	7.5	5
3	7.04	3.52	3	13.2	8.8
4	10.56	5.28	3	15.4	8.8
3	7.04	3.96	4	15	12.5
4	5.28	2.64	2	11	8.8
3	7.04	2.64	4	12.5	10
3	7.04	3.96	3	10	7.5
3	6.6	2.64	Average 15-7 GPCD		
3	8.8	2.64			
3	5.28	3.52			
2	5.28	1.76			
Average 8-4 GPCD					

Average water use for Toilet 4-11 GPCD

In case of non flushing toilet user 77% respondents use minimum 4-7 GPCD water for toilet purpose (Figure 4.5) For maximum use more than 50% use 7-10 GPCD of water for toilet use (Figure 4.6). On the other hand for flushing toilet more than 50% user use minimum 7-12 GPCD (Figure 4.7) of water and use maximum 12-15 GPCD (Figure 4.8) of water for their toilet purpose.

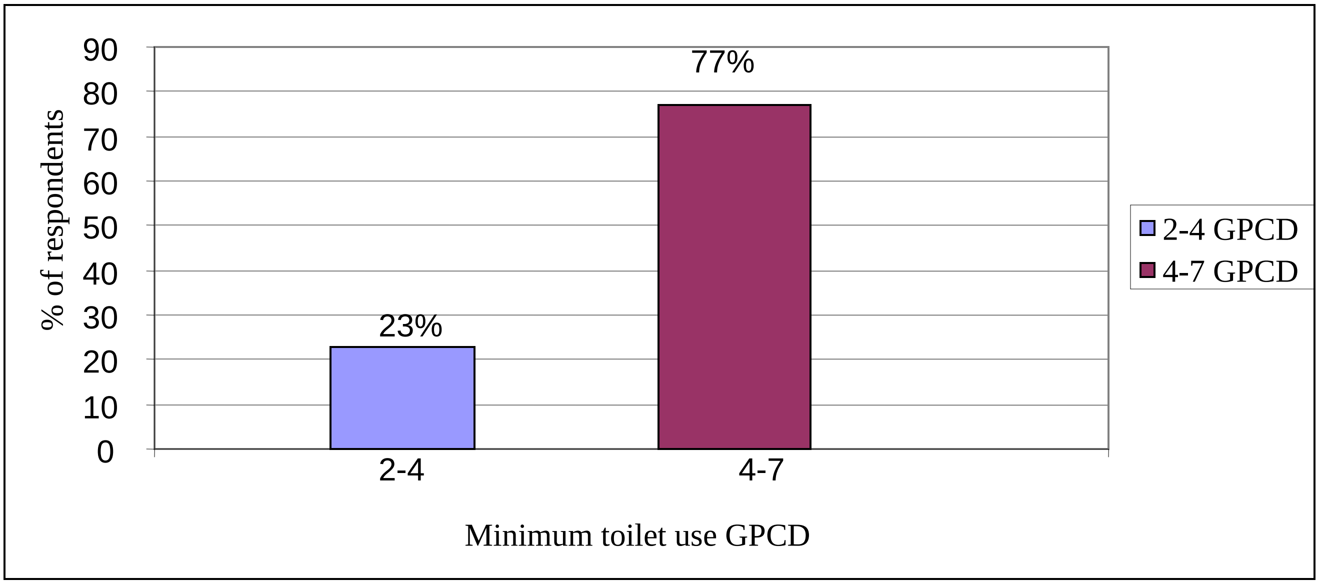

Fig. 4.5 Minimum range for toilet use (Non flushing toilet)

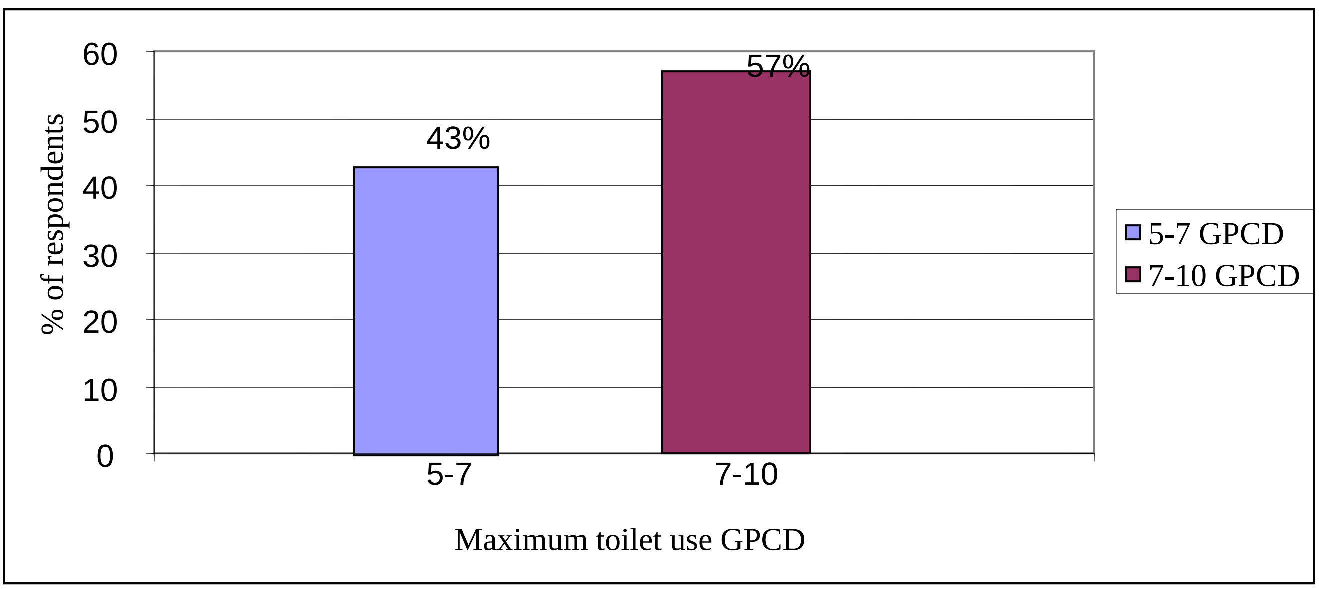

Fig. 4.6 Maximum range for toilet use (Non flushing toilet)

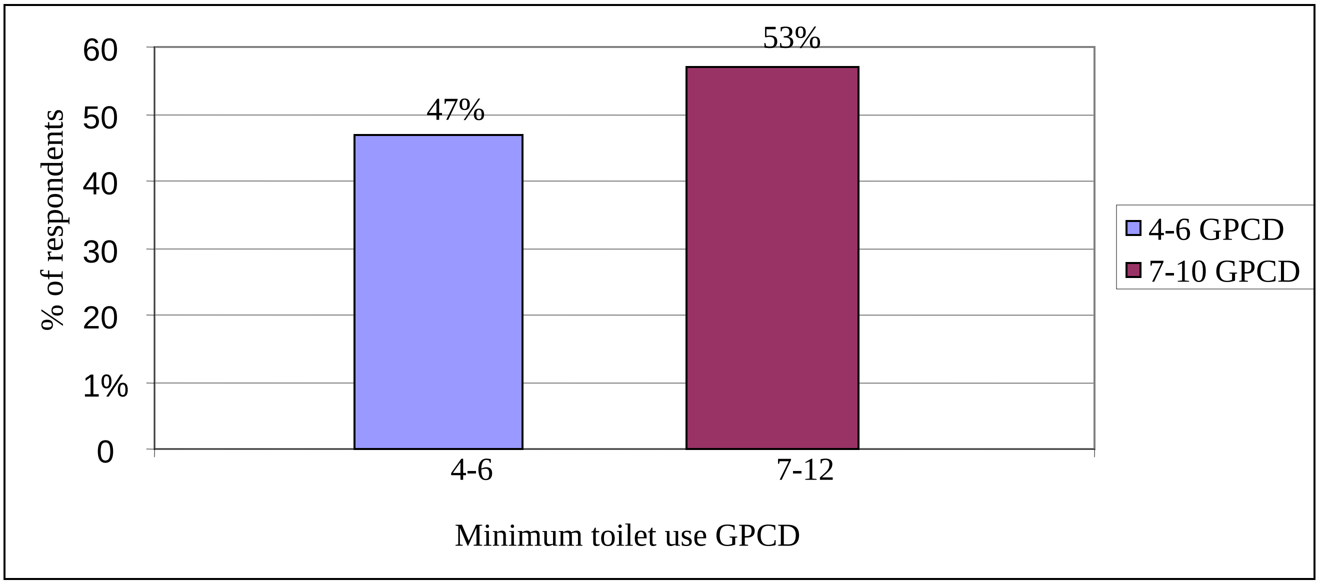

Fig. 4.7 Minimum range for toilet use (flushing toilet)

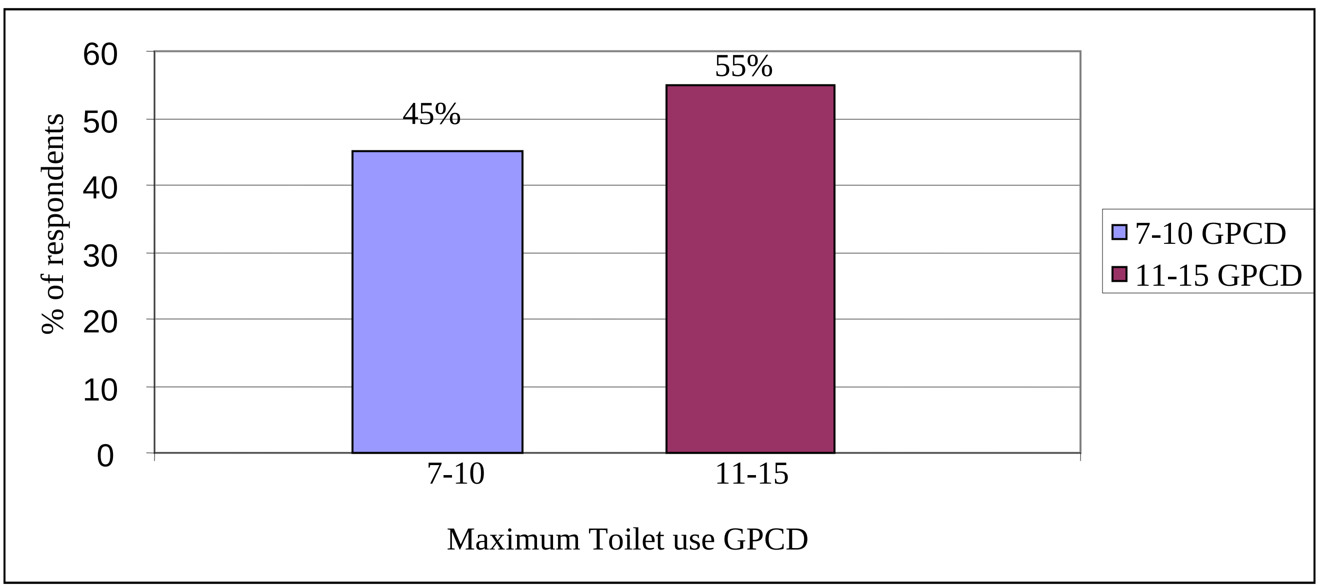

Fig. 4.8 Maximum range for toilet use (flushing toilet)

4.8.4 Faucets uses

People use faucets for various purposes as like shave, brush teeth, wash hands and face etc. Based on the survey average limits for faucets use is 7 GPCD to 12 GPCD (Table 4.6).

Table 4.6 Water requirements for faucets use

Faucets use					
Number of respondents	Maximum (GPCD)	Minimum (GPCD)	Number of respondents	Maximum (GPCD)	Minimum (GPCD)
3	14	8	3	14.08	9.6
2	15	8	1	16	14
2	15.4	8.8	4	14	10
2	10	4.8	3	12.8	6
2	8.8	5.6	1	16	12.8
1	11	4.8	2	13	7.8
7	12.8	9.6	3	11.2	8
3	12	7.5	1	14.08	8.8
2	15	10.5	2	9.6	8
3	16	10	1	13.2	11
2	10.4	7.8	4	11.0	6.4
3	14.08	6.6	2	12.8	8
4	12.8	6	2	11.2	6.4
2	16	8	4	12.32	8.8
2	9.1	6.5	1	16	8
2	12.32	5.5	2	14.4	8.4
2	10	4.5	3	9.1	6.5
2	15	10	3	12.8	11.2
2	10.56	7	2	11.2	9.6
2	11.2	7.2	3	13.125	7.5
1	11.2	6	Average 12-7		
1	16	11.2			

According to survey data 40 % respondents use minimum 7-9 GPCD water for faucets use on the other hand only one out of 4 respondents use 4-7 GPCD water (Figure 4.9). In case of maximum use more than 60% respondents use 8-12 GPCD water to meet their faucets use (Figure 4.10).

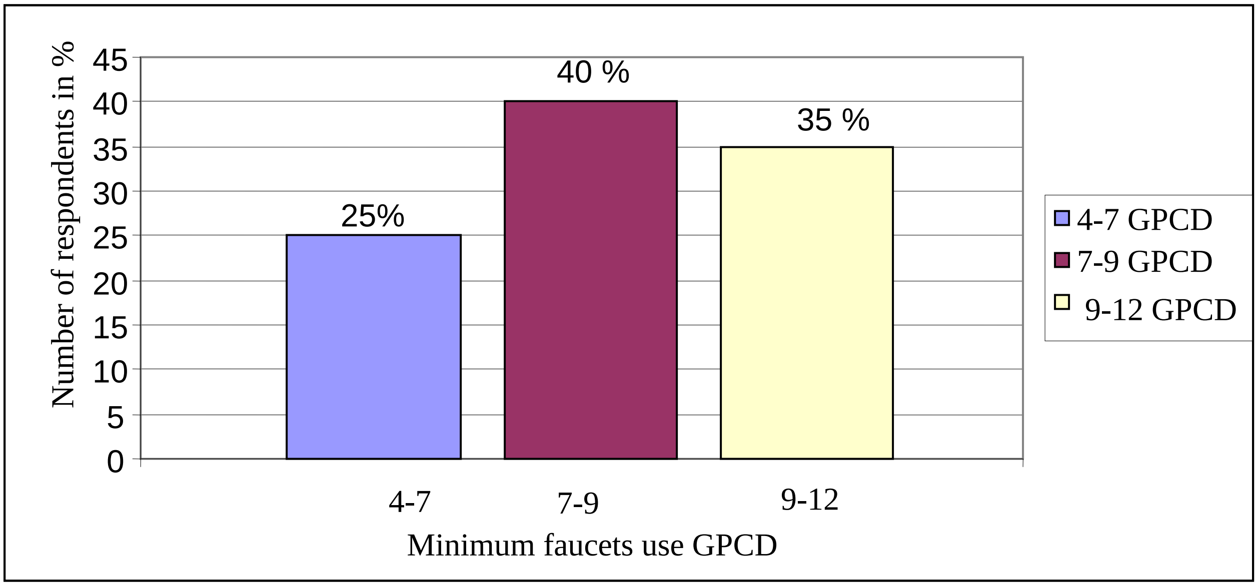

Fig. 4.9 Minimum range for faucet use (GPCD)

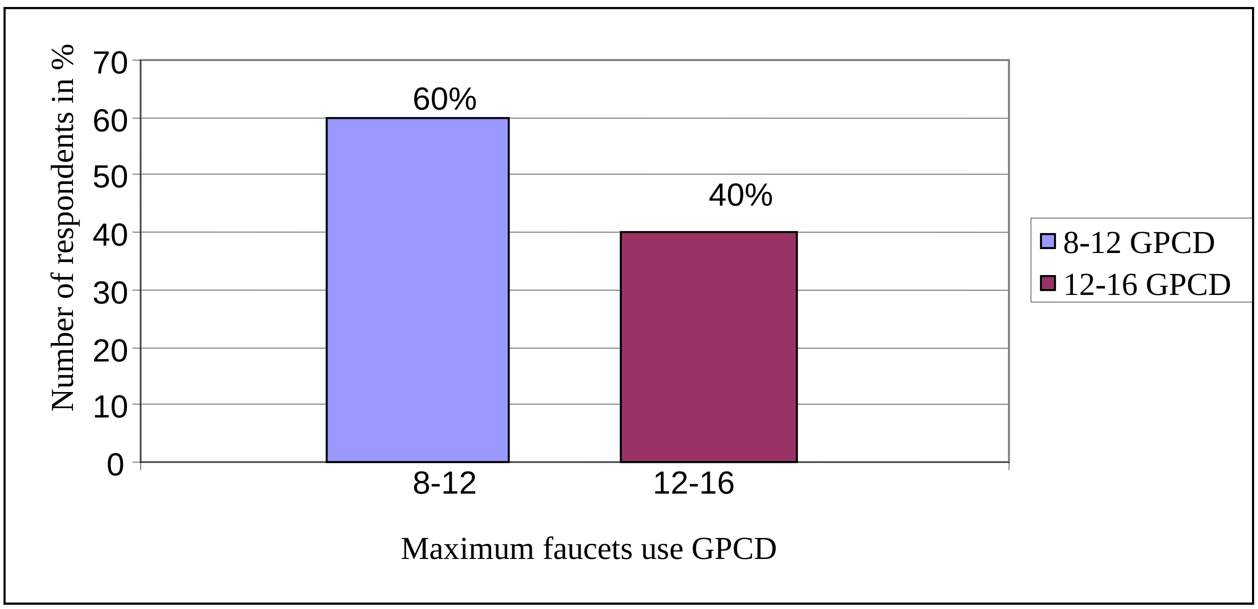

Fig. 4.10 Maximum range for faucets use (GPCD)

4.8.5 Dish Washing

Dish washing machine is not available in most of the house holds at Dhaka city. Most of the people wash the dirty dish by hand. The Calculation for this category water requirement is done based on the total water requirements for a house and divided it into whole family member. The Average limit for this type of requirements is 4 GPCD to 9 GPCD (Table 4.7).

4.8.6 Laundry

Most of the households at Dhaka city do not have washing machines and wash their clothes by hand. But some households use washing machines for laundry. The number of bucket per use has been estimated to measure the water laundry consumption. Washing cloth or Laundry is not taken every day in a week. For this the study considers whole week water requirements for laundry use and divided it by seven day and total family member. According to survey the average limits of water consumption for laundry is 2-4 GPCD (Table 4.7).

4.8.7 Other uses (Indoor washing)

Water is also used for indoors room, furniture and equipment cleaning purpose. Estimate the average number of minute's water is used outdoors for purposes other than watering each week. Or also used for indoor washing. The Limit range for this purpose is 2 to 3 GPCD (Table 4.7).

Table 4.7 Water requirements for dish wash, laundry and others (GPCD)

Dish wash GPCD		**Laundry GPCD**		**Drinking+ Cooking**		**Others**		**Total**	
Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
9.60	8	1.49	1.11	1.5	1	2.34	1.56	49.03	32.19
5.71	2.86	1.99	1.2	1.5	1	1.93	1.3	52.93	27.76
8.8	7.2	5.2	3.7	1.5	1	2.73	1.82	64.23	36.92
9.6	8	2.23	1.11	1.5	1	3.64	1.82	63.97	30.73
9.6	6.4	2.8	1.48	1.5	1	3.64	1.82	51.01	27.67
13	11	2.23	1.8	1.5	1	4.55	2.27	62.28	35.87
6.67	5.33	3.25	2.16	1.5	1	2.28	1.5	56.00	33.39
6.86	3.43	3.25	1.3	1.5	1	1.95	1.3	48.36	31.13
6.67	4	3.03	1.5	1.5	1	5.31	2.27	58.05	37.55
7.5	3	2.28	1.7	1.2	1	2.84	1.13	56.82	32.53
12.9	5.7	3.25	1.95	1.2	1	3.9	1.95	58.05	35.00
6.5	3.25	4.82	1.93	1.9	0.8	0.76	0.45	64.56	32.53
8.67	3.33	4.5	2.25	1.2	1	2.52	1.7	59.69	27.28
12	4.3	2.68	1.7	1.2	1	1.95	0.86	65.33	28.86
9.6	6.4	5.14	3.09	1.2	1	1.7	1.25	64.74	37.24
8.8	5.28	3.21	1.54	1.2	1	3.26	2.42	57.09	35.34

Dish wash GPCD		Laundry GPCD		Drinking+ Cooking		Others		Total	
Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
8	5	4.95	2.7	1.2	1	2.17	1.7	46.42	27.42
5	4	3.48	2.79	1.2	1	1.63	1.3	63.81	36.59
5	3	3.87	2.47	1.2	1	1.63	1.3	50.82	29.89
8	6	3.9	1.95	1.2	0.8	2.6	1.95	64.74	32.34
8	2.5	3.25	1.46	1.2	1	2.6	1.46	65.21	34.22
8.67	3.47	3.9	1.7	1.2	1	3.9	1.7	57.67	28.97
5.09	2.18	3.55	1.89	1.2	1	2.89	1.47	53.33	31.34
8	3.2	3.12	1.95	1.2	1	6.24	3.25	58.36	41.50
6.67	2.67	3.79	1.625	1.2	1	2.6	1.625	57.06	31.08
5.33	2.33	2.6	1.62	1.2	1	3.8	2.1	62.01	35.45
4	3	3.26	1.46	1.2	1	3.25	1.6	61.75	33.58
8	2.86	4.5	2.57	1.2	1	3.34	1.86	63.84	32.69
6.67	2.67	3.75	3	1.2	1	3.25	2.167	65.87	33.63
8	8	4.5	3.6	1.2	1	2.6	2.08	69.10	42.08
10	4.17	3.75	2.25	1.2	1	3.25	1.3	59.70	34.02
12	5	4.5	3.37	1.2	1	4.88	1.95	61.88	40.92
5.71	2.28	2.57	1.9	1.2	1	2.23	1.1	56.91	31.78
8.67	3.67	4.5	3	1.2	1	3.9	1.7	64.47	46.17
7.5	3	3.38	2.25	1.2	1	2.44	2.3	63.52	37.85
7.43	2.28	3.86	2.57	1.2	1	2.79	1.49	65.98	35.87
9.6	4	5.2	3.9	1.2	1	3.71	2.23	65.95	39.09
8	3	4.55	3.4	1.2	1	3.48	1.86	47.41	29.00
8	3.33	3.79	3	1.2	1	3.1	2.48	63.23	29.37
9.33	2.67	4.55	3	1.2	1	3.25	2.6	53.01	27.23
8	3.33	8.67	6.5	1.2	1	5.57	3.87	60.56	39.46
9.6	4	6.5	5.2	1.2	1	5.57	3.7	56.36	35.24
6.5	2.75	5.69	4.06	1.2	1	4.18	2.9	54.09	35.47
12	5	8.13	4.88	1.2	1	4.64	3.48	69.01	37.00
10.4	4.8	4.55	3.64	1.2	1	4.64	3.7	54.47	35.06
6.67	3.33	4.04	3.54	1.2	1	5.78	3.7	59.59	34.03
8	4	4.55	3.8	1.2	1	4.64	3.7	66.19	40.30
9.6	4	5.46	3.64	1.2	1	5.57	3.34	64.03	43.98
6.86	2.86	5.25	4.55	1.2	1	3.98	3.18	60.59	36.49
10	3.5	4.55	3.4	1.2	1	4.64	3.48	57.00	34.29

Depending on survey data and above discussion the survey summery for the average micro component of household demands can be written as like Table 4.8

Table 4.8 Average per capita water consumption in daily house hold activities (Based on the study survey)

SL No.	**Item**	**Limit Range(GPCD)**	**Average (GPCD)**
1	Drinking and Cooking	0.8-1	1.15
2	Bath Room(Single Bath)	8-14	11
3	Toilet	4-11	7.5
4	Faucets	7-12	9.5
5	Dish wash	4-9	6.5
6	Laundry	2-4	3
7	Others	2-3	2.5
8	Total	28-54	41 (186 LPCD)

Therefore people need water 28-54 GPCD (127-245 LPCD) water for drinking as well as other purpose such as bathing, toilet, and hand washing (faucets), dish washing (kitchen) and laundry. Basically it was found that the all high income group and less than 50% of middle income group houses have flushing system toilet and they take bath from shower. Their water consumption is higher than the houses having no flushing toilet and shower. The average water consumption for these two groups is shown the Table 4.9

Table 4.9 Water consumption for Different type plumbing fixtures houses

House Types	Minimum water use GPCD	Maximum water use GPCD
Houses having toilet flushing and shower	34	62
Houses having no flushing toilet and shower	28	48

Beside this other domestics areas for water demand are in car washing, gardening, building construction and other developments works. Usually water in a society is also used for other purposes rather than domestic uses such as commercial use, public uses, and livestock etc.

In absence of other reliable data the survey result has been compared with the per capita water consumption for other countries in the world .The purpose is to make the survey results more acceptable. Domestic's consumption in other cities in the Asia and Dhaka is shown in Table 4.10

Table 4.10 Comparison of per capita water consumption between different cities in the Asia and Dhaka

Country	Domestics uses in LPCD
Colombo	119
Delhi	110
Karachi	197
Kathmandu	68
Kuala Lumpur	132
Manila	127
Osaka	263
Ho ChiMinh	167
Dhaka	**186 (41 GPCD)**

(ADB, 2004 and Study calculation)

Outdoor water use in Dhaka city varies considerably in different apartments. The apartment which have some places for garden and if all flats have their own car then the out door use become more high than other types of apartments. Generally the out door use is less than 5 gallons per person per day.

Based on the survey analysis future water requirements will be increased. As currently, pail toilets need about 4 L per use and will be replaced by flush toilets in future. Toilet consumption will surely increase, and the amounts will differ greatly depending on whether water-saving flush toilets (6 L / flush) or usual flush toilets (10 L / flush) are introduced. With respect to clothes-washing, the current popular method is washing by hand. The consumption of water for laundry per capita is low. It will be replaced by a fully automatic washing machine. The usual automatic type consumes about 150-200 L per load. If the automatic washing machine becomes widely used, the amount of water consumption for laundry use will become higher than the present. Bath consumption will also differ if people will replace the traditionally bathing style like shower and bucket with running tap by using bath tub. There is one factor that would increase water use in kitchens in the immediate future. That is if people will use dish washer to wash the dirty dish. Thus, when planning the future water supply in Dhaka city the study have to encourage people to install water-saving appliances and devices in conjunction with water planning. It will avoid a waste of time and money, and over-development.

4.9 Attitudes and Preferences of the Residential Water User's Questionnaire Survey Result

Keeping an adequate supply of high quality water flowing from taps and disposing of wastewater requires considerable effort and expense. The less People use, the less effort and expense are required to supply us with water. The smaller the volume of wastewater produced, the less it costs to treat it. Where sewage treatment plants are already overloaded, this reduction would lessen pollution by improving waste treatment. With today's high costs for water, sewer service, and energy, conservation through efficient plumbing fixtures and appliances can result in significant homeowner savings.

4.9.1 Reliability of the Water Supply Network

4.9.1.1 Water pressure and operational problems

The fact that more than two out of three citizens use a water deposit device (Bucket / Jar to store water) in their residence (Figure 4.11) indicates that the water supply network has in some extent operational problems that need to be examined and repaired. The use of water reduced pressure devices however, indicates no major water pressure problems. The others do not use anything. They just use the supply water.

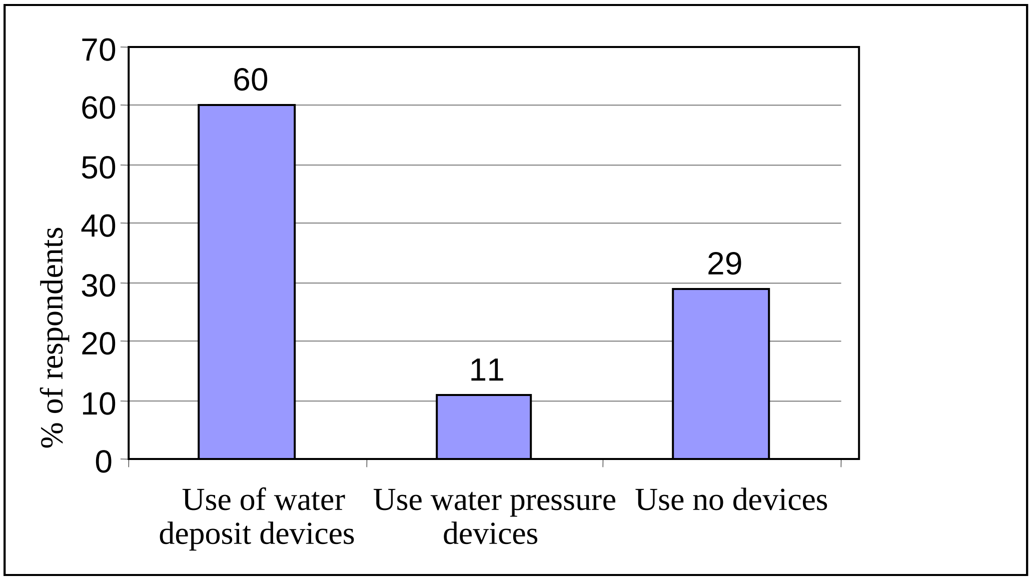

Fig. 4.11 Use of water deposit and water pressure vessel devices

4.9.1.2 Frequency of water breakdown

According to the survey, (Figure 4.12), a substantial part of the respondents, almost one out of three, claim frequent water break down. It is important to note that this frequency may become double before some year ago. This drawback needs to be seriously taken into consideration as it reduces the reliability of the supply network.

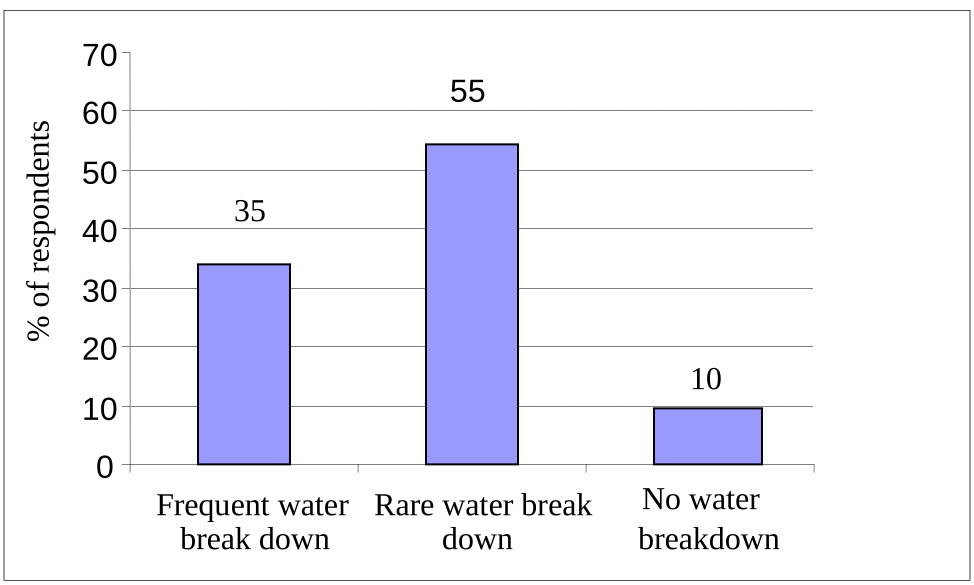

Fig. 4.12 Frequency of water breakdown

4.9.2 Reliability level of tap water quality

Water quality problems mostly connected with long term health risks are considered to be of first priority for the citizens of Dhaka. In this context, the reliability level of tap water appears to be very low, (Figure 4.13). The situation seems to be worse today than previous year. The justification for this fact must lie rather in the old and poorly maintained water supply infrastructure, which creates problems in the taste; purity and odor of tap water, than in actual water quality degrade incidents. Although most respondents find tap water quality not satisfactory, a substantial part of the respondents, around seven out of 10, (Figure 4.13), trust and drink permanently tap water, with only boiling and without the use of additional water cleaning devices that improve taste and odor of water. However, a significant 13% of the respondents claim that use some times bottled water for drinking purposes, although its price is 3000 times higher than the price of the tap water. This is a proof that the bottled water industry has done an excellent job in promoting its product as a safe alternative to tap water, even though it is well known that bottled water has been subject to much less stringent health regulations.

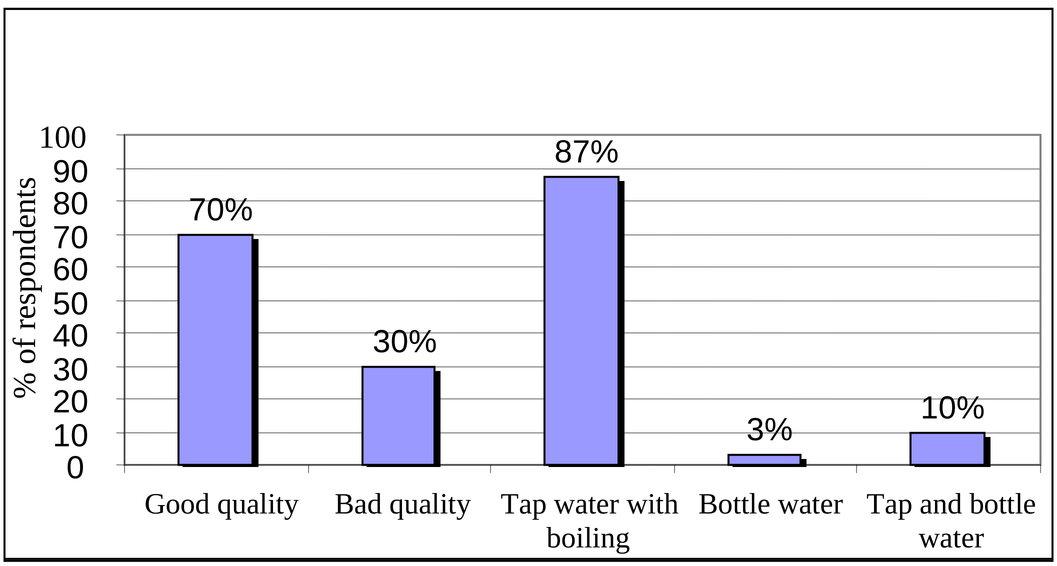

Fig. 4.13 Level of public satisfaction and trust to use with regard to tap water quality

4.9.3 Willingness to reduce consumption

Most consumers, as shown in Figure 4.14, claim they cannot reduce their consumption rates without impact on their quality of life. This means that they are not ready to save water either because they think they are not using more water, almost one out of three respondents claims they are ready to reduce consumption without any change in their quality of life. In this category of consumers, water conservation methods could be applied with great success.

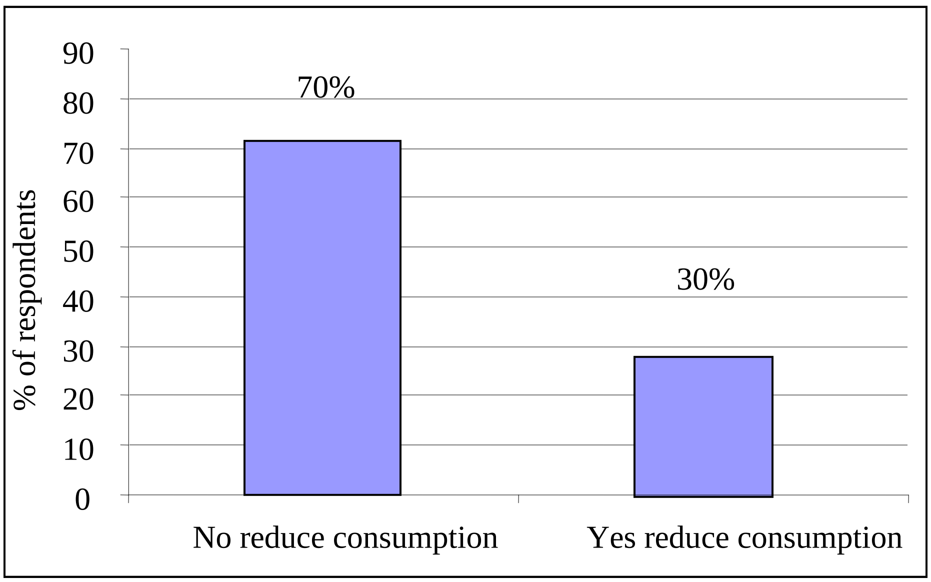

Fig. 4.14 Willingness to reduce consumption with no impact in quality of life

4.9.4 Acceptability of demand versus supply management options

Poor popularity and low acceptability level of the demand management options in Dhaka water supply is the result of this part of the survey. As shown in Figure 4.15, three out of four consumers are reluctant to adapt demand management practices as they believe that the solution to water shortages will come mostly from the construction of new engineering projects. Only one out of four people believe today that water conservation through the use of economic tools and information policies may be the solution to future water shortages. Thus demand management practices gain low social acceptability.

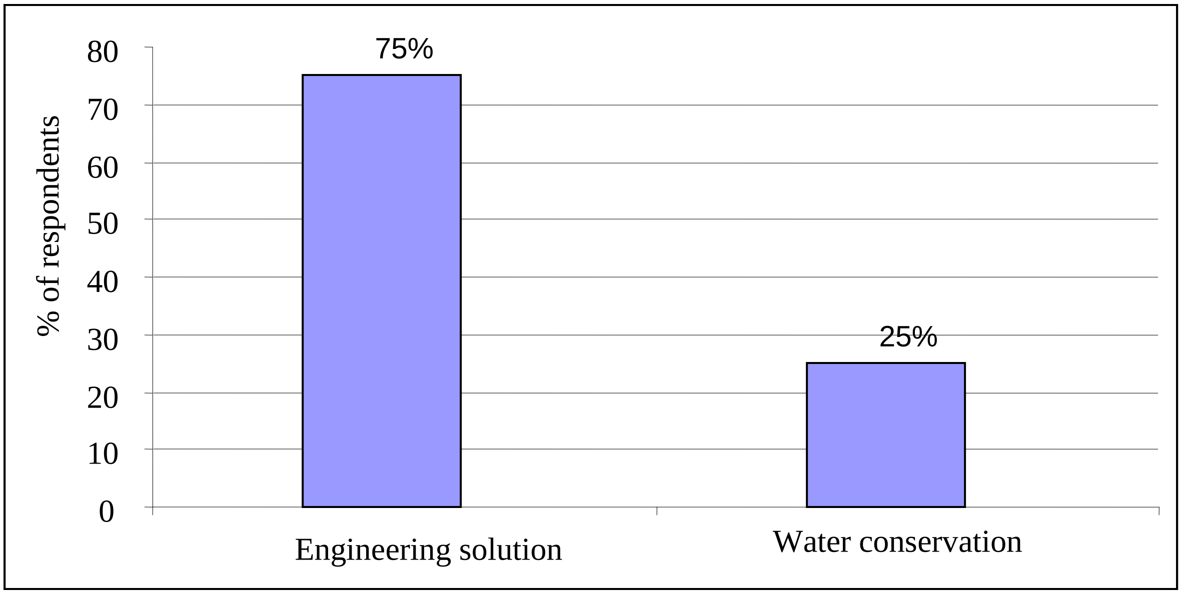

Fig. 4.15 Acceptability of demand versus supply management options

4.9.5 Water Pricing Policy

4.9.5.1 Valuation of water price

The majority of the respondents (Figure 4.16) believe that water price is acceptable. Those people pay the house rent 5-6 Taka/ Sq. ft/ month (about 10%) think that the water price is high. Other category who pays the house rent 11-13 taka/ sq.ft/month think the water tariff is low. According to the survey which is 15% of the total respondents. This can be explained by the fact that the pricing policy during the last 10 years has remained nearly unchanged, which means that the price of water has actually decreased in real term.

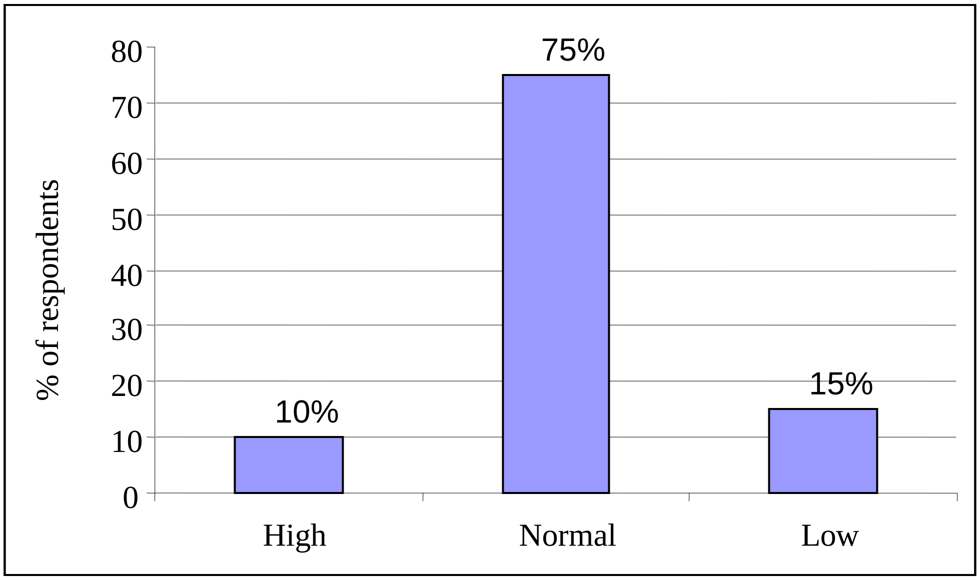

Fig. 4.16 Valuation of water price

4.9.5.2 Water pricing policy as an incentive for water conservation

It is interesting to note that almost one out of five respondents, (Figure 4.18), consider water pricing to be an effective tool for water conservation. However there is ground for public awareness and information policies, as more than half of the respondents don't believe in the effectiveness of the measure of water pricing indicating either that residential water use is not dependent on price, or that water price and its rate structure today is too far from acting as an incentive for water saving and conservation. Among them the water utility can find the perfect target group of its potential campaign for water conservation. Figure 4.17 shows that the low level of water tariff in Dhaka city compared with other countries in the world.

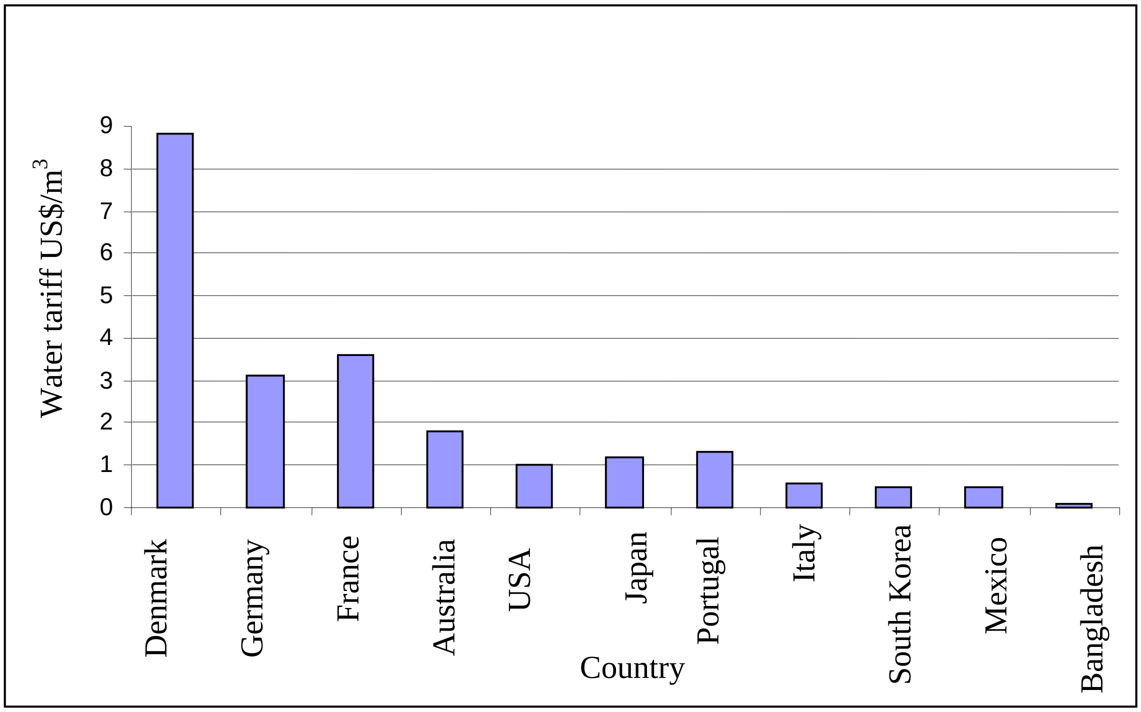

Fig. 4.17 Low level water tariff in Bangladesh comparing with other countries in the world

It is obvious that the current price of water in the city of Dhaka cannot promote its conservation since only one out of five respondents modifies their consumption taking into account its price Figure 18. The majority of the water consumers claim that their water consumption habits are not affected by the price of water at all. Among those who characterizing themselves as poor consumers, only affected by the water pricing policy. As expected, those who are ready to modify their water consumption in relation to the price are the consumers, who believe that the price of water is high.

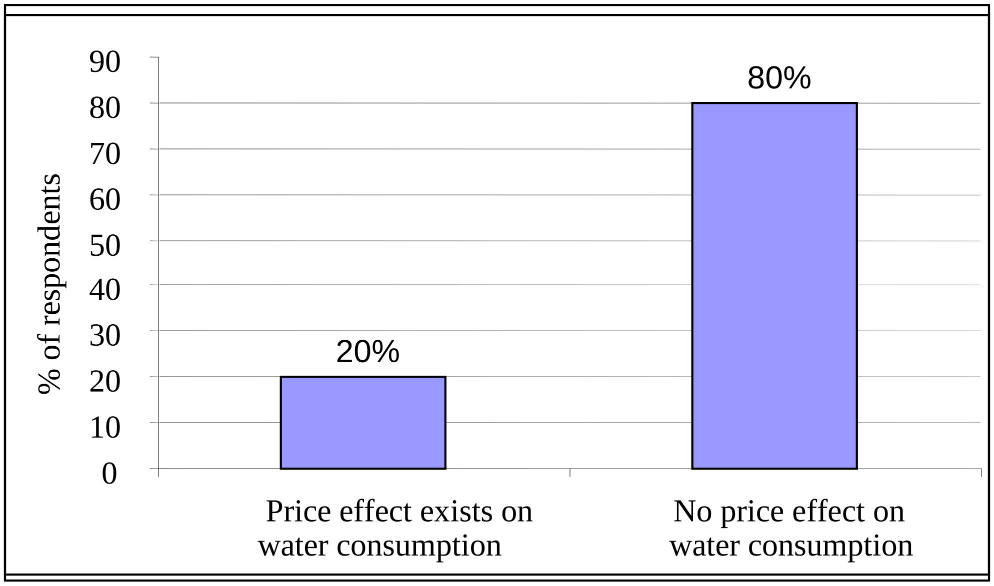

Fig. 4.18 Price effect on water consumption

4.9.5.3 Willingness to pay

More than half of the respondents are willing to pay extra for the improvement of the water services, with the more popular raise in water price for the majority of them being 10–20%, (Figure 4.19). However the significant 55% of respondents not willing to pay anything extra should be seriously taken into consideration by the water utility and should be connected with the low reliability of its infrastructure and services. These results are not satisfactory as more people today believe that the price of water is low enough.

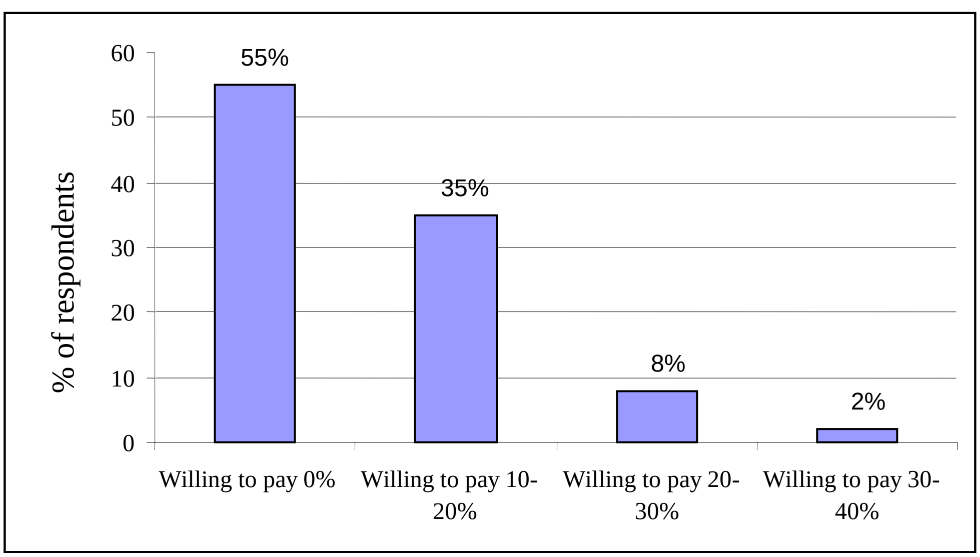

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Fig. 4.19 Willingness to pay (WTP) for water services improvement

4.9.6 Public Awareness

4.9.6.1 Sensitivity to the existence of water related

Problems The majority of people, nine out of ten, are aware concerning the existence of some kind of water related problems today, while only 1 out of ten is in an optimistic mood believing that no problems exist at all, (Figure 4.20). The current water problems are specified both as water availability and water quality ones. Water quality problems are more emphasized by the consumer's com- paring to the water resources availability ones, while the combination of both is the most popular option.

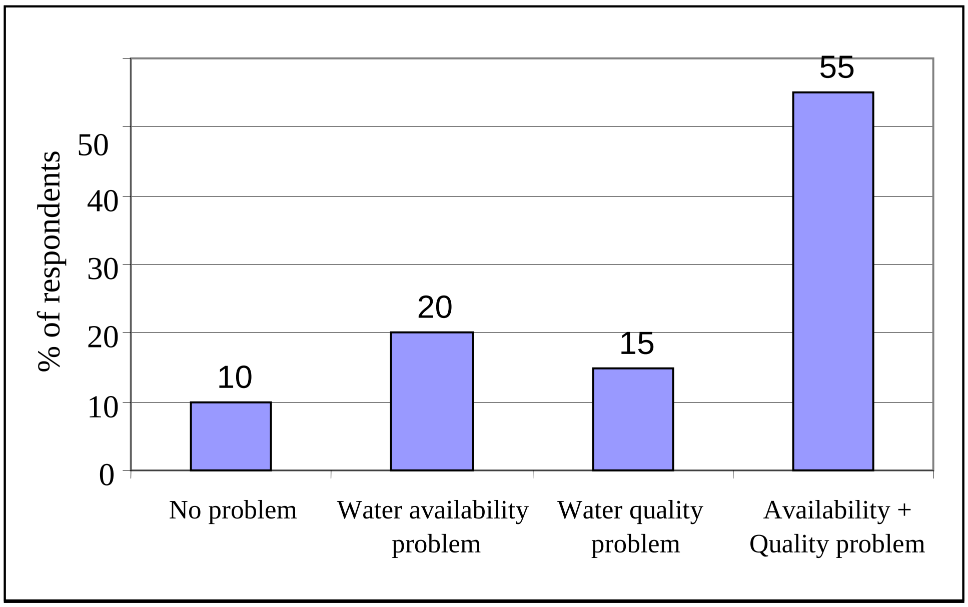

Fig. 4.20 Current water problems

4.9.6.2 Need for information policies

Public information levels are extremely low since the majority of the respondents ask for better information concerning water issues (Figure 4.21). The respondents are willing to get informed mostly from special editions issued by the water agency or local media (radio, TV, newspapers). The percentage exceeds 100 because the respondents had the opportunity to answer to multiple choices.

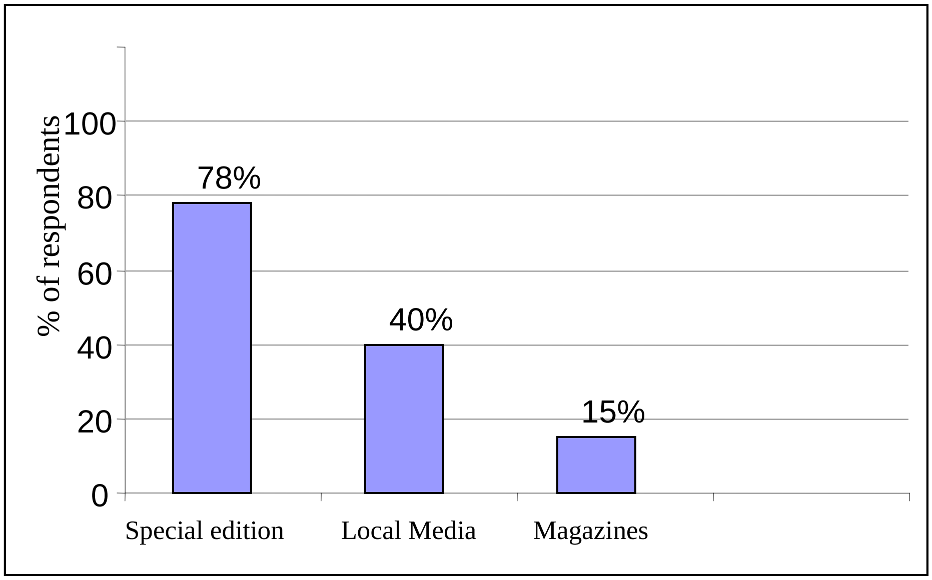

Fig. 4.21 Need and kind of information policy

4.10 Savings of Water from Efficient Plumbing Fixture with Habitual Change

Communities could save hundreds of millions of dollars on water and sewage facilities through water conservation. Bathing and flushing the toilet account for most water consumption in homes. Drinking and cooking are insignificant compared to the other uses. Figure 4.22 details typical domestic use.

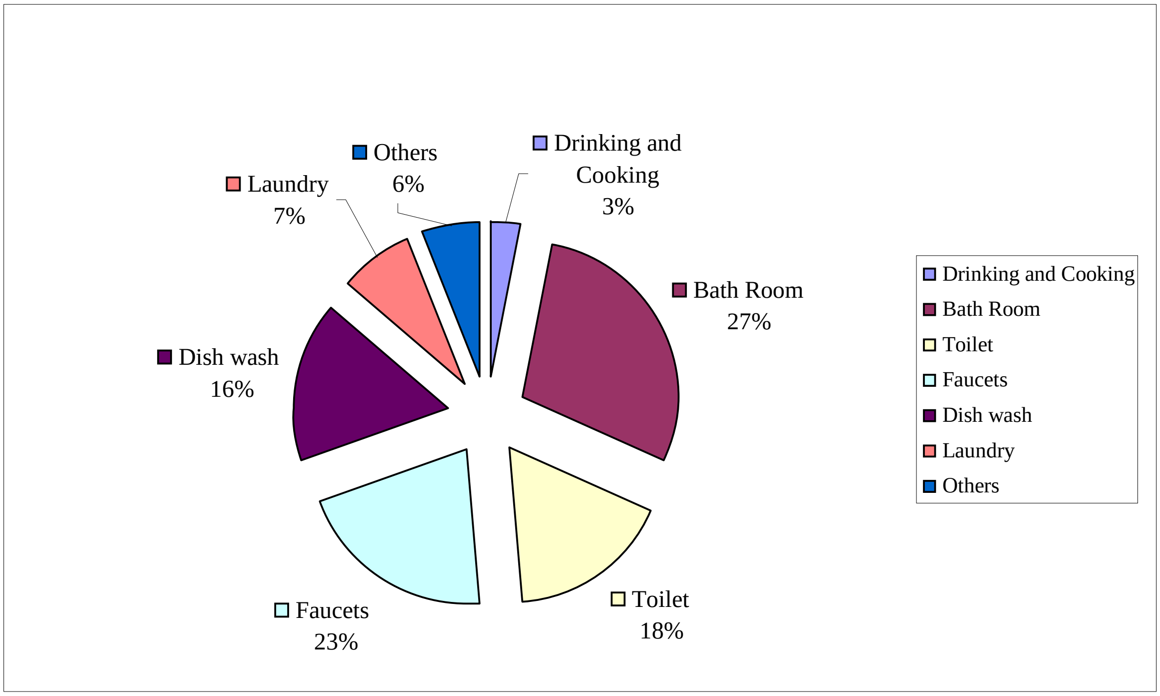

Fig 4.22 Household water consumption

4.10.1 Saving from toilet

Toilets and bath utilize the most water (45% of total indoor use). As discuss earlier there are two category of toilet water user in Dhaka city. Category 1 has flushing toilets. Category 2 has non flushing toilet.

According to the survey, about 45% users are in category 1. Both water savings plumbing fixtures and habitual change have the effective impact to save the water from flushing toilet. Replacing conventional 2.2 gal (4 US gallons) per flush (gpf) toilets with 1.33 gpf (1.6 US gpf) toilets throughout the home will save approximately 2.0-5.0 gallons(2.4-6.0 US gallons) of water per day per person, which translates into over 700- 1800 gallons (850-2100 US gallons) each year per person (Table 4.1). Low-flush toilets, like the 1.33 (1.6 US) gpf models are required in all new construction in the Dhaka City. Air arrested toilet and dual flushing toilet will be another conservation devices to save the water. Avoid flushing the toilet unnecessarily is a habitual measure. Dispose of tissues, insects and other similar waste in the trash rather than the toilet and save gallons every time.

According to the survey about 55% people are in category 2 who use jug after toilet. In this category user can save only water from their habitual change. Average people of this category use 4-8 GPCD (Avg. 30 L). But it was recommended that (6-10 LPCD) is the basic requirement of water for this type of sanitation purpose (Table 2.5). Thus depending on the frequency of use water can be saved from this type of toilet. It can be recommended that if they reduce the use of one jug from each toilet use (considering 5 times in a day) approximately 1.5 -2.5 gallon of water will be saved per day per person which means 550-900 gal/ person /year water can be saved. The saving of water from two category shows in Table 4.11 and Figure 4.23

Table 4.11 Estimated water saving from water efficient plumbing fixture and habitual change in toilet use

Category 1	**Frequency of use**	**Daily water use without water conservation device(2.2 gal/ flush) gpcd**	**Daily water use with water saving device(1.33 gal / flush) gpcd**	**Daily water savings with water saving devices(gal / person)**	**Annual water savings (gal / person)**
Flushing Toilet savings from conservation devices	3 times in a day	6.6	3.99	2.61	952.65
	4 times in a day	8.8	5.32	3.48	1270.2
	5 times in a day.	11	6.65	4.35	1587.75
	6 times in a day	13.2	7.98	5.22	1905.3
Category 2	Frequency of use	Daily water use	Daily conservative use(gpcd)	Daily water savings with conservative practices (gpcd)	Annual water savings (gal / person)
Non flushing toilet (Habitual savings)	3 times 4 jug / use (0.44 gal/ jug)	5.28	3.96	1.32	481.8
	4 times 4 jug / use (0.44 gal/ jug)	7.04	5.28	1.76	642.4
	5 times 4 jug / use (0.44 gal/ jug)	8.8	6.6	2.2	803
	6 times 4 jug / use (0.44 gal/ jug)	10.56	7.92	2.64	963.6

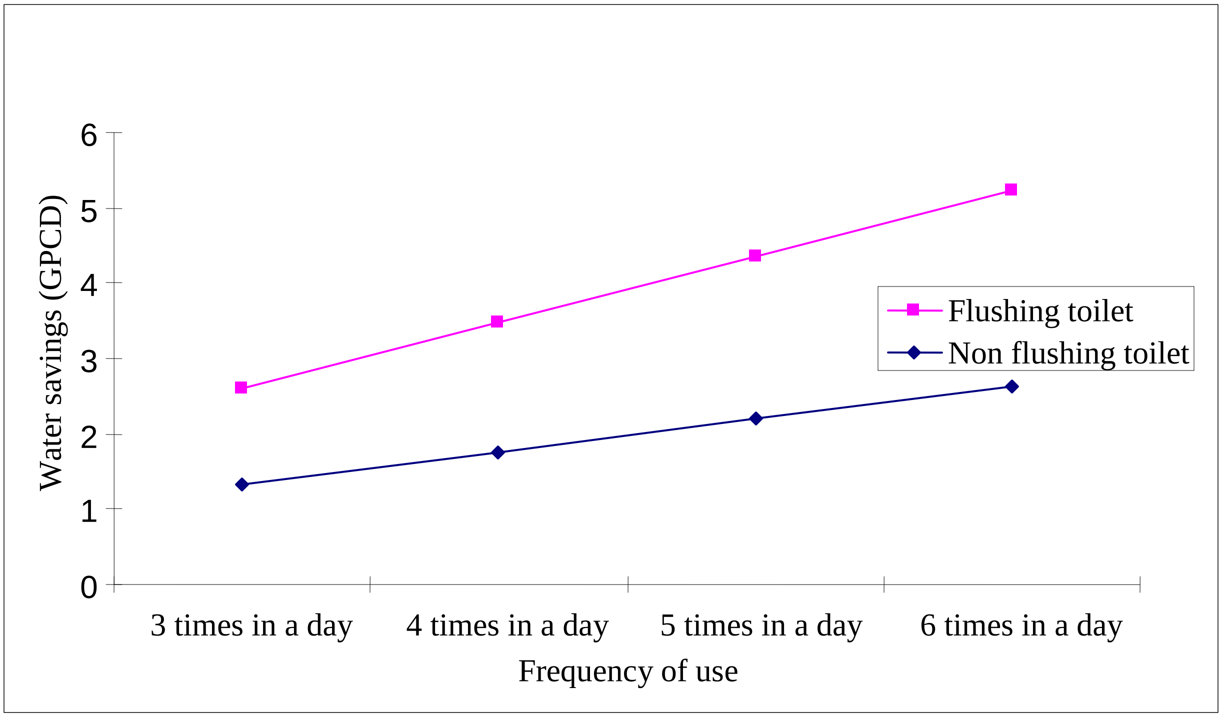

Fig.4.23 Water savings from flushing and non flushing toilets

4.10.2 Water saving from low shower heads and habitual change in bathing

For category-1 (people who use shower for bath), replacing conventional 2.5 gpm showerheads with the low-volume, 1.67 gpm models will save approximately 4-8 gallons of water per day per person at house hold (Table 4.12). Low-volume showerheads are inexpensive, simple to install, and can save large amounts of water and energy. Category 2 uses bucket for bath. They can save water only from habitual change. According to the several studies it has been recommended that basic water need for bathing for a human is 15-20 LPCD (Table 2.6). But Average people in Dhaka city use 11GPCD (50LPCD) water for their bathing purposes. Thus the category 2 can use 25% less water for taking bath. If they use one bucket less (4.55 gallon or 20 liters water from their daily habit, the water will be saved approximately 1600 gallon of water per person per year. Both saving shows in Table 4.12 and Figure 4.24 and 4.25

Table 4.12 Estimated water saving from bathing

Item	Frequency of use	Daily water use without water conservation device (2.5 gal/ flush)	Daily water use with water saving device (1.66 gal / flush)	Daily water savings with water saving devices (gal/person)	Annual Water savings (gal/person)
Shower	5 min in one bath/ day	12.5	8.3	4.2	1533
	6 minutes in one bath / day	15	9.96	5.04	1839.6
	7 min in one bath / day	17.5	11.62	5.88	2146.2
	10 min in one bath / day	25	16.6	8.4	3066
Using bucket	3 bucket(4.55 gal) in one bath /day	13.65	9.1	4.55	1660.75
	4 bucket(4.55 gal) in one bath /day	18.2	13.65	9.1	3321.5
	3 bucket (4.55 gal) in each bath (two times)/day	27.3	9.1	18.2	6643

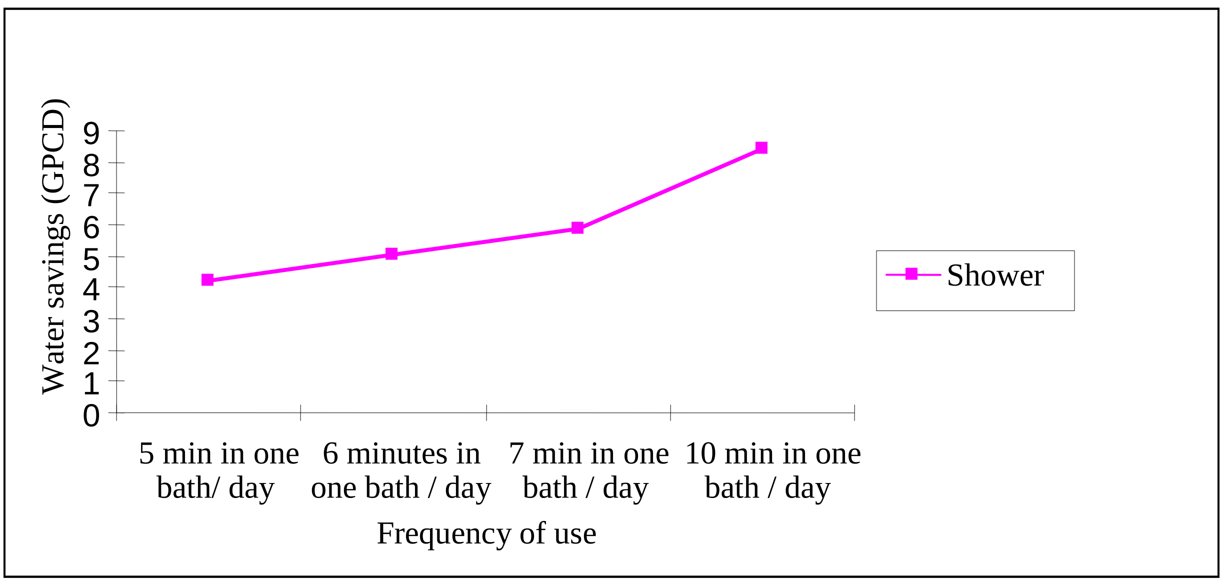

Fig. 4.24 Water savings from bath (Category 1)

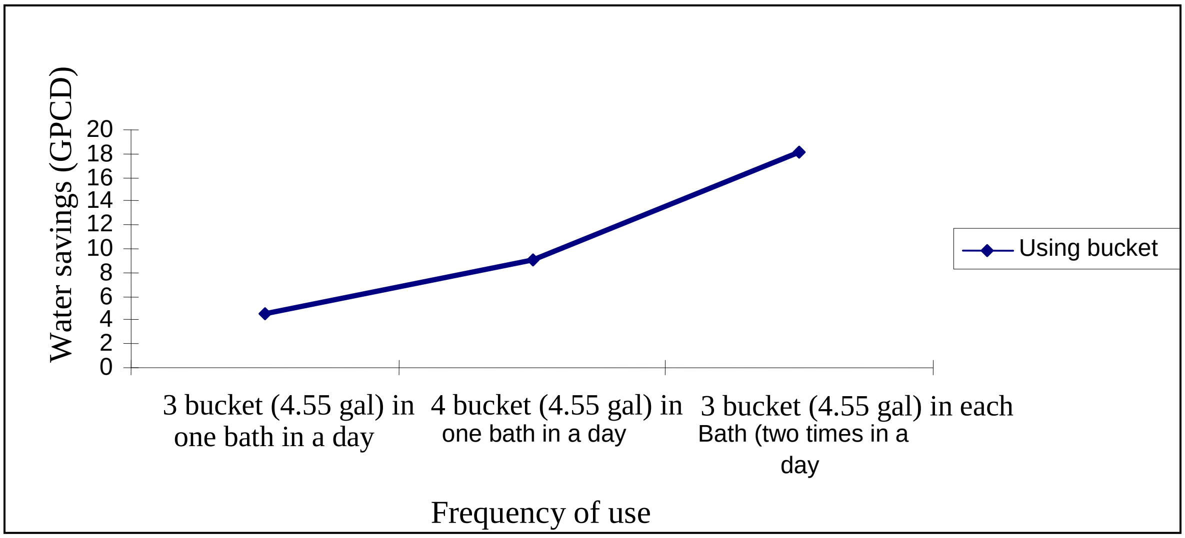

Fig. 4.25 Water savings from bath (Category 2)

4.10.3 Water savings from faucets water use

As per survey the conventional faucet flow rates are 2.5gpm, 2.2 gpm or 2.0 gpm. The people are habitually running the faucets with full flow rate. Replacing typical faucets with 1.33 gpm models or changing the behavior of the people to reduce the flow rate during the use of faucets water will save approximately(3-8 gpcd) 1200- 2900 gallons of water (Table 4.13) per year per person in your home. Figure 4.26 shows the water savings for different frequency of use of water

Table 4.13 Water savings from faucets use

Item	Frequency of use	Daily water use without water conservation device (gal/person)	Daily water use with water saving device (gal/person) (Faucets rate 1.33 gpm)	Daily water savings with water saving devices (gal/person)	Annual Water savings (gal /person)
Faucets	7 minutes in a day (2.5 gpm)	17.5	9.31	8.19	2989.35
	7 minutes in a day (2.2 gpm)	15.4	9.31	6.09	2222.85
	7 minutes in a day (2 gpm)	14	9.31	4.69	1711.85
	6 minutes in a day (2.5 gpm)	15	7.98	7.02	2562.3
	6 minutes in a day (2.2 gpm)	13.2	7.98	5.22	1905.3
	6 minutes in a day (2.0 gpm)	12	7.98	4.02	1467.3
	5 minutes in a day (2.5 gpm)	12.5	6.65	5.85	2135.25
	5 minutes in a day (2.2 gpm)	11	6.65	4.35	1587.75
	5 minutes in a day (2.0 gpm)	10	6.65	3.35	1222.75

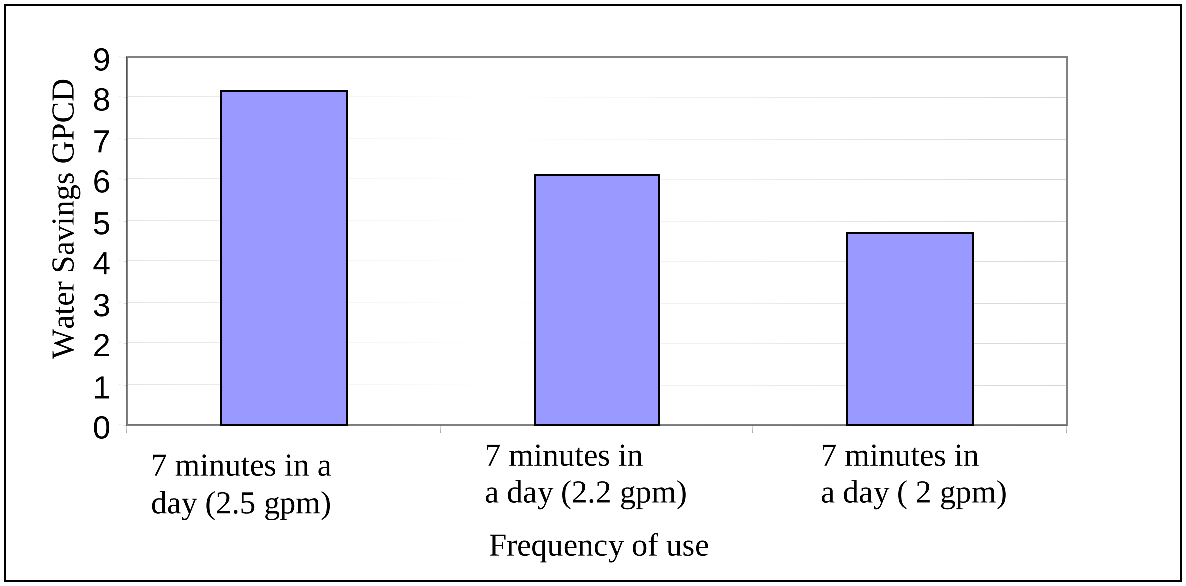

Fig. 4.26 water savings from faucets use

4.10.4 Water savings from dishwasher

Washing clothes and dishes consumes the second largest amount of water (23%). After this water has been used, it becomes wastewater and drains to a sewer line. According to survey a house of 5 people required maximum 9 GPCD water to wash the dish. But only two loads will require if they use new dishwasher. In that case 1.5 GPCD water will require per person. Introducing new automatic dishwashers save water, as well as energy, by limiting hot water use.

Potential savings from water conservation practices are shown in Table 4.14. Though the savings of water from dishwasher is not a confirmed saving. Because the water requirements for dish wash vary home to home depending on the family member.

Table 4.14 Estimated water savings from various conservative practices

Item	Daily water use without water conservative practices (gal/person)	Daily water savings with water conservation practices (gal/person)
Toilet	5-13	2-5
Shower	12-18	4-8
Faucets	10-17.5	3-8
Dishwasher	4-9	**7.5***
	Total use 31- 57 GPCD	9-21

* Savings from dishwasher is not considered here. As this option still unavailable in Dhaka city

Thus according to the above discussion about 30 % water can be saved by the conservation practices in our daily house hold life.

4.11 Benefits of Water Savings or Conservative Practices

The most obvious advantage of domestic water saving from toilet, bathroom etc is that it potentially can replace some potable water consumption in uses. Reduce the water use may offer financial savings to homeowners and helps to mitigate the water crisis in Dhaka city. However, diminished sewer flows could potentially result in insufficient flows to carry waste to the sewer plant (e.g. pipes with low slopes), or may result in a high strength sewage that combined with lower flows may lead to odor and corrosion problems in the centralized sewerage systems.

4.11.1 Minimize the water deficit

The average family of six uses required 246 gallons of water in a day – 89790 gallons in a year. By savings 15% water from daily uses, 13468 gallons of freshwater has been saved each year by this family. In Bangladesh alone at Dhaka city 550 MLD shortage of water supply specially at summer season. By savings 15% water from daily use among the 15% consumer of DWASA, 54 MLD deficit of water can be recovered. Moreover waste water load on municipal sewerage lines have also been reduced.

4.11.2 Cost savings for the dweller

There is savings from the reduction in people water use. Depending on the habit and system, the total savings may not offset people expenses. In order to estimates the possible water and cost saving by water conservation practices the study is considered 3 scenarios. The scenarios considered in this study are shown in Table 4.15.

Table 4.15 Total water demand and payable bill for different scenarios

Scenario	**Building Type**	**Total number of Flat**	**Total number of People**	**House hold use in LPCD**	**Total water demand in a month m^3/month**	**Total payable bill in Taka per Year**
Scenario 1	Single	12	60	186	334.8	51425
scenario 2	Single	40	200	186	1116	171418
scenario 3	Community	160	800	186	4464	685670

NB: Considering per capita consumption 41 GPCD / 186 LPCD

By practicing water conservation the saving in water demand and saving in water bill for different scenarios (Table 4.16) will give people more interest to save the water.

Table 4.16 Saving in water bill for three scenarios by savings of water

Scenario	Water savings percentage	Water savings amount LPCD	Total savings of water from the apartment m^3/month	Total Cost saving per month	Total Cost saving per year in Taka	Total Cost saving per year in US$
Scenario 1	10	19	34	430	5158	74
	15	28	50	645	7737	111
	20	37	67	860	10315	149
	30	56	101	1289	15473	223
Scenario 2	10	19	112	1433	17192	248
	15	28	168	2149	25789	372
	20	37	224	2865	34385	495
	30	56	336	4298	51577	743
Scenario 3	10	19	448	5731	68770	991
	15	28	672	8596	103155	1486
	20	37	895	11462	137540	1982
	30	56	1343	17192	206309	2973

NB: Combined Tariff (Water tariff +Sewer tariff) 12.80 taka per m^3

By savings 10%-30% water, the water bill savings for the city dweller has been estimated for the three scenarios. The estimated values are approximately 5000-15000 Taka per year for scenario-1, 17000-51000 taka per year for scenario-2 and 68000-200000 Taka per year for scenario-3. More water and more cost can be saved for scenario-3 with single grey water or reclaimed waste water reuse process. Thus reuse system can be installed for scenario 3. Yearly water demand and cost saving for three scenarios by only 15% of water savings is shown in Figure 4.27

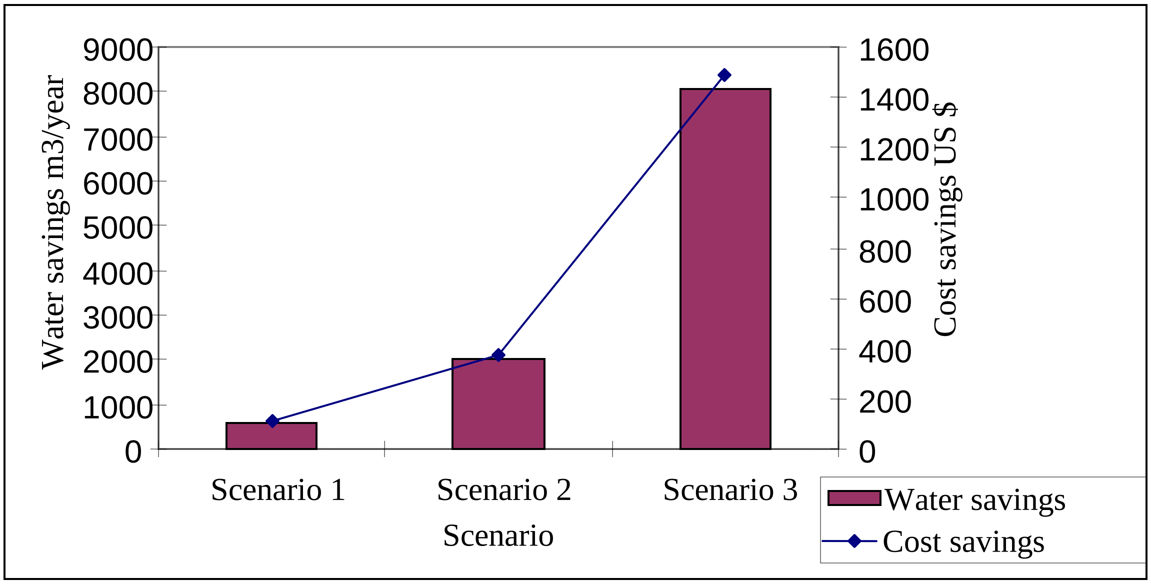

Fig. 4.27 Water and cost savings for three scenarios by savings 15% water from daily use

Some times the city dwellers have been suffering for water crisis through out the month. In month April –May some people receive water on an intermittent basis. And they depend on the DWASA Vehicle water or buy bottle water to fulfill their requirements. With reference to Table 3.6 about 1100L vehicle cost becomes 75 taka. So per m^3 water cost become 66tk whereas normal flat rate is 6.05 taka per m3. On the other hand the average bottle water rate is 11000 Taka/m^3. And lowest bottle water (Jar water) rate is 3000 Taka/m^3 (Table 3.7). People have to buy water from the authority and shop in high price. Moreover DWASA have not enough vehicle support to supply the water to 2 million. Conversely most of the people have not enough money to buy this type of water. By savings the water from daily use the cost saving can be compared with the vehicle and bottle water cost. The Table 4.17 and Table 4.18 show the cost saving for three scenarios comparing with the DWASA vehicle water rate and bottle water rate

Table: 4.17 Saving in water cost comparing with DWASA vehicle water cost by savings of water

Scenario	Savings percentage	Vehicle water Unit rate taka/m^3	Total Cost saving per month in Taka	Total Cost saving per month in US$
Scenario 1	10	66	2216	32
	15	66	3324	48
	20	66	4432	64
	30	66	6649	96
Scenario 2	10	66	7387	106
	15	66	11081	160
	20	66	14775	213
	30	66	22162	319
Scenario 3	10	66	29550	426
	15	66	44324	639
	20	66	59099	852
	30	66	88649	1277

Compared to DWASA vehicle water rate, the cost saving by 15% conservative use of water for scenario 1 is 32 US$, for scenario2 is 160 US$ and for scenario 3 is 639 US$. The cost savings for 3 scenarios is showed in the Figure 4.28 comparing normal tariff and DWASA vehicle water rate.

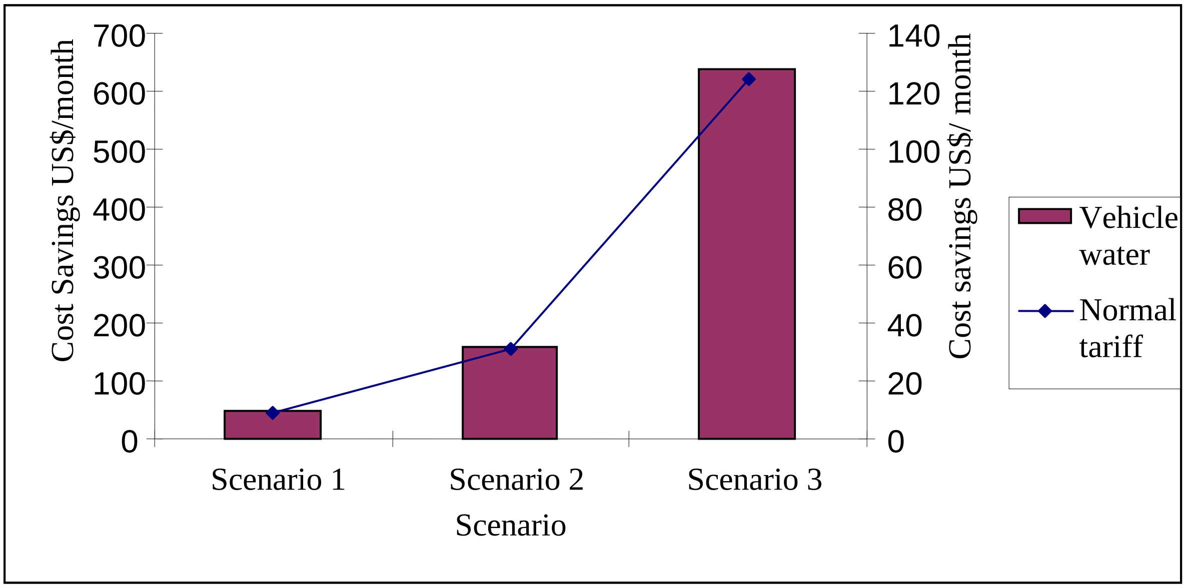

Fig. 4.28 Cost savings by 15% savings of water comparing with vehicle water rate and normal tariff

Table 4.18 Saving in water cost comparing with bottle and Jar water cost by conservative practices of water

Scenario	Savings percentage	Bottle water rate (Average) Taka/m3	Jar water rate (minimum) Taka/M3	Average cost savings per month in Taka	Minimum cost saving Taka per month in Taka	Average cost saving per month in US$	Minimum cost savings per month in US$
Scenario 1	10	11000	3000	369369	100737	5322	1451.54
	15	11000	3000	554054	151106	7983	2177.31
	20	11000	3000	738738	201474	10645	2903.08
	30	11000	3000	1108107	302211	15967	4354.63
Scenario 2	10	11000	3000	1231230	335790	17741	4838.47
	15	11000	3000	1846845	503685	26612	7257.71
	20	11000	3000	2462460	671580	35482	9676.95
	30	11000	3000	3693690	1007370	53223	14515.4
Scenario 3	10	11000	3000	4924920	1343160	70964	19353.9
	15	11000	3000	7387380	2014740	106446	29030.8
	20	11000	3000	9849840	2686320	141929	38707.8
	30	11000	3000	14774760	4029480	212893	58061.7

The cost savings for three scenarios comparing with bottle water and jar water by practicing 15% conservative use of water is shown in figure 4.29

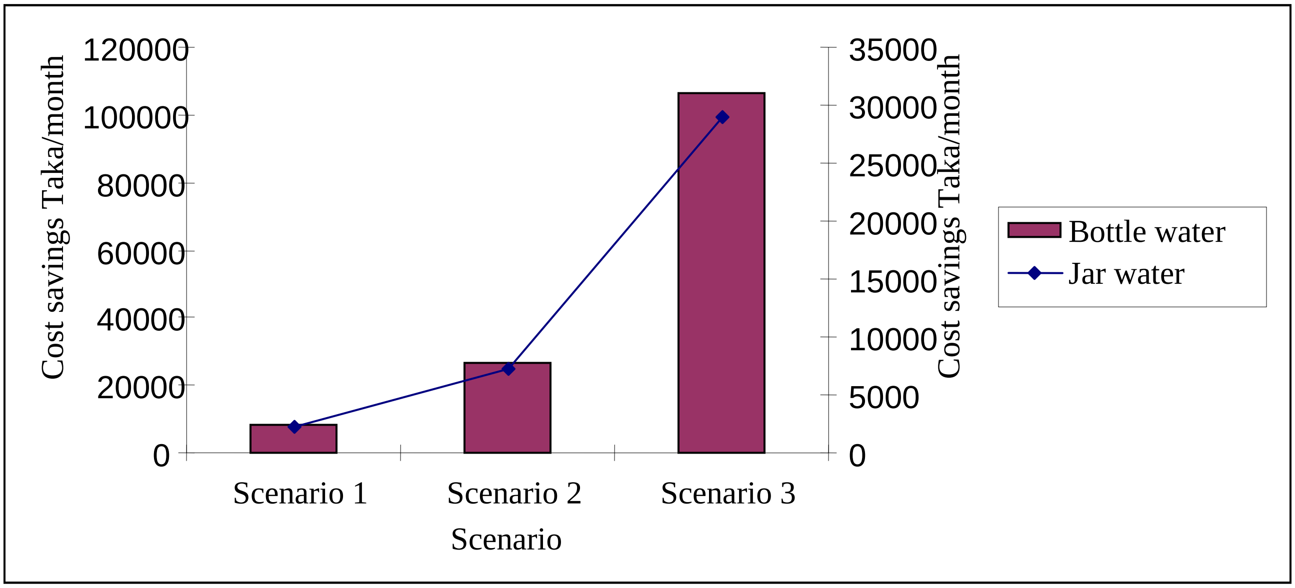

Fig. 4.29 Cost savings by 15% savings of water comparing with bottle water and jar water rate

4.11.3 Electricity savings for the authority

A significant amount of energy required to pump and treat the water for use. By saving the water, decrease in energy consumption will support the authority to minimize the energy crisis in Dhaka city. Table 4.19 shows the per unit water production cost for different DTWs.

Table: 4.19 Electricity unit and cost per m^3 water production

Name of water pump	**Electricity cost per m^3 water production, in taka**	**Electricity unit per m^3 water production (Kwh)**
Mohammadia Housing Society	1.21	0.25
Rafiq Housing	1.57	0.3
Dhaka Udan	1	0.31
Monsurabad	1.13	0.24
Tikkapara	1.37	0.26
Iqbal road	2.09	0.43
Average	1.4	0.3

NB: Off peak Rate= 3.43 taka per unit (Kwh)
Peak Rate= 7.12 taka per unit (Kwh)
Flat Rate= 4.12 Taka per unit (Kwh)
(DWASA, 2010)

On an average 0.3 unit (Kwh) of energy required for per m^3 water production from DTws. The below Table 4.20 shows the energy saving by savings the different percentage of water for three scenarios

Table: 4.20 Energy savings by savings of different percentage of water

Scenario	% of water savings	Water savings in m^3/day	Water savings in m^3/month	Electricity unit saving per month from national grid
Scenario 1	10%	1.1	33.5	10
	15%	1.7	50.2	15
	20%	2.2	67.0	20
	30%	3.3	100.4	30
scenario 2	10%	3.7	111.6	33
	15%	5.6	167.4	50
	20%	7.4	223.2	67
	30%	11.2	334.8	100
scenario 3	10%	14.9	446.4	134
	15%	22.3	669.6	201
	20%	29.8	892.8	268
	30%	44.6	1339.2	402

NB: Electricity unit per m^3 water production is 0.3 Kwh (Table 4.20)

Hence saving only 15% of water for scenario-1 the study shows that 15 units (Kwh) energy can be saved from the national grid per month. Whereas scenario- 3 shows the electricity saving amount is 201 units (Kwh) which can give an effective support to supply the electricity of a house in Dhaka city for whole month. Water and electricity savings per month for three scenarios by savings 15% of water from daily uses is shown in Figure 4.30

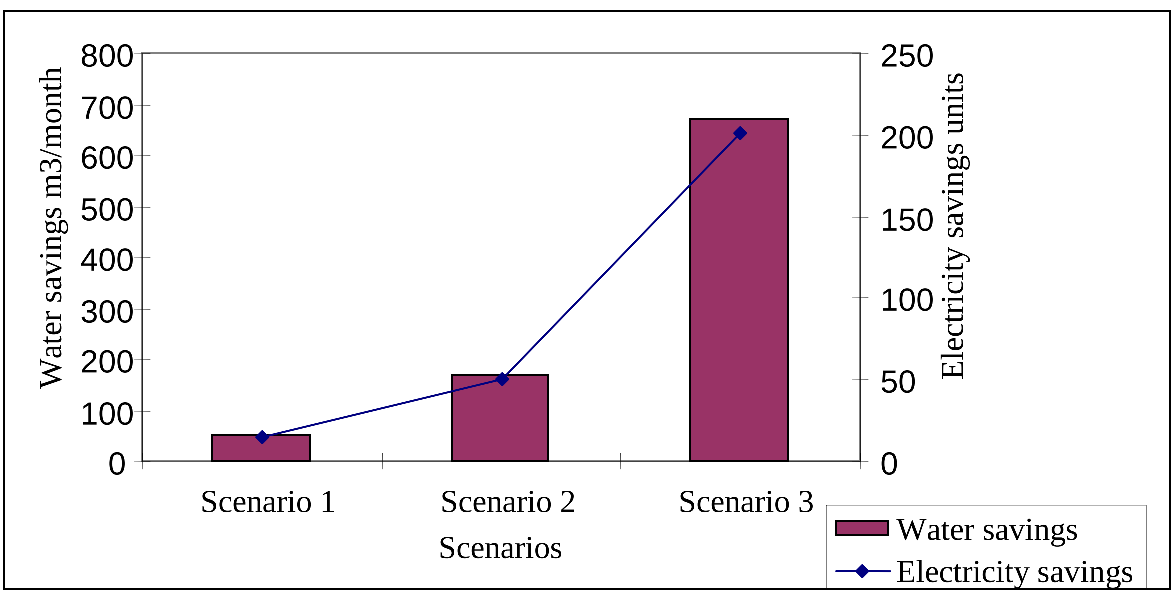

Fig. 4.30 Water and electricity savings per month by savings 15% water from daily uses

4.12 Reuse of House Hold Waste Water

Reuse of household waste water will be an effective tool for water conservation practices. Freshwater is a limited resource which has increasing competing alternative uses for it. With frequent drought the need to look for alternate water sources has become imperative. The less expensive supply options have already been exhausted and access to new water sources involves increased incremental costs. Reuse is emerging as the next major options to fill the widening gap between demand and supply.

4.12.1 Availability of grey water and its possible use

Each household produces considerable amounts of gray water. The gray water quantities generated at an average household was obtained from the study survey. The gray water generation rates as calculated from the data in the study ranged from 21 to 39 GPCD which averaged at 30 GPCD. This number constitutes about 73% of the total water consumption in a household. Since grey water from kitchen sinks (about 16%) is not easily recyclable because of the content of the water, reuse of kitchen water may be excluded. The spatial grey water sources and quantity from a resident has been shown in Table 4.21

Table: 4.21 Source and quantity of potentially reusable (grey water) water.

SL No.	Water source	Water uses range (GPCD)	Average water uses (GPCD)	% of use
1	Drinking and Cooking	0.8-1.5	1.15 (Non reusable)	3%
2	Bath Room	8-14	11 (Reusable)	27%
3	Toilet	4-11	7.5(Non Reusable)	18%
4	Faucets	7-12	9.5 (Reusable)	23%
5	Dish wash (Kitchen)	4-9	6.5(Reusable)	16%
6	Laundry	2-4	3 (Reusable)	7%
7	Others	2-3	2.5(Non Reusable)	6%

Summery: Water demand per capita=41GPCD=186 LPCD

Reusable amount per capita=30 GPCD=136 LPCD

Maximum reusable in percentage=73% per capita.

Reusable water excluding kitchen waste water=57%=23 GPCD

Waste water may be collected from bathroom and faucets for outside purposes like vehicle washing, windows washing, fire protection, and dust control, building construction, highway medians beautification and maintenance, Play ground like golf courses etc. If collected using a separate plumbing system from black water, domestic waste water can be recycled directly within the home and used for flushing the toilets (18% of the total use) of either immediately or processed and stored. Thus faucet water can be used directly for toilet flushing as like Fig 2.13. Recycled grey water of this kind is never clean enough to drink, but filtration and microbial digestion can be used to provide water for washing. Relatively clean grey water (57%) except kitchen waste water may be applied directly from the sink to the garden or container field, as it receives high level treatment from soil and plant roots.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1 Conclusions

Water shortages, deterioration of water quality, ground water lowering, non availability of surface water and environmental constraints, the government / water authorities need to consider and to invest in water conservation practices and waste water recycling. In this study, possible conservative use of water has been proposed. Benefits of these conservative practices also have been shown. The literature review and study analysis reveals the following key drivers

(i) The study shows that the average water consumption for household activities is 28-54 GPCD in Dhaka city.

(ii) The houses having flushing toilet use more water than the houses having non flushing toilet. According to the study survey the water consumption for flushing toilet is 7-15 GPCD. Whereas the non flushing toilet water requirement is 4-8 GPCD.

(iii) Installing water-efficient plumbing fixtures, appliances contribute and habitual changes are the major tools for water conservation. The study shows that 9 GPCD water can be saved from toilet, bathing and faucets use by water conservation practices.

(iv) From one apartment building of 60 people- it has been observed that with 15% reduction from daily water uses, approximately 375 gallons of water can be saved each day. The cost of this savings will be equivalent to 7700 taka (111 US$) per year at present water tariff and the corresponding energy savings will be 180 KWh per year. This amount is equivalent to 576 US$ of DWASA vehicle water and 6.6 Million Taka (96000 US$) of bottled water.

(iv) Study shows that 34% system loss, non metered connections are the main difficulties to implement water conservation program.

(vi) Study suggests 57% of household water can be reused for non potable purpose.

5.2 Recommendations for Further Study

1. A detail study and investigation may be carried out over the whole year (summer and winter season) upon the fluctuation of the water consumption in household level with time.

2. A detail study with more samples may be carried out considering slum areas houses to find out the more perfect and more reliable water consumption result.

3. A further study (quality and treatment) on the reuse of grey water may be performed for household level as reuse of waste water can be a viable option for water conservation practice.

4. A study regarding the water pricing policy may be considered to identify the effect of water price on water consumption.

5. A detail study about the unaccounted and system loss for DWASA supply to identify the impacts of organizational performance on water management.

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Appendix A

Table A1 Water tariff in different year at Dhaka city (in Taka per thousand liters)

Period	Domestic/ Community	Industrial/Commercial
1990-1992	2.76	8.97
1992-1993	3.17	10.32
1993-1997	3.49	11.35
1997-1998	3.58	11.92
1998-1999	3.67	12.75
1999-2000	3.93	13.39
2000-2002	4.13	14
2002-2003	4.3	15
2003-2004	4.75	15.75
2004-2005	5	16.54
2005-2007	5.25	17.5
2007-onward	5.5(0.08US$)	18.25(0.26 US$)

(DWASA, 2007)
Note: 1US$=69.4 Taka

Table A2 Zone wise and category wise number of connection

Zone	Domestic (Nos)	Commercial (Nos)	Industrial (Nos)	Community (Nos)	Offices (Nos)	St. Pipes (Nos)	NOR (Nos)	Total
I	51,771	950	257	180	173	-	-	53,331
II	22,825	931	128	75		-	-	23,959
III	26,932	838	52	68	77	-	100	28,067
IV	53,908	724	224	308	34	-	2,454	57,652
V	46,649	1,063	855	137	355	-	2,828	51,887
VI	27,300	878	107	90	8	-	-	28,383
VII	10,226	407	44	30	11	-	268	10,986
Govt.	251	255		329	119	1	-	955
Total	239,862	6,046	1,667	1,217	777	1	5,650	255220

(DWASA, 2008) NB: NOR= Non official record

Table A3 Water line (Length in Km, 2009)

Size	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Total
100 mm	180.43	72.68	116.59	211.71	183	183	25.15	972.56
150mm	145.74	50.43	76.94	134.42	149	149	15.8	721.33
200mm	67.3	27.44	43.72	69.95	100	100	10.65	419.06
250 mm	5	5	1.2	30.3	1.3	1.3	6	50.1
300mm	40.71	15.38	26.19	30.84	36.22	36.22	4.82	190.38
350mm							0.85	0.85
400 mm	2	2.5	6	2.3		-	1.23	1.23
450 mm	7	0.5	12	11	11	11	1.5	54
500 mm		3.11					2.11	5.22
600 mm	2.7	1.2				-	0.44	4.34
700 mm							1.89	1.89
800mm							66.69	66.69
1000mm			2.4		-	-		2.4
1200mm	2.92							2.92
1400mm	4.25					-		4.25
1800mm	0.71							0.71
Others	5	6	2	10	-	-	-	23
Total	463.76	184.24	287.04	500.52	480.52	480.52	137.13	2,533.73

(DWASA, 2009)

Table A4 Deep Tube Wells in operation in different months

Year	**Month**	**Zone I**	**Zone II**	**Zone III**	**Zone IV**	**Zone V**	**Zone VI**	**Zone VII**	**Total**
2007	July	76	42	72	96	93	73	13	465
2007	August	76	42	72	96	94	73	13	466
2007	September	78	42	72	96	96	73	14	471
2007	October	78	42	72	96	97	73	14	472
2007	November	78	42	72	96	97	73	14	472
2007	December	78	42	72	96	97	73	14	472
2008	January	79	42	73	96	99	74	14	477
2008	February	79	42	73	99	99	74	14	480
2008	March	81	42	73	99	99	76	14	484
2008	April	81	42	73	99	99	76	14	484
2008	May	81	42	73	99	100	76	14	485
2008	June								

(DWASA, 2008)

Table A5 Deep tube well capacity in MLD (2006)

Year	**Month**	**Zone I**	**Zone II**	**Zone III**	**Zone VI**	**Zone V**	**Zone VI**	**Zone VII**	**Total**
2005	July	251.4	171.8	200.17	273.87	265.3	168.72	33.77	1365
2005	August	251.4	171.8	217.57	273.87	262.66	169.9	33.77	1380.9
2005	September	252.4	171.8	197.74	273.87	255.73	174.85	33.77	1360.2
2005	October	252.72	172.8	200	280.54	267.79	179.21	33.77	1386.8
2005	November	242.2	172.8	190	280.54	271.98	179.21	33.77	1370.5
2005	December	238.2	172.8	192	280.54	266.48	185.9	33.77	1369.7
2006	January	235.7	172.8	192	280.54	258.62	175.29	33.77	1348.7
2006	February	241.2	172.8	284	280.54	249.81	168.37	33.77	1430.5
2006	March	262.3	172.8	284	280.54	262.9	162.17	33.77	1458.5
2006	April	241.2	172.8	284	283.84	271.01	169.55	33.77	1456.2
2006	May	262.3	172.8	284	293.74	277.08	174.58	54.43	1518.9
2006	June								
Total		2731	1897.8	2525.48	3082.4	2909.4	1907.7	392.1	15446

(DWASA, 2007)

Table A6 Deep tube wells capacity in MLD (DWASA, 2008)

Year	Month	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Total
2007	July	292.89	157.25	251.06	311.48	317.4	193.68	45.42	1569.2
2007	August	292.89	157.25	251.6	311.48	317.71	194.67	45.42	1571
2007	September	292.89	157.25	251.6	311.48	319.72	203.54	42.39	1578.9
2007	October	258.59	213.21	251.6	311.48	319.72	205.6	42.39	1602.6
2007	November	258.59	184.1	251.6	311.48	319.72	194.33	41.51	1561.3
2007	December	270.84	184.1	266.67	311.48	322.12	197.7	42.66	1595.6
2008	January	260.78	184.1	266.67	311.48	326.24	194.56	42.66	1586.4
2008	February	256.79	137.23	266.67	283.32	326.24	194.56	125.25	1590.1
2008	March	272.42	186.53	266.67	283.32	268.06	194.56	127.6	1599.2
2008	April	268.35	216	266.67	265.06	268.06	194.56	127.6	1606.3
2008	May	268.35	152.2	266.67	287	268.06	194.56	136.4	1573.2
2008	June								
Total		2993.38	1929.22	2857.48	3299.06	3373	2162.3	819.3	17434

(DWASA, 2008)

Table A7 Deep tube wells daily water production in MLD (2008)

Year	Month	Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI	Zone VII	Total
2007	July	254.43	153.8	250.9	254.72	317.4	193.68	34.07	1459
2007	August	254.43	146.25	250.9	254.72	317.71	194.67	38.33	1457.01
2007	September	262.75	141.85	250.9	254.72	319.72	203.54	42.39	1475.87
2007	October	258.59	157.24	248.7	254.72	319.19	205.6	42.39	1486.43
2007	November	293.03	184.1	242.18	254.72	319	194.33	41.51	1528.87
2007	December	270.84	176.66	257.9	254.72	322.12	197.7	42.66	1522.6
2008	January	260.78	176.66	266.67	254.72	326.24	194.56	41.27	1520.9
2008	February	256.79	57.63	266.67	263.7	326.24	194.72	125.25	1491
2008	March	272.42	172.37	229.9	263.7	256.4	185.19	125.25	1505.23
2008	April	268.35	138.07	228.6	229	256.4	177.01	102.3	1399.73
2008	May	250.66	147.19	229.9	277	322.45	184.56	128.24	1540
2008	June								
Total		2903.07	1651.82	2723.22	2816.44	3402.87	2125.56	763.66	16386.6

(DWASA, 2008)

Table A8 Water works capacity in MLD

Year	Month	Water Production Capacity (MLD)				
		Dhaka Water Works	N Ganj Water works East	N. Gonj Water works West	Saidabad surface water treatment plant	Total
2007	July	39.1	1	34.07	225	299.17
2007	August	39.1	1	34.07	225	299.17
2007	September	39.1	1	34.07	225	299.17
2007	October	39.1	1	34.07	225	299.17
2007	November	39.1	1	34.07	225	299.17
2007	December	39.1	1	34.07	225	299.17
2008	January	39.1	1	34.07	225	299.17
2008	February	39.1	1	34.07	225	299.17
2008	March	39.1	1	34.07	225	299.17
2008	April	39.1	1	34.07	225	299.17
2008	May	39.1	1	34.07	225	299.17
2008	June					

(DWASA, 2008)

Table A9 Actual water productions from water works (MLD)

Year	Month	Water Production Capacity (MLD)				
		Dhaka Water Works	N. Ganj Water works East	N. Gonj Water works West	Saidabad surface water treatment plant	Total
2007	July	20.59	0.64	14.35	220	255.58
2007	August	17.34	0.19	10.32	207.61	235.46
2007	September	17.91	0.19	10.85	210.47	239.42
2007	October	19.44	0.29	12.63	216.06	248.42
2007	November	17.05	0.2	10.22	216	243.47
2007	December	12.23	0.17	11.24	205.17	228.81
2008	January	15.08	0.19	11	209.2	235.47
2008	February	14.7	0.18	10.69	204.18	229.75
2008	March	15.49	0.24	11.07	216.19	242.99
2008	April	15.18	0.24	11.69	223.5	250.61
2008	May	18.78	0.24	11.92	223.5	254.44

(DWASA, 2008)

Table A10 Water Production per day in Dhaka City

Source	Production capacity MLD	Actual production		Source wise % of production
		MLD	% of capacity	
Ground water	1,573.24	1,540.00	97.89%	85.82%
Surface water	299.17	254.44	85.05%	14.18%
Total	1,872.41	1,794.44	95.84%	100.00%

(DWASA, 2009)

Table A11 Zone wise number of connection based on metered and non- metered

Zone	Metered	Non metered	Total
I	42079	11572	53651
II	15446	8513	23959
III	24300	3763	28063
IV	38656	18932	57588
V	32972	18839	51811
VI	23305	5108	28413
VII	4948	5880	10828
Govt.	650	305	955
Total =255220			

(DWASA, 2008)

Table A12 Physical and non-Physical losses of supplied water of DWASA

Non-Physical Losses	Physical Losses
1. Non- metered connection	1.Pipe leaks
2. Illegal connection	2.inproper service connection
3. Defective meters	3.Miscellaneous
4. Faulty reading/billing	

(DWASA, 2008)

Table A13 Ground Water Table Declinations

Year	Depletion (meter)
1996	-26.6
1997	-28.15
1998	-30.45
1999	-31.86
2000	-34.18
2001	-37.78
2002	-41.87
2003	-46.24

(Okubo et al., 2006)

Table A14 Water requirements questionnaires survey

Water Requirements Questionnaires		
Address/ Location		
House Area(Sq ft)		
House Rent (Taka per Month)		
Water tariff (Per month in Taka)		
Total number of people in your household.		
	Maximum	Minimum
BATHROOM		
How many showers are taken each person each day in your household?		
What is the average length (in minutes) of each shower? **Enter 6.3 if you are unsure.**		
What is the flow rate (gallons per minute) of your showerhead? Enter 2/2.5/4.15 gallon/ minutes (9L/11.5L/18.5L) for standard showerhead; 1.67(7.5L) for low flow.		
OR		
If shower is not available how many Bucket used for each person per each bath?		
What is the size of Bucket? For small bucket 4.5 Gallon(20L), for Medium Bucket 6.5Gallon(30L)		
OR		
How long the tap running during Bath in minutes		
Flow rates during bath in gallon per minutes. 2-2.5 gal/ min for standard **(1.3 gallon per minutes for low flow)**		
Water requirements per capita per day in gallons (1 Gallon=4.55L)		
TOILETS		
Average number of times each person flushes a toilet in your house per day. **Enter 4 if you are unsure**		
How many gallons does your toilet use per flush? Enter 2.5-4.25 gallon/min if you have a standard toilet; 1.33 if you have a modern low volume toilet		
OR		
If Flush toilet is not available how many Jug of water use for each toilet time for cleaning the toilet.		
Put 0.44 Gallon (2L) per Jug for usually jug.		
Water requirements per capita per day in gallons (1 Gallon=4.55L)		
FAUCETS		
How many times each day does each household member use faucets to shave brush teeth, wash hands and face?		
How many minutes does the water run during each use?		
Flow Rate (Gallon per minutes) for unsure enter 2 - 2.5 or 1.33 (for low flow)		
Water requirement per capita per day in Gallons (1Gallons=4.55L)		

WASHING DISHES		
How many times are dishes washed **by hand** each day?		
How many minutes does the water run during each wash?		
Flow Rate (Gallon per minutes) **for unsure enter2- 2.5 (9L)**		
OR		
If you have a dishwasher, how many times is it used each week?		
The average dishwasher uses **15 gallons** of water per load, change this number if yours is different		
water requirements per capita per day in Gallons (1 Gallons=4.55L)		
LAUNDRY		
How many loads of laundry are done by members of your household each week		
The average washing machine uses **55 gallons of water per load,** change this number if yours is different.		
OR		
How many times Laundry Taken in a week		
If Washing machine not available how many Bucket water required for each laundry.		
For medium bucket 6.5 gallons (30L) per bucket.		
Water requirements per capita per day in Gallons (1Gallon=4.55L)		
Out Side/ Inside washing Water use(Average assumption)		
LAWN WATERING & OTHER USES		
How many times your lawn is watered each week?		
How many minutes is the lawn watered per watering?		
Flow rate 2 gallons For low flow rate		
Water is also used outdoors to wash cars, fill pools, and rinse outdoor furniture and clean equipment. Estimate the average number of minutes water is used outdoors for purposes other than watering each week		
Flow rate 2 gallons For low flow rate		
Or Estimates the number of Bucket (Bucket) required for		
For the above mention work. 4.55 Gallon for normal bucket		
And		
How many times you wash your indoor in each week		
Estimate the average number of bucket required for indoor washing		
For the above mention work. 4.55 Gallon for normal bucket		
For other purpose water requirements need total number of user in the building		
Water requirements per capita per day in Gallons (1 Gallon=4.55L)		
Water requirements for Drinking and cooking per person per Day in Gallon (1 gallon=4.55L)		
Total Water requirements per capita per day(GPCD) in a house		

Table A15 Attitude and preference on water conservation questionnaires sample

General demography	Number	
Address		
Family member		
Sex		
Male		
Female		
Age limit		
0-18		
18-40		
40-60		
>60		
Education		
Below S.S.C		
H.S.C		
B.S.C or Above		
Income		
Water conservation Questionnaires	**Yes**	**No**
Water pressure and operational problem		
Do you have problem in supplied water pressure?		
Water deposit devices		
Do you use water deposit device in your home?		
Frequent of water break		
Do you face frequent of water break?		
Reliability level of tap water quality		
Do you have reliability on tap water, in respect of taste, odor, and purity?		
Do you use tap water for drinking without boiling ?or		
Do you use tap water for drinking with boiling ?or		
Do you use bottle water for drinking?		
Water Consumption attitude		
Do you have sense about their water consumptions?		
Willingness to reduce consumption		
How many people have no interest to reduce water consumption willingly?		

Acceptability of demand versus supply management options		
Do you think engineering oriented solution needed to reduce water consumption? or		
Do you think conservation and information policy needed to reduce water conservation?		
Water pricing policy		
Do you think water price is acceptable? or		
Do you think water price is high? or		
Do you think water price is low?		
Water pricing policy as an incentive for water conservation		
Do you think increase water price will reduce water consumption? or		
Do you think increase water price will not reduce water consumption? or		
Do you have no idea on this issue?		
Willing to pay		
Are you willing to pay extra for improvement of water services if water price rises?		
Public awareness		
Do you think Dhaka have water availability problem? or		
Do you think only quality problem ?or		
Do you think Dhaka have quality and availability problem?		
Need for information policies		
Do you need information concerning water issue?		
Media of information		
Do you want to get information from water authority? Or		
Do you want to get information TV, radio, newspaper? Or		
Do you want to get information magazines?		

Table A16 Deep aquifer DTWs (DWASA, 2010)

SL No.	Well No	Location	Date of completion	Fixture Depth L (m)	Pump Housing Dia (mm)	Pump Housing Length L (m)	Well pipe Dia (mm)	Well pipe Length L (m)
1	104	Bashaboo-4 (South-Kadamtala Sang.)	14.12.99	168	450	82	200	21
		Do R1 (Deep aquifer)	10.09.07	324.7	450	92.18	200	173.53
2	114	Shah-Shaheb Lane (Doyagonj-2)	4.6.95	150	450	60	200	27
		Do R1 (Deep aquifer)	03.11.07	328.77	450	98.47	200	182.92
3	171	RM Das Lane (Deeper Aquifer)	08.03.06	330.05	450	92.27	200	184.47
4	242	Suritola Primary School (Deeper Aquifer)	29.06.06	325.36	450	92.84	200	178.96
5	304	Solimullah Rd (Mdpur-8)	1995	130	450	60.5	200	14.9
		Deep Aquifer	5.8.05	303.75	450	92.3	200	152.43
6	313	Green Road-3	1984	129.27	450	42.6	200	28.9
		Do R2	4.5.2001	126	450	91	200	1.88
		Deeper Aquifer	9.5.06	317.53	450	97.38	200	158.23
7	351	Taj Mahal Rd (DCC Park)	19.11.2000	132	450	87	200	1
		Deep Aquifer	29.9.04	281.53	450	91.31	200	126.82
8	352	Uttar Adabar	25.12.00	115	450	77	200	4.5
		Deep Aquifer	30/05/05	278.89	450	80.08	200	142.76
9	367	Shahi Mosjid-Lalmatia (Deep Aquifer)	25.9.05	291.82	450	91.64	200	143.77
10	369	Abahoni Math (Deeper Aquifer)	2.3.06	294.65	450	92.96	200	145.25
11	370	Monipuri Para-Agriculture (Deeper Aquifer)	26.4.06	301.4	450	93.73	200	145.78
12	402	Section-6, PS-16 (Block C)	1988	121.6	500	48	200	20.4
		Do R3 OHT	12.11.00	121.1	450	83	200	7.32
		Deeper Aquifer	30.3.06	300.2	450	92.42	200	148.75
13	405	Section-10, PS-28 (OHT)	1990	137	450	50	200	33
		Do R1	16.11.98	13.9	450	22	200	15.24
		Do R2	19/11/03	136	450	91	200	0.6
		Deeper Aquifer (Boottled Plant)	18.3.06	303.25	450	98.47	200	151.4
14	413	Lalasarai-1	1994	133	450	60	200	24
		Do R2	2.9.00	136	450	84	200	7
		R3 (Deeper Aquifer)	5.06.06	310.31	450	99.62	200	148.78
15	414	Shawrapara-1 (West)	1996	129	450	60	200	14.9
		Do R2	11.6.02	135	450	90	200	7.5
		Do R-3 (Deep Aquifer)	7.1.04	276.31	450	97.53	200	116.81
		Do-R4 (Deep)	11.08.07	296.9	450	97.56	200	137.19
16	415	Bangla College	1980	97.5	450	42.6	200	16
		Do R1	19.1.01	111	450	75	200	3
		Do R-2 (Deep Aquifer)	28/7/04	277.9	450	90.8	200	125
17	416	Pirerbag	19.5.98	159	450	66	200	30

SL No.	Well No	Location	Date of completion	Fixture Depth L (m)	Pump Housing Dia (mm)	Well pipe Length L (m)	Dia (mm)	Length L (m)
		Deep Aquifer	1.12.05	294.31	450	91.82	200	139.12
18	420	Monipur-1	1990	149	450	49	200	51
		Do R-1	21/2/02	119	450	86	200	1
		Do R-2 (Deep Aquifer)	05.02.05	288.82	450	89.55	200	140.24
19	429	Ibrahimpur	1995	133	450	60	200	12
		Do R-1 (Deep Aquifer)	5.4.04	276.17	450	90.2	200	120.9
20	434	Sangbadik Polli	1997	129	450	60	200	12.3
		Do R-1(Deep Aquifer)	2.5.04	264.2	450	92	200	108.16
21	439	SPARSO	7.12.98	129.5	450	72.2	200	3
		Do R-1 (Deep Aquifer)	6.8.05	274.06	450	99.23	200	112.93
22	443	Baisteki	24.2.99	133	450	70	200	2
		Deep Aquifer	10.9.05	300.1	450	91.97	200	146.34
23	444	Agargoan-2 (BNP Bosti)	4.1.99	133	450	66	200	15
		Do R-1 (Deep Aquifer)	16.12.04	289.61	450	92.53	200	134.73
24	452	Mirpur 2/D (Shikka upokaran kendro)	10.11.99	110	450	66	200	10
		Do R-1 (Deeper Aquifer)	11.09.05	295.65	450	90.03	200	143.8
25	478	**Mirpur DOHS (Deep Aquifer)**	03.01.05	273.5	450	93.42	200	117.73
26	479	**Habuler Pukur Par (Deep Aquifer)**	15/06/04	282.15	450	127.2	200	127.2
27	486	Bindu Bitto Goli (Deep Aquifer)	2.11.05	306.85	450	98.47	200	154.87
28	489	Kayllanpur Road No-5 (Deeper Aquifer)	17.4.06	296.65	450	92.38	200	142.97
29	494	Rupnagar Tin Shed Coloney (Deeper Aquifer)	28.06.06	305.86	450	97.56	200	152.13
30	495	12/D Shahidnagar (Deeper Aquifer)	19.08.06	281.25	450	96.03	200	138.1
31	496	Mirpur 12-C (Deep Aquifer)	28.02.07	291.13	450	92.05	200	137.39
32	507	T.B Gate, Mohakhali	1996	164	450	60	200	39
		Do R-2 (Deep Aquifer)	8.08.04	273.37	450	92.32	200	119.35
33	521	Tejgaon-9	1993	150	450	61	200	50
		Deep Aquifer	20.9.05	283.81	450	95.96	200	137.65
34	529	Tejkuni Para	1993	138	450	61	200	22
		Do R-1	3.5.02	136	450	96	200	13
		Deeper Aquifer	12.06.06	306.96	450	93.01	200	157.92
35	**590**	**P.M. Relief Godown (Deep Aquifer)**	26.01.07	307.57	450	91.92	200	153.76
36	595	DOHS Baridara (Deep)	22.09.07	300.18	450	98.38	200	140.02
37	596	Banani Rajuk park (deep)	02.10.07	325.96	450	98.62	200	171.34
38	602	Nayatola Shishu Park	2.5.99	150	450	76	200	21
		Do R-1 (Deep Aquifer)	29/06/04	244.08	450	94.18	200	102.51

SL No.	Well No	Location	Date of completion	Fixture Depth L (m)	Pump Housing Dia (mm)	Well pipe Length L (m)	Dia (mm)	Length L (m)
39	610	Moha Nagar	1994	157	450	49	200	30
		Do R1	15/11/98	159	450	72	200	24
		Deep Aquifer	26.7.05	279.09	450	93.27	200	129.72
40	622	Khilgaon-8	1997	169	450	61	200	46
		Do R-1 (Deep Aquifer)	04.10.04	303.25	450	91.41	200	155.49
41	634	Lichu Bagan	130.9.96	152	450	67	200	21
		Do R-1 (Deep Aquifer)	24/3/05	293.09	450	90.09	200	152.34
42	639	Gulbag	3.6.98	151	450	72	200	21
		Deep Aquifer	17.11.05	304.93	450	91.46	200	160.06
43	644	Siddeshari-1 (Boys School)	1994	164	450	60	200	42
		Do R-1 (Deep Aquifer)	04.01.05	279.34	450	91.46	200	128.96
44	648	New Eskaton	20.1.98	142	450	66	200	18
		Do R-1(Deep Aquifer)	01.11.04	279.11	450	91.46	200	124.61
45	650	Osmani Uddyan	27.4.96	158	450	60	200	37
		Do R-1 (Deep Aquifer)	04.02.05	300.81	450	91.46	200	147.36
46	654	A.G.B Colony	26.6.97	103	450	67	200	27
		Deeper Aquifer	28.12.05	318.62	450	92.79	200	168.28
47	677	**Bonosree Block-A (Deep Aquifer)**	9.6.05	328.58	450	91.64	200	172.38
48	678	Goran Road No-8 (Deeper Aquifer)	7.5.06	327.44	450	93.09	200	175.3

(DWASA, 2010)

Table A17 Change of well pipe depth for different location DTWs

Well No	**Location**	**Date of completion**	**Well pipe length(m)**
104	Bashaboo-4 (South-Kadamtala Sang.)	14.12.99	21
	Do R1 (Deep aquifer)	10.09.07	173.53
114	Shah-Shaheb Lane (Doyagonj-2)	4.6.95	27
	Do R1 (Deep aquifer)	03.11.07	182.92
304	Solimullah Rd (Mdpur-8)	1995	14.9
	Deep Aquifer	5.8.05	152.43
352	Uttar Adabar	25.12.00	4.5
	Deep Aquifer	30.05.05	142.76
413	Lalasarai-1	1994	24
	R3 (Deeper Aquifer)	5.06.06	148.78
414	Shawrapara-1 (West)	1996	14.9
	Do R-3 (Deep Aquifer)	7.1.04	116.81
	Do-R4 (Deep)	11.08.07	137.19
416	Pirerbag	19.5.98	30
	Deep Aquifer	1.12.05	139.12
443	Baisteki	24.2.99	2
	Deep Aquifer	10.9.05	146.34
529	Tejkuni Para	1993	22
	Deeper Aquifer	12.06.06	157.92
610	Moha Nagar	1994	30
	Deep Aquifer	26.7.05	129.72
Well No	Location	Date of completion	Well pipe length(m)
622	Khilgaon-8	1997	46
	(Deep Aquifer)	04.10.04	155.49
634	Lichu Bagan	130.9.96	21
	Do R-1 (Deep Aquifer)	24/3/05	152.34
639	Gulbag	3.6.98	21
	Deep Aquifer	17.11.05	160.06
654	A.G.B Colony	26.6.97	27
	Deeper Aquifer	28.12.05	168.28