A STUDY ON DOMESTIC WATER CONSUMPTION PATTERN IN TONGI BAZAR AREA

A thesis submitted in partial fulfillment

of the requirements for the degree of

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Author's Declaration

We are Md Nur Hossain (18206036), Jannatul Adun Farzana (17306060), Jannatul Maua Farhana (17306061) declaring that this thesis report on "A Study on Domestic Water Consumption Pattern in Tongi Bazar Area" has only been prepared under the supervision of Prof. Dr. Md Tarekh Rasul and Mohammed Motaher Hossain for the partial fulfillment of the degree Bachelor of Science in Civil Engineering (BSCE). It has not been prepared for any other purpose, reward, or presentation and has not been submitted by us for any Degree, Diploma, Title or Recognition before.

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Abstract

This research work examines domestic water consumption pattern in residential houses of Arichpur, Tongi Bazar area, to understand its use and explores the impact of insights from distribution logic by using 50 residents survey data collected by research students. Water crisis has recently become a major problem in Tongi area, where overpopulation and industrialization have significant impact on water table depletion. The population of Tongi municipal is about 410000. The water supply of Tongi area cannot meet the total demand. As the scarcity of drinkable water is increasing day by day, reducing water consumption should be a top priority.

We conducted a survey of 50 families in Arichpur and Tongi Bazar area to determine the quantity of consumable water people require in their daily usages. Mainly, the survey was conducted in apartments, semi pacca houses and tin shade houses of the that area. Primary information's has been obtained through questionnaire surveys and discussions with people from different disciplines. Other information regarding water supply and management, wastewater disposal system etc. was collected from authority and municipal officials by informal discussions.

The research demonstrates how much water people need for various activities separately (like bathing, drinking, toilet, faucets, washing, cooking etc.). We have observed 128 LPCD's per-person consumption of water. According to the research, there is also a chance of water savings, greywater reuse (approximately 54% of greywater may be reused), financial savings, and resource savings from a decrease in people's daily water use, depending on habit and system. The main obstacles to conservation measures in the Tongi area are system failure in the primary distribution system, non-metered connections, lower water rates, and a lack of knowledge regarding the value of water.

The research also shows the statistical analysis of water consumption with other variables such as households family members, monthly income, monthly water bill, flat area etc. Correlation and regression values of these variables helped us to determine the relation type, significancy and future predictions depending on water consumption. In regression analysis, we have found the R square value 0.579, which indicates the predictions based on variables would be 57.9% accurate. For example, when 1 person in a family increase depending on that water consumption increases by 65.468 liters. We used Excel and SPSS statistical analysis software to do these assumptions.

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CHAPTER 1

INTRODUCTION

1.1 General

In our country water scarcity is a major concern nowadays specially in the urban areas. Although Bangladesh is riverine country and there are many sources of water but due to huge population, poor water management and distribution system it has become a major issue. Bangladesh is the tenth most densely populated country in the world. Where the population is almost 164.8 million and here lives 1237 people per square kilometer. Dhaka the capital of Bangladesh, is one of the most densely populated cities with a population of 21.1 million in the urban area and 10.3 million in the city with a density of 47,400 people per square kilometer. This makes it the sixth most densely populated city in the world and the ninth largest city in the world. (Population Stat, 2021).

Most of the towns and cities of Bangladesh depend on deep tube-wells for supply of drinking water. But as a result of rapid decline in recharge area over the local groundwater basins and excessive withdrawal rate, water level 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).

In most regions of the world, urban water supply has identified as a key element in socioeconomic growth. Considering the quality of urban living in particular, this is currently a significant public health issue in Bangladesh. Access to clean water is a key goal of the Millennium Development Goals, and the amount and accessibility of safe drinking water is a crucial indicator of sustainable development (MDGs). Yet, more than 70% of the urban population in developing nations either receives unclean water, has insufficient access to it, or both. (Kamal, 2003).

For the usage of home water, there are several suggestions and prescriptions. For instance, the World Health Organization has provided data on per capita water usage based on supply and access. They range from 5 to 20 LPCD for basic access, an average of 50 LPCD for intermediate access, and 100 to 200 LPCD where there is no access. (WHO 2003).

The most essential requirement should be devoted to reducing water consumption in the context of a growing water crisis. Implementing the required precautions on the part of the authority and the customer to conserve water not only satisfies the water demand and lessens the strain on the sewerage line, but it also lowers costs for the water supplier, the consumer, and the city as a whole. With some water reuse developments, such as the reuse of recycled water, rainwater collection, and so forth, there are areas of strength for the reception of moderate water use. In order to provide a sufficient supply of water in the city, it is also necessary to update the current water distribution infrastructure.

1.2 Objective of the Study

Water is the most important resource to sustain life. Water resources are challenged in our country today due to pollution and overuse of the local resources. The objective of this paper therefore is to examine the pattern of household water consumption in a specific area of the town as well as sources of water supply in the area.

(i) To determine the amount of water, a person consume in different domestic purpose (like bathing, drinking, toilet, faucets, cleaning, kitchen etc.).
(ii) To investigate the possible sustainable use of water in daily household life.
(iii) To determine the relations between water consumption and other factors of households and future prediction based on them.

The quantitative evaluation will demonstrate the possibilities for environmental sustainability. The study will improve knowledge of potential cost reductions from the perspectives of customers and authorities. This assessment will outline a number of strategies that can be used to help the Tongi area's current water scarcity. The study's conclusion draws attention to the possibilities for conserving provided drinking water and its role in addressing the water crisis in the Tongi area.

CHAPTER 2

LITERATURE REVIEW

2.1 Information of Study Area

Tongi a municipal under Gazipur city corporation, there's approximately 410000 people's living around this area. It is situated between latitudes 23.8833 and longitudes 90.4, 23° 52′ 60″ North, 90° 24′ 0″ East. Tongi is one of 43 cities in Bangladesh and ranks 6 in the Bangladesh population. It's a sub-urban area which is developing day by day. It's one of the most important industrial zones in the northern part of Dhaka city as this area is consist of so many industries such as Masco group, Bata, Aftab group and other garments and industries in Tongi BSCIC area. Most of the people living here are related to those industries and from the workers of those industries to the officials most of them lives on that area. That's why there's different types of citizens with different economic conditions lives in the same residential zones of Tongi area.

In our country, the rivers Buriganga, Turag, Balu, Shitalakhya have been turned into the most contaminated and hazardous river due to the industries situated near those rivers. These rivers' water is constantly being contaminated by medical and agricultural waste, untreated or partially treated sewage effluents, sewage-polluted stormwater runoff, untreated wastewater runoff from neighboring residential areas and industries, and various industrial and domestic wastes. The river closest to Bangladesh's major industrial area, Tongi, is the Turag River. Numerous manufacturers, such as those producing metals, clothing, textiles, papers, fibres, medical products, and food are located in Tongi, which is regarded as the country's industrial town. These industries lack any effluent treatment plant (ETP), which contaminate the surrounding land, waterways, soil particles, and surface. Due to the use of water from industrial zones for drinking and residential uses, this mechanically contaminated water eventually mixes with Turag River, Tongi khal, as well as other freshwater bodies and considerably pollutes these reservoirs of freshwater. (Mia, Md & Zakir, H. ,2014).

The majority of recent researches have observed the effects of real income data on water use using proxy-income variables as a substitute. As proxies for wealth, this study utilizes households' ownership of plumes, showers, flush latrines, dryers, water rates, and reserves. The size of the family must be taken into account because it affects water usage. It is clear that having children in the home and having a larger family are both correlated with higher consumption rate. (Nauges and Thomas 2000; Cardoso 2013)

2.2 Groundwater

Excluding some few hilly locations, groundwater is the primary source of water supply in Bangladesh. Water-bearing strata at depths ranging from 0 to 20 m below ground cover completely cover Bangladesh. The soil is primarily layered and consists of sand and silt

alluvial deposits with irregular lenses of clay. The medium-grained sand deposited at the lower reach by the powerful rivers the Ganges, the Brahmaputra, and the Meghna River with its branches is the main component of the groundwater components. By pumping in wells, groundwater can be simply extracted for the production of water supply systems. In the monsoon, the water which has been withdrawn for multiple uses is restored.

Visually, groundwater seems fresh, transparent, and has little number of suspended solids. Its temperature is also quite stable. The bacteria and fungi that harm human health and are often found in huge numbers in surface waters are absent from groundwater as well. The dissolved pollutants are removed by the gradual filtration process in the fine-grained soil where the surface waters percolate to create ground water. Furthermore, the deficiency of oxygen and nutrients prevents the growth and survival of dangerous microorganisms in that environment. Water may dissolve some minerals during its gradual ascent through the earth as a general solvent. As a result, depending on the soil properties, groundwater may include minerals in various amounts. (M. F. Rahman June 2000)

2.2.1 Groundwater Situation in Bangladesh

Except for a few locations, Bangladesh's groundwater is accessible at shallow depths. Groundwater levels are at or near the surface from August to October, and they are at their lowest from April to May. Groundwater recharges in May, rising as a result, and typically peaks in late July of each year. Surface water levels and fully refilled aquifers are balanced between July and October by stable groundwater levels. As a result of the quick drainage of surface water and changes in base levels, groundwater levels start to decline in October. Groundwater levels in some parts of Bangladesh are drastically declining during the summer periods due to groundwater extraction. (M. F. Rahman June 2000)

2.2.2 Groundwater Depletion

Ground water depletion is increasing day by day due to the excessive use of ground water. Groundwater is easy to access in every part of our country and mostly it becomes in a condition that it can be used without any major treatment. In table 2.1 it shows the depletion rate of ground water table in different parts of Dhaka city from year 1995 to 1999.

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

Table 2.1 indicates the variation in depths to underground water table between the years 1995 and 1996, 1996 and 1997, 1997 and 1998, and 1998 and 1999. And the average annual declines for various locations in Dhaka city are shown in Figure 2.1

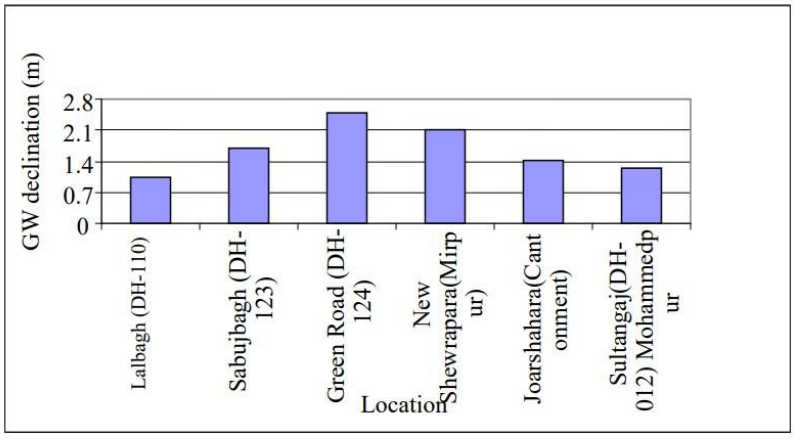

Fig.2.1 Average ground water declination from year 1995-1999 at different places in Dhaka (Afzal et al., 2000)

A huge extraction is causing the groundwater level to gradually decline. As a result, Dhaka may no longer have access to groundwater sources as a drinking water source.

2.3 Surface water

Until 1997, the primary source of drinkable water was ground water. But at that time, due to the rapid expansion in population and industry, it was exceedingly difficult to meet the demand for water via ground water. Surface water for Dhaka may be obtained from the city's river systems. For the waterbodies, these are Buriganga, Shitalakhya, Turag, and Tongi Khal. Around the city of Dhaka, the three minor rivers Turag, Balu, and Tongi Khal are mostly related to the major rivers Buriganga and Shitalakhya. (Figure 2.2)

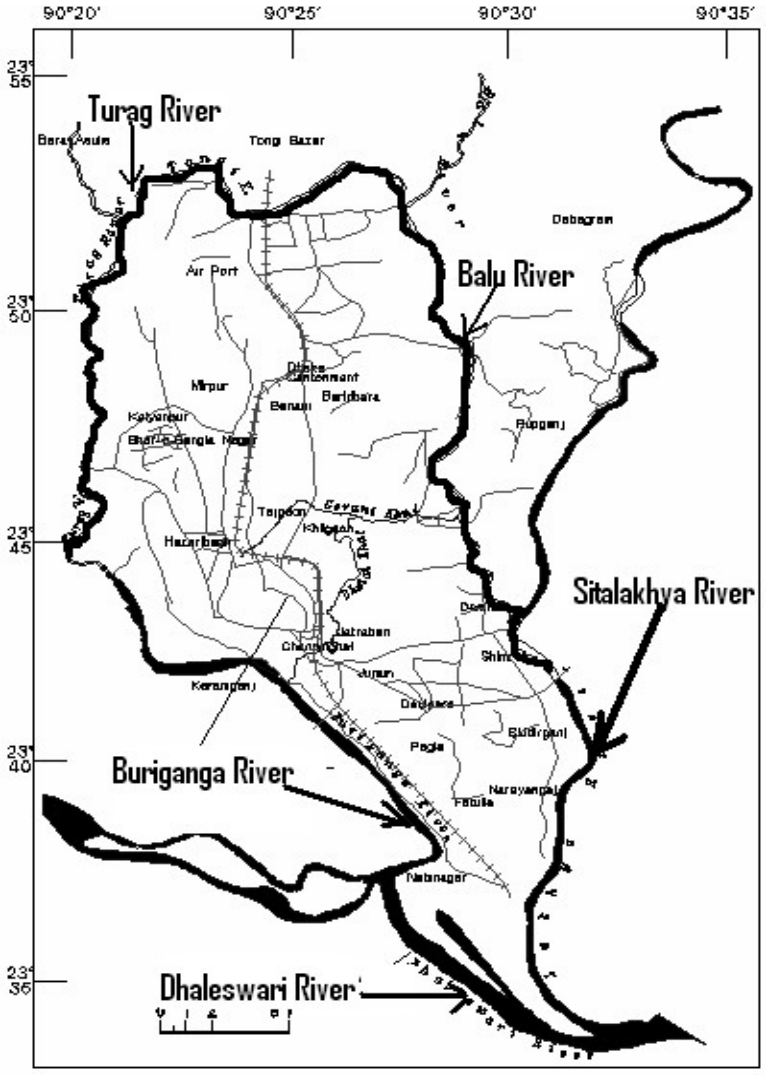

Fig.2.2 Peripheral Rivers of Dhaka (Anwar, Md. Shibly, 2010)

2.3.1 Surface water pollution

Surface water is polluting rapidly nowadays. Due to the excessive deposit of waste in the rivers and water bodies of Dhaka region, the pollution level is increasing day by day. Water from the peripheral rivers of Dhaka has turned in dark color due to excessive discharge of

the human effluents, industrial wastes, medical wastes, untreated sewage etc. In rainy season the water quality becomes slightly good but in other seasons the water quality remains the worst quality possible. This is a waste of drinkable water resource, as we know almost 71% of planet is covered with water but only 2.5% is drinkable. (Shiklomanov, 1993).

2.4 Residential Water Demand

Residential water uses factors take into account both indoor and outdoor applications. (Mayer et al. 1999) reported that the difference in indoor usage was related to household size and square footage of the home, a proxy for average earnings and quantity of bathrooms, and age of family members in a survey of 1,188 families in 12 U.S. locations, included Phoenix (small children add less to faucet use than teens and adults). The existence of a pool was the most important factor in determining outdoor use. Houses with pools typically use more than twice as much outdoor water as houses without pools. The number of square feet a home had, the size of the lot, and the proportion of the property that was utilized for irrigable landscaping were all tied to outdoor use. Since higher-income households tend to have larger homes and lots as well as a higher likelihood of having swimming pools, affluence is strongly ingrained in these characteristics. Similar conclusions about the significance of wealth and household size have been made for Masvingo, Zimbabwe, and Melbourne, Australia (Aitken et al. 1991). (Dube and van der Zaag 2003).

2.5 Economics of Water Consumption

Although a few economic conditions have been detected in recent research, domestic water use is generally price inelastic (Corral-Verdugo et al. 2003). Urban households with greater incomes are more elastic than those with lower incomes (De Oliver 1999). Because it is regarded as being necessary for all human activity, water is typically affordable in the developed world (Berk et al. 1980). People pay mostly for the delivery of water as a service rather than the resource itself (Corral-Verdugo et al. 2003). Under specific circumstances, financial incentives that reduce water consumption include price increases and progressive block rate systems (Vickers 2001). However, public regulatory bodies that control the price of water frequently protect consumers from having to pay the entire cost of the resource, which limits the adoption of pricing regulations that would promote conservation (Morehouse 2000). As a result, the cost of paying the water bill is usually minor in household budgets (Hamilton 1983), particularly in more affluent families where knowledge of water rate structures is fairly low.

The impact of price or consumer education on water use was not directly tested in our investigation. Over a period of two years, we observed and compared the water use of households under one set of market conditions, in order to better understand the causes of the disparity in consumption between higher and lower income households. (YABIKU February 2015)

2.6 Wastewater Collection Systems

The collection systems of the generated wastewater (from municipal/industrial sources) can generally be classified into three groups as illustrated below.

Sanitary sewers - Sanitary sewers are developed to collect domestic, industrial and commercial wastewaters. These sewer types are useful when rainfall is uneven, for areas with rocky strata, and in areas with steep drainage. Since the sizes of sanitary sewers are usually smaller, they are effective particularly when finance availability is a constraint. However, these sewers often do not promote self-cleansing velocities, unless laid at steep gradients. As such, flushing is often mandatory for such systems, which in turn increases operational costs.

Storm sewers - These sewers are employed for the collection of storm runoff from roofs, streets etc., followed by disposal of the collected runoff toward a receiving water channel. Storm sewers are usually larger than sanitary sewers, and are generally operated undergravity flow.

The main advantages of separate sewerage systems (i.e., sanitary and storm sewers) can be enlisted as: smaller waste water treatment works are required. Storm water can be pumped when necessary. Wastewater and storm sewers may follow optimum route and depth. Less variation in terms of wastewater flow and strength. Absence of road grit in wastewater sewers. However, there are also some disadvantages of separate sewer systems, such as: Additional costs are required for the construction of two separate pipes. Storm water does not flush accumulated wastewater solids. Lack of storm water treatment.

Combined sewers - In a combined sewer system, domestic, industrial and storm sewage are carried together. The advantages of combined sewer can be illustrated as: Lower pipe construction costs. Economical in terms of occupying space. Allows dilution of sewage, which can reduce input load into the treatment plants. Bigger sizes render adequate cleaning provisions. Allows some treatment of storm water.

Despite of the benefits of combined sewers, they also incur some disadvantages - Combined sewers allow solid siltation, due to lower flow velocity in dry weather. As such, these systems are not feasible in regions, where annual rainfall distribution is uneven. May demand higher pumping cost, if the flow is pumped into treatment plants. Can incur greater variation of wastewater flow and strength to treatment plants. Grit removal is necessary. (Tanvir Ferdous Saeed November 2013)

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The aspect of this research is the estimation of the water demand for household uses by questionnaire survey. The study's primary goal is to assess how much water people need for various home tasks (Bathing, drinking, toilet, faucets, washing, cooking etc.). This chapter's primary goals are to explain the methodology and data collection used to (1) evaluate the status of the water supply in the Tongi area, (2) measure actual per capita water consumption by activity using domestic water usage, and (3) to look into the behavior and opinions of the consumers of that area with regard to water sustainability. Future water scarcities have been predicted using population data that has been gathered and evaluated.

3.2 Methodology and Data Collection

The approximate quantity of water an individual uses depends on their mindset, consciousness, habits, activity level, and the temperature and humidity of the environments. For instance, humans will need more water in the summer than in the winter. Instead of an exact, defined amount, a person can offer ideas us of how much water they required. People can estimate their daily water requirements based on their activity. The survey's goal is to figure out how much water is needed for household use. To determine an individual's daily water requirement, it is important to examine their water-saving habits.

3.3 Selection of Study Area

For the study we have chosen a place where people of every economy class live together. Our study area is a small area of Tongi named Middle Arichpur. Which is near the BSCIC industrial zone and Tongi Bazar Area. The major water supply source in Tongi area is the supply water provided by the Tongi municipal and the private submersible pumps of the household owners. Most of the houses has both of those water supply system as most of the time there's shortage of water supply from the municipal. This area is consisting of every type of houses apartment buildings, semi pacca houses, tin shade houses. In different types of houses different types of economic class people lives and their usages of water depends on the facilities available in those houses. That’s why Arichpur area is the best location to get varity of data about water consumption in different types of houses and users.

3.4 Data Collection

We conducted a survey in our study area by visiting 50 houses of that area. We informed the goal of our research to the residents and asked some questions regarding water consumption

practices of those residents. The questionnaire was about the amount of water they used in their daily usage such as bathing, cleaning, cooking, drinking, washing, toilets, gardening, livestock, vehicle washing etc. We also gather the information of family's income, income source, number of family members, flat area etc. The questionnaire included the information about the quality of water of that area, water sources, regularity, billing methods. All those data were gathered to analyze the possible outcome about per capita water consumption, sustainable water consumption practices and sanitation system of that area. Later we have found out the relations between different variables regarding water consumption to predict the relations. The survey was conducted in about 10 days then we began our further approaches. As these data are based on peoples opinion we have assumed some variables and these may not be exactly accurate as some people may have given unrealistic opinions.

3.5 Statistical Analysis of The Sample

Researcher applied multiple linear regression to predict the variables related with water consumption. The four assumptions of linear regression will meet in our research. These are as follows -

- Linear relationship - The independent variable, x, and the dependent variable, y, have a linear connection.
- Independence - The residuals are independent, which is a quality. In time series data, in particular, there is no connection between sequential residuals.
- Homoscedastic - The residuals' variance is constant for all values of x.
- Normality - The model's residuals are distributed normally.

The outcomes of our linear regression may be inconsistent or even inaccurate if one or more of these basic assumptions are failed. (Statology, 2022)

3.6 Survey Questionnaires

Questions in the survey were asked about things like:

- The sample's demographics (gender, age, source of income, family members, monthly income etc.)
- Water supply condition (is it regular or irregular, reasons)
- Water quality (is it good or poor, water color, taste, odor, use of filter, boiling or any other methods.)
- Water consumption in different purposes such as bathing, cleaning, cooking, toilets, livestock's, gardening etc.
- Water billing methods, source of water, drainage system.
- Peoples' opinion on water consumption

The detailed form of survey questionnaire is shown in Table A1

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

There's still plenty of water sources in Tongi. Within the Tongi region, there were numerous ponds, lakes, canals, and two major rivers. Additionally, there was a lot of groundwater present. Because of this, city residents are comfortable with having enough reserves for all demands. Water is typically never more than a few steps away for most individuals. To relieve their thirst, individuals merely need to turn a tap, open a faucet, or touch a switch. But for other others, it's a difficult thing to locate. As every house of this area doesn't get proper water supply, so the less privileged peoples are the sufferer.

The current research places more emphasis on water consumption in the Tongi area due to the growing population, enormous water demand, decline in ground water level due to surface water pollution, and other factors. Domestic water conservation has an impact on the conservation of resources in addition to saving money for home owners. Sustainable water consumption techniques also reduce the amount of fresh water that is required from the traditional water delivery system.

4.2 Scarcity of Water in Tongi

In Tongi there are very few water treatment plant and most of them are private property. The plants which area supervised by the municipal are very old structured and has older technology for treating water. Private water treatment plants produce water mainly for drinking purpose and that's why the price of water of those plants are more than the municipal supply water. It is not affordable for the use of every type of consumption. So, there is always a scarcity of water noticed in this area. Most of the time municipal supply can't provide properly due to huge demand of water.

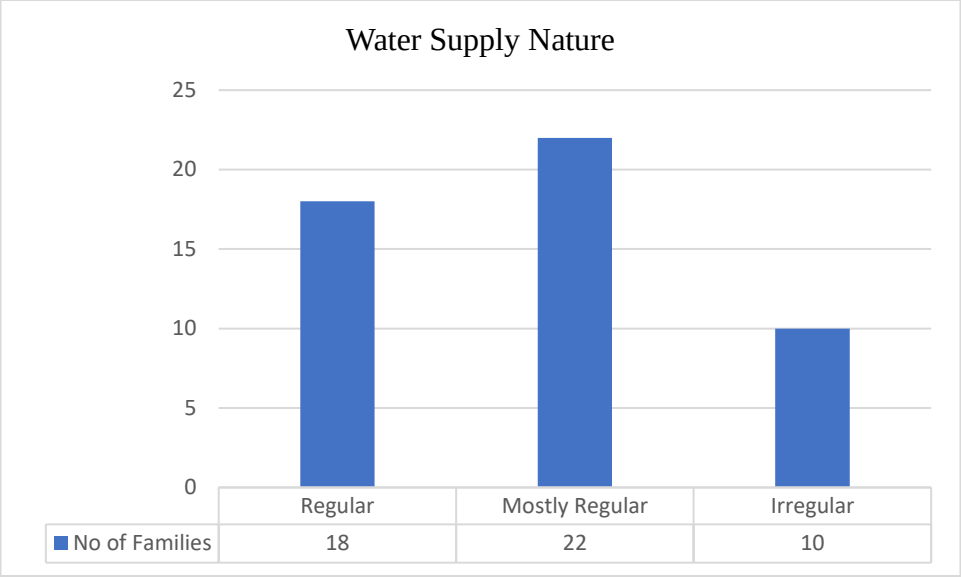

Fig.4.1 Water supply nature of Tongi area

In this figure 4.1 it shows the availability of water in our survey area. The data collected from 50 households we've found the difference of supply in each house. Almost 18 houses had no problem with the water supply system, they had the facilities of both municipal supply and groundwater connections. 22 families said they had found the supply mostly regular, they faced problem with the supply system but not always. Rest of the 10 families had irregular supply of water. They mostly depend on the municipal supply that's why they faced such problem as they had no alternative.

4.3 Water supply from different sources in Tongi area

In Tongi area the main water supply source for domestic use is ground water and surface water which comes from the water plants of the municipal. Most of the houses of that area depends on supplied water provide by the municipal. From the survey we have observed that from 50 houses only 6 houses depend on the ground water, means those houses collects their own water by using submersible pump from the ground. Then they store it in the reservoir tank. They only pay the electricity bill for using the pump. While almost 29 houses use supply water provided by the municipal. These houses don't have any other source of water so when the water shortage occurs from the municipal supply, they need to suffer a lot. And other 15 houses have both municipal supply and ground water access. These houses don't have any suffering from water scarcity. Because whenever there is lack of water supply from the municipal, they can use the ground water collected by the pumps. Even some families which have only municipal supply water access, when they can't get enough water, they go to neighboring houses to collect water for their daily needs, as some neighboring houses has both water supply facilities. Figure 4.2 shows the water supply sources of 50 households of that area.

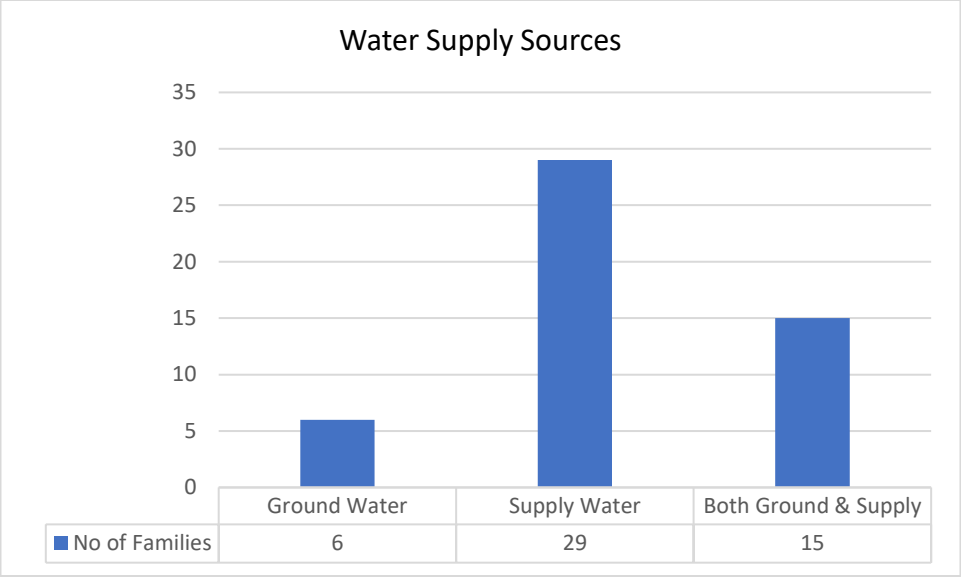

Fig.4.2 Water supply sources for the households of Tongi area

4.4 Descriptive Statistics of the sample

Descriptive statistic shows the detailed overview of the sample. In this table we can observe the highest values, lowest values, mean, standard deviations, skewness and kurtosis values. Mean is the average value of the samples. Standard deviation shows the difference in ratio of the average of that sample. For example, mean value for total water consumption is 127.92 LPCD, standard deviation value is 41.75, it means the water consumption rate of the samples should be 41.75 LPCD more or less than 127.92 LPCD. These analytical data are concerning flat area, earning members, family members, total income, water bill, total water consumption, their distribution confirms the representative of the random sample. These data were generated using SPSS software to find the accurate statistical values.

Table 4.1 Descriptive Statistics of the sample

Samples	N Statistics	Range Statistics	Minimum Statistics	Maximum Statistics	Mean Statistics	Standard Deviation
Flat Area (SFT)	50	1400	200	1600	612	360.8
Earning Members	50	1	1	2	1.4	.5
Family Members	50	6	2	8	4.34	1.25
Water Consumption (LPCD)	50	232.4	70.6	303	127.92	41.75
Number of Flats	50	1	1	2	1	.14
Monthly Water Bill (BDT)	50	900	100	1000	320	161.6
Monthly income (BDT)	50	91000	9000	100000	33960	22040

Water Consumption of a Family	50	1266	249	1515	549.094	241.085

Average families live in the flats which has an average area of 612 square feet. Here the largest flat area is 1600 square feet and the smallest one is 200 square feet. In the survey we found that apartment buildings have bigger flats while tin-shade houses have smaller flats. Every family had an earning member some had two. Average income of the families was about 33960 BDT/month. Highest earning family earned about 100000 BDT/month and the lowest one was found about 9000 BDT/ month. Most of the families had one earning member while few families had two earning members. Most of the families lived in one unit flat, only one family was found that lived in two units. Average families had the number of family members of 4-5 persons, the smallest family was found that had 2 members and the largest one had 8 members. We found the average water consumption of 128 LPCD and the highest water consumption was recorded 303 LPCD and the lowest was 70.6 LPCD. Average water bill for most of families was about 320 BDT/month, the highest one was 1000 BDT/month and the lowest one was 100 BDT/month. Water bill was fixed for some families, the house owners set a standard bill whether they used more or less they had to pay the fixed amount. People of this area use this method as there is no metered connection provided by DWASA or Tongi Municipal. Standard deviation shows the average variability of the samples from its mean value. In this study it is visualized properly, mean value for water consumption was 127.92 LPCD and its standard deviation was 41.75 LPCD. It means the rate of water consumption is either 41.75 LPCD higher or lower than the mean value 127.92 LPCD. The main difference of standard deviation can be seen for income value. Here the mean value is 33960 BDT and the standard deviation is 22040 BDT. This is a huge amount for the sample, this predicts the data set has big difference in the variables. It happened due to the large difference between highest and lowest values of the sample.

4.5 Correlation and Regression Analysis

Correlation and regression analysis of the variables has been done to interpret the relation between variables of the data set. Here our goal was to find the relation of family size, monthly income, flat area, monthly water bill etc. with water consumption. From the analysis we can predict the possible relations between the survey data.

4.5.1 Correlation analysis

For analyzing connections among numeric or descriptive data, correlation can be used. In other words, it's a measurement of the degree of a relationship. Correlation analysis is the investigation of the relationships between different variables. In this table, the correlation between the variables is shown. We can predict future behavior by using correlations to determine the relationships that various variables have. In this research, determining what the future holds for water supply, consumption, quality, etc., is important.

For this analysis we considered the Pearson correlation as it is widely used to determine the strength and association between the two variables. Negative values show that if variable value increases, then other variables value decreases. If the value is close to zero then the correlation between the samples is very weak. From the table below we can see the variables of family member is negative and close to zero, it indicates the relation between water consumption and number of family member is negative and very weak. It means water consumption doesn't depend on the number of family members. Then the variable of monthly income of a family has positive correlation, it means it is strongly related with water consumption. From the survey we have also noticed that peoples water usage changed with their income as higher income peoples has more privilege than lower income people. The correlation values are shown in table 4.2

Table 4.2 Correlation between variables water consumption per day, family members, monthly income

Correlations						
Pearson correlation		Water consumption per day	Family Members	Flat area	Monthly income	Monthly water bill
	Water consumption of a family per day	1.000	.515	.458	.692	.384
	Family members	.515	1.000	.390	.328	.288
	Flat area	.458	.390	1.000	.651	.729
	Monthly income	.692	.328	.651	1.000	.502
	Monthly water bill	.384	.288	.729	.502	1.000

4.5.2 Regression analysis

Regression analysis is the statistical measure to determine the variables of a sample are how strongly related with one dependent variable and other independent variables. In this study we have collected 50 households' data where there were many types of variables. From those we selected the amount of water consumption as a dependent variable and number of family member, flat area, monthly water bill, and monthly income of a family as independent variable. Then we have done linear regression to find out to relation between these data.

In the table 4.3 model summary of the regression analysis has been shown, where the values of R, R squared and Standard error of the estimate is given.

Table 4.3 Model summary of the data

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.761[a]	.579	.541	163.28576
a. Predictors: (Constant), Flat area, Family members, Monthly income, Monthly water bill				
b. Dependent Variable: Water consumption per day of a Family				

Here, in this table R squared value 0.579 means that the model that explains 57.9% variation in the response variable around its mean. It means that the independent variables Flat area, Family members, Monthly income, Monthly water bill and the dependent variable Water consumption per day has r squared value 57.9% which reveals that 57.7% of the variability observed in the target variable is explained by the regression model. This interpretation shows that the predictions about dependent variable water consumption based on the independent variables can be almost half accurate as the value is 57.9%.

4.5.3 ANOVA (analysis of variance)

In the table 4.4, ANOVA (analysis of variance) of the regression analysis has been shown, it is used to determine whether or not the means of the independent groups are equal. Here the values of Sum of Squares, df, Mean Square, F and the significancy of the model is shown.

Table 4.4 ANOVA (analysis of variance) of the regression analysis

ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F-stat	P-stat Sig.
Regression	1648177.018	4	412044.255	15.454	0.000008
Residual	1199800.830	45	26662.241		
Total	2847977.848	49			

a. Dependent Variable: Water consumption per day of a Family

b. Predictors: (Constant), Flat area, Family members, Monthly income, Monthly water bill

An ANOVA uses the following null and alternative hypotheses:

i) Null hypothesis H_0: All group means are equal.

ii) Alternative hypothesis H_A: At least one group mean is different from the rest.

F statistic value is the ratio of mean square values. It indicates that the larger the F-statistic, the greater the variation between sample means relative to the variation within the samples. Here the value is 15.454, it shows that there is a difference between group means as the value greater. And the P- statistics shows the significancy of the samples. As the value is 0.000008 which less than 5% (P statistics value less than 5% is significant and more than 5% is insignificant). It rejects null hypothesis H_0 as the value is less than 5%. H_0 is rejected means

that a significant influence of multiple regression model occurs over the dependent variable per capita water consumption.

Table 4.5 Coefficient values of the regression analysis

Coefficients					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model	B	Std. Error	Beta		
(Constant)	53.005	88.077		.602	.550
Family members	65.468	20.291	.341	3.226	.002
Monthly income	.007	.001	.637	4.958	.000008
Flat area	-.092	.110	-.138	-.837	.407
Monthly water bill	.099	.211	.067	.471	.640
a. Dependent Variable: Water consumption per day					

Here in table 4.5 the coefficient values of the regression analysis are shown, the expected water consumption value is 53.005 when the variables values are zero. Which means that the other variables which has significant relation with constant variable will increase or decrease with the change of variable values. Here we can see monthly income and family members has significant relation with the dependent variable water consumption. Coefficient value for family members is 65.468 which shows it has positive value, a positive coefficient suggests that as the independent variable increases, the depended variable tends to increase. So, when number of family members will increase by 1 person the average water consumption will increased by 65.468 liters. For monthly income coefficient value is 0.007 which is positive, for this variable with the increase of monthly income, water consumption will increase. Monthly water bill and flat area do not have a significant relationship with water consumption, so there will be no variance if the variables are changed.

In figure 4.3 shows the normality of the residuals which indicated it is normally distributed. The bell-shaped curve indicates the normality of the variables. The highest point of the curve indicates the mean value and the width indicates the standard deviation.

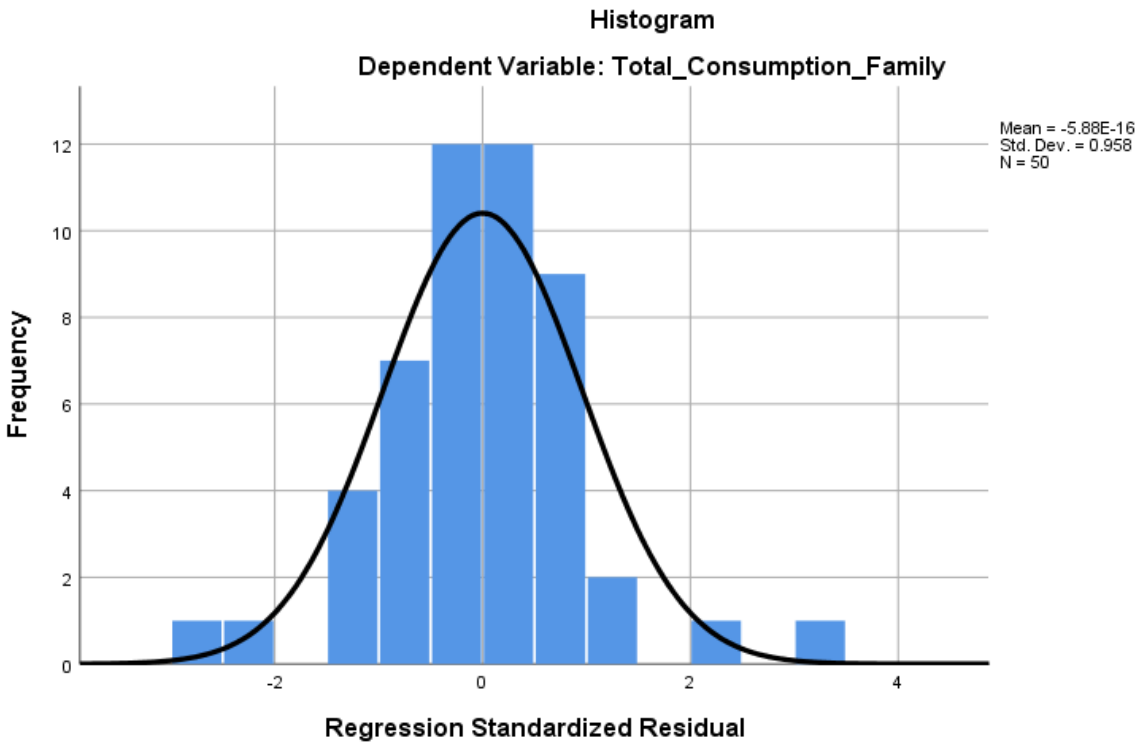

Fig.4.3 Regression standardized residual.

4.6 Quality of Water

From the survey we have found the quality and availability of water which is used for household usages. This data was collected based on the opinion of the people of those households who consumes the water. There were two major water sources available, one of them is supplied water which comes from the municipal water tanks and another one is ground water which is supplied to the houses by using submersible pump. Apartment buildings have the facilities of submersible pumping system which helps to collect the ground water, whereas tin-shade houses don't have such facilities, thus people living on those houses needs to depend on supplied water provided by the municipal. Even some buildings had both facilities. So, they didn't have to worry about water supply. Cause most of the time water supplied by the municipal was not available on that area due to unplanned urbanization and lack of management from the authority. In the figure below it shows the quality of water on that area.

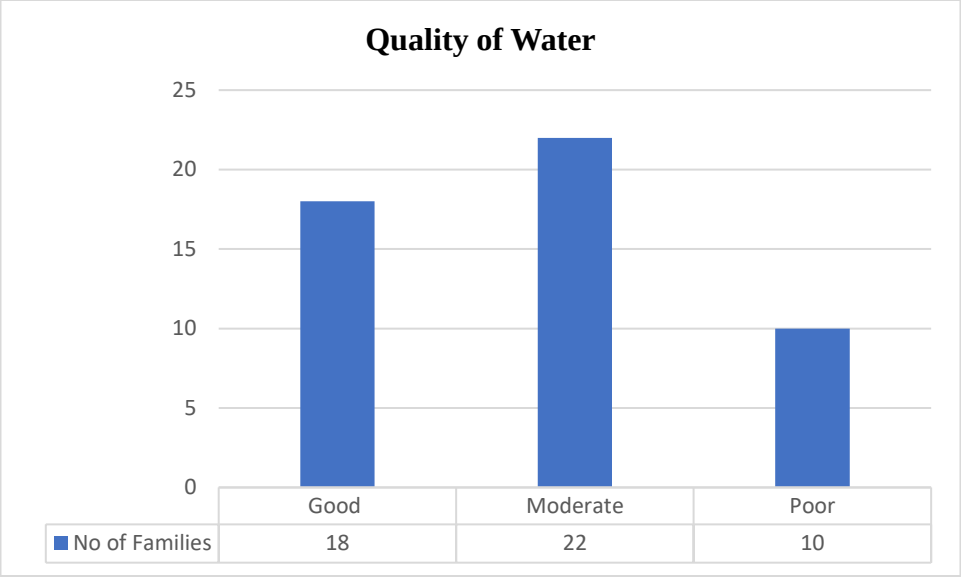

Fig.4.4 Quality of water on Tongi Bazar area.

From figure 4.4 it is portrayed that almost 18 families observed the quality of water is good, while 22 families think the quality of water is moderate, here moderate means that the water quality changes time to time, sometimes they observe some irregularities in odor, taste or color. And 10 family complained about the quality of water as poor condition. They found either bad taste of water, bad smell, bad odor or different color in water which is constant. In the figure below it shows the percentages of the reasons behind poor water quality -

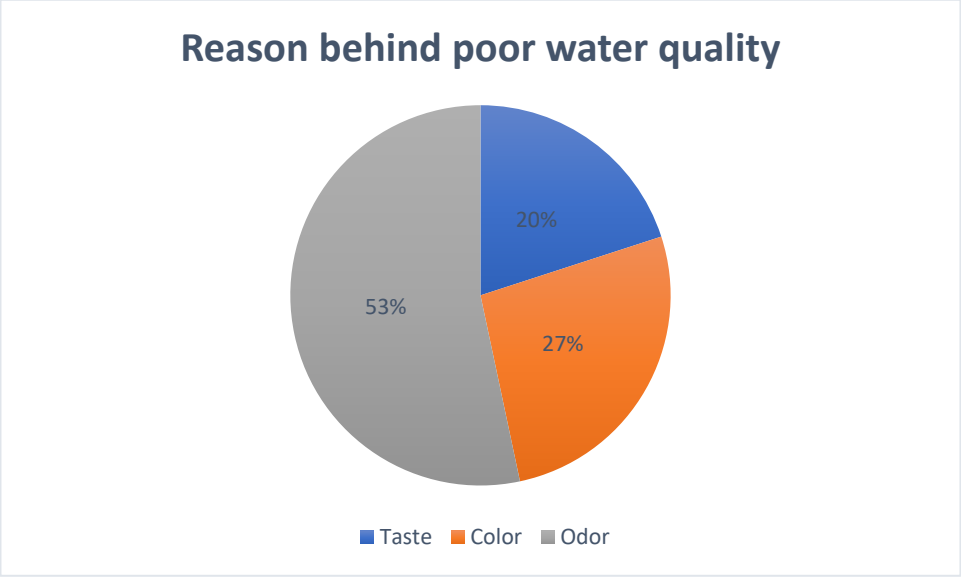

Fig.4.5 Reason behind poor water quality

In figure 4.5 the pie chart indicates the reasons behind poor quality of water. From the families who found the water quality was poor, based on their opinion we have identified the reasons behind the poor quality of water. Almost 20% families found problem in the taste of

water, 27% faced problem with water color and the rest of 535 found problem in the odor of water. Basically, people who complained about the poor quality of water most of them used municipal supply water. After taking their opinion we also did some field taste to match their opinion, there was presence of suspended solid. Thus, the water supplied by municipal is not ready to consume for drinking purposes directly. People need to boil or use filter to make it drinkable.

4.7 Domestic Water Consumption

In this section percentage of domestic water consumption is being discussed, and the per capita water consumption of each family of the sample has been shown. The percentage of water consumption in each households' usages is shown in the figure 4.6.

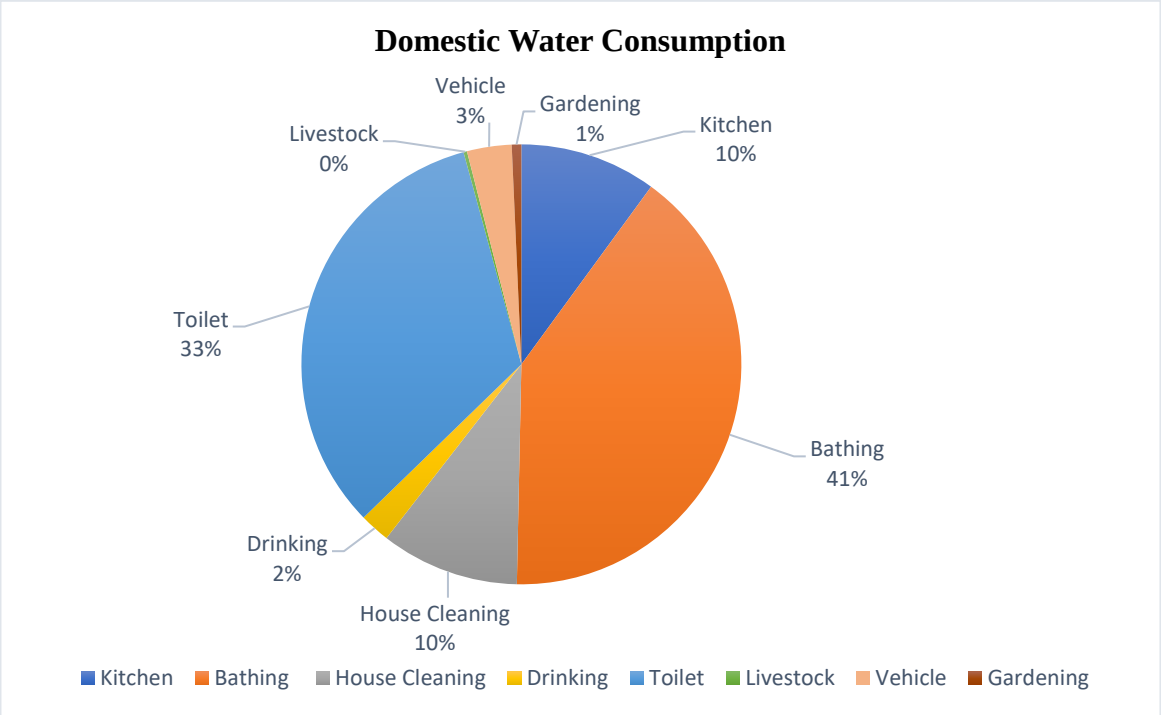

Fig.4.6 Percentage of per capita water consumption in different usage

Domestic water consumption means the per capita water consumption of the people living in a residence. It depends on the family size, gender, age of the family members etc. If in a family there is more children's than adults then the rate of water consumption will be different than the opposite type of family. Same goes for number of female and male in a family which changes the consumption rate. In figure 4.6 the pie chart shows the average water consumption of the families of that area. The criteria of domestic consumption are divided into some parts, as we have collected the data of water use in kitchen, bathing, house cleaning, drinking, toilet use, livestock and poultry, personal vehicle wash, gardening. From the survey data of 50 families, we have estimated an average water consumption of 128 LPCD. From these 128 liters, 10% water is being used in kitchen, 41% for bathing, 10% for

house cleaning, 2% for drinking, 33% in toilet use, 0% for livestock and poultry (It is showing 0% because of the amount is very less than one in percentage and very few families had livestock that is why the consumption rate is almost zero after averaging it), 3% for vehicle wash, 1% for gardening. This is the average rate of consumption in the households. But the percentages vary from family to family. Some families use more water in their activities and some use less. It varies from person to person also. In the figure 4.7 shows the per capita water consumption of each house. From this we can see the differences of consumption rate and lowest to highest consumption.

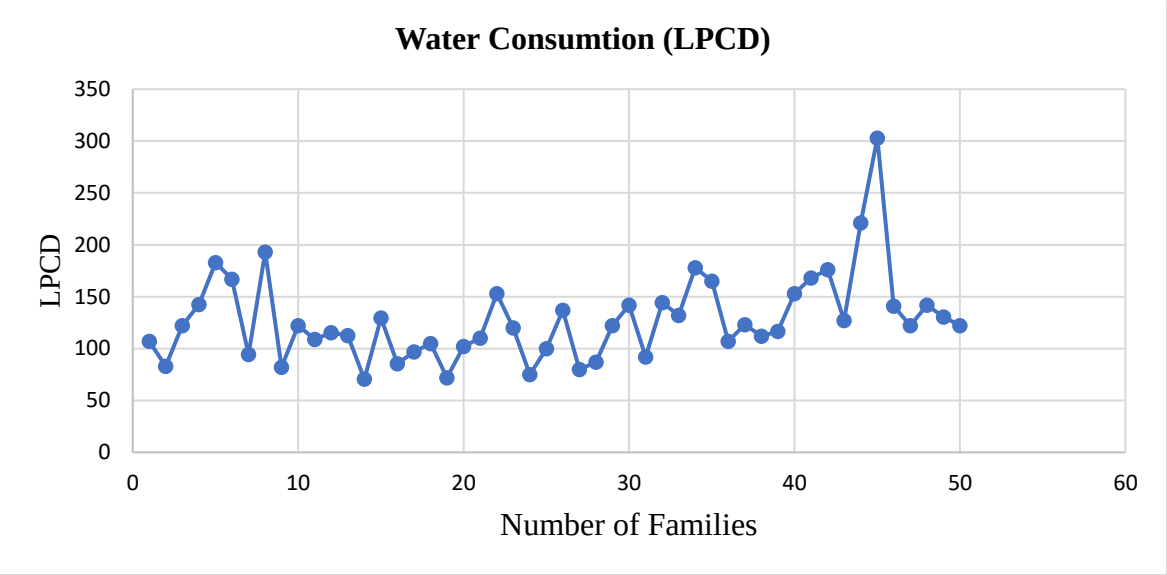

Fig.4.7 Per capita water consumption in the households

4.8 Organizational Problem (Non metered connections and billing system)

Organizational problem is a major concern for water consumption in this area. Due to poor distribution system and management, there is so many non-metered connections in that area. People pays a fixed amount for which cannot measure the proper amount of water they've used. People should pay for what they've used. In this case some people use more water and some people use less, but both parties need to pay the same amount for their different consumption.

In this study we have observed too much irregularities in water bill and consumption rate. In the graph below it shows the differences between the amount of monthly water bill and the amount of water consumption per day. The highest water consumption rate in a family observed is 1515 liters per day and the lowest was 249 liters per day. The family which uses the highest amount of water pays only 500 BDT per month whereas the lowest consumed family pay almost the same, 400 BDT per month. If those family would pay for the amount of water they've used then this sort of dissimilarities wouldn't happen. This problem is created due to non-metered connections in that area. If the authority made sure that every house had metered connections then both consumers and suppliers would get proper

treatment. From the figure 4.8 it is clearly portrayed that the differences are too much concerning and it is injustice towards some people whereas some people get the benefit of it.

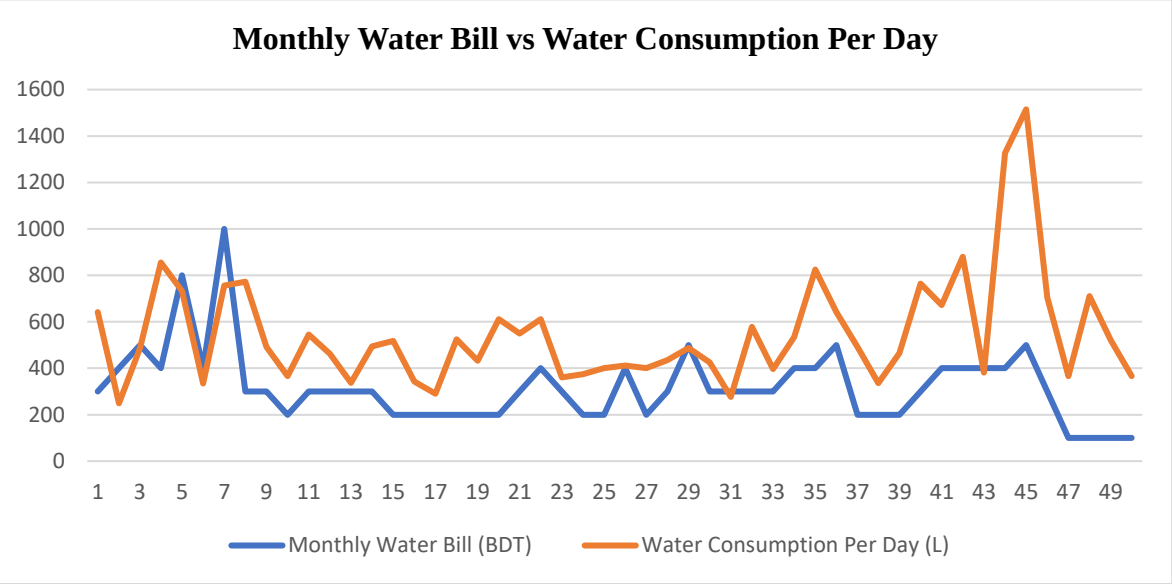

Fig.4.8 Differences between monthly water bill vs water consumption per day

4.9 Water Consumption Based on Socio Economic Condition

Socio economic condition shows the diversity of people's financial condition living in that area. In our survey area there was different types of people with different occupation. As it is a sub urban zone people of various economy class lived in a that area together. That's why there are different types of houses such as Apartment buildings, Semi pacca houses, tin shade houses. People lives in those houses based on their economic condition. Most of higher economical class families lives in apartment buildings, and lower economy class people lives in tin shade and semi pacca houses. Even the flat area differs due to this reason.

In the figure 4.9 it shows the relation between monthly water consumption and monthly income of the sample families. Here the highest income observed is 100000 BDT per month and the lowest recorded is 9000 BDT per month. Most of the family has 1-2 earning members. The highest amount of water consumption was recorded in a family was 45450 liters per month and lowest was recorded 7470 liters per month. The graph clearly portrays that families which has higher income consumes more water than families with lower income. As people who has higher socio-economic condition get more privileges such as good residence, better sanitation system, proper supply of water etc. They can use alternates if they face any problem with regular water supplies, but others depends on the municipal supply and suffers the most.

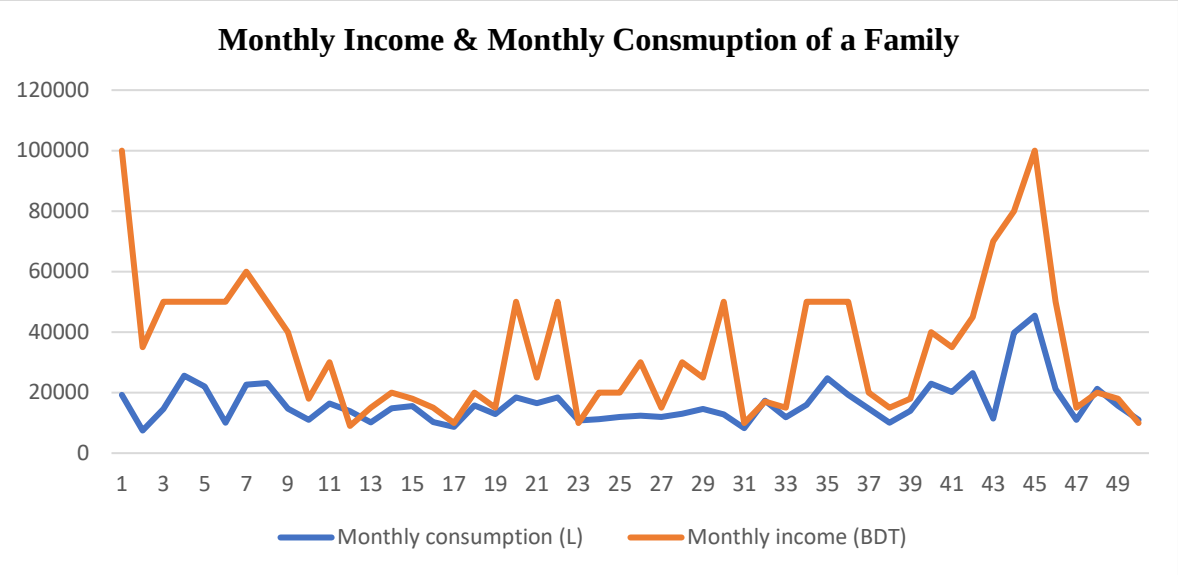

Fig.4.9 Monthly income and monthly water consumption of a family

4.10 Wastewater Disposal system

Wastewater is the water which produces from the usage in different cleaning activities of households such as house cleaning, kitchen use, toilets, faucets etc. There are two types of wastewater produces from domestic usage. These are Blackwater and Greywater. Blackwater is the water which comes directly from the toilets and it is not reusable without treatment. Greywater comes from the faucets, baths and kitchen activities, it can be used in activities like gardening, vehicle cleaning and other activities which doesn't require fresh water. For wastewater disposal there is some specific methods, in our country wastewater is disposed in septic tanks and drains, which later goes to the sewer. In the graph below it shows the wastewater disposal system of 50 houses of our survey area. From the graph we can see 6 houses have the septic tank facility. Once these tanks fill up, they remove the sludges using pump and discharge it in the drain or nearby waterbody. 28 houses have only drainage connection so they discharge both black and grey water in the drain directly. And 16 houses have both septic tank and drainage connection, this is the ideal disposal system and not harmful for environment.

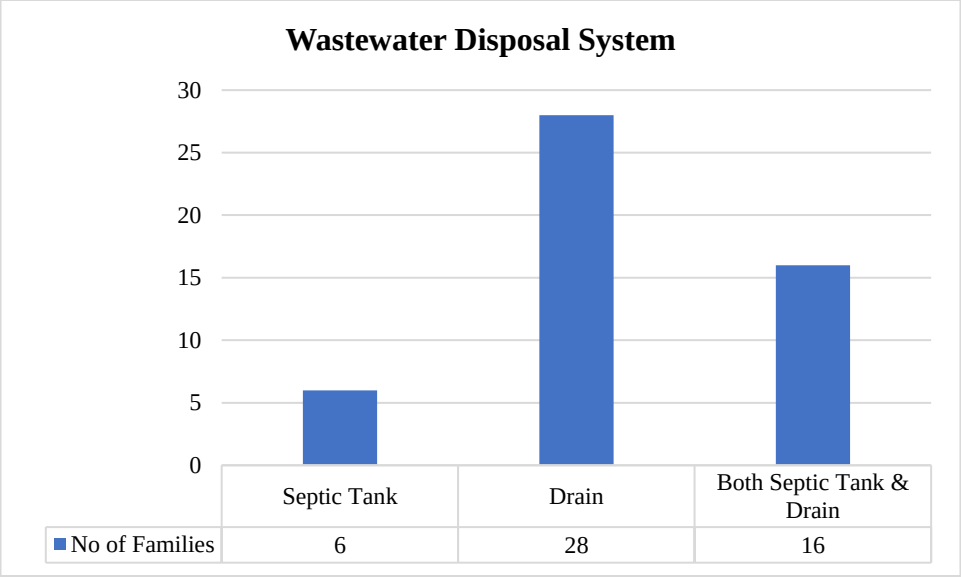

Fig.4.10 Wastewater disposal system

In figure 4.10 it shows the wastewater disposal system of the houses. In the survey area there was many types of wastewater disposal system applied on those houses. Almost every apartment has both septic tank and drainage system for waste water disposal. Black water goes to septic tank in which one chamber holds the sludges and another chamber holds the wastewater. And grey water goes directly in the drain. This is the desired disposal system for every houses. But some old buildings and tin-shade houses only have either septic tank or direct line to drain. Which pollutes environment and it is not desired and no one is concerned about it. As there is no waste water treatment plant in that area, these drain water directly goes to the Turag River without any treatment, this is how it contributes to more pollution in Turag River.

4.10.1 Possible Reuse of Domestic Wastewater

Gray water is produced in significant amounts from every resident. The research provided the amount of gray water produced by a typical household. The findings were used to measure the average gray water generation rate, which came to 82.5 LPCD. This figure represents roughly 64% of the total water used by a home. Reusing kitchen water may not be an option because grey water (approximately 10%) from sinks is difficult to recycle due to the water's composition. Table 4.2 illustrates the domestic sources of grey water and the amount coming from a household.

Table 4.6 Water consumption in different usage and identification of usable and non-usable water.

SL No.	Water source	Average water usage (LPCD)	(%) Percentage of use
1	Kitchen	13 (Reusable)	10
2	Bathing	51.5 (Reusable)	41
3	House Cleaning	13 (Reusable)	10
4	Drinking	3 (Non reusable)	2
5	Toilet	42 (Non reusable)	33
6	Livestock	0.5 (Non reusable)	0
7	Vehicle	4 (Reusable)	3
8	Gardening	1 (Non reusable)	1

Summary: Water demand per capita= 128 LPCD

Reusable grey water= 81.5 LPCD

Maximum reusable grey water= 64% per capita.

Reusable grey water except kitchen usages = 54% = 71.5 LPCD

For outdoor uses such as building construction, highway peripheral aesthetics and maintenance, playgrounds including soccer fields and golf courses, automobile cleaning, windows washing, fire prevention, and dust control, greywater may be collected from baths and sinks. Domestic greywater can be recycled instantly inside the household and used to flush toilets (33 % usage) or it can be stored and processed if it is collected using a separate plumbing system from black water.

CHAPTER 5

CONCLUSION

5.1 Conclusions

Water crisis, poor quality of water, groundwater depletion, surface droughts, and negative environmental consequences require the government and authority to be concerned about the facts and ensure sustainable water consumption practices and wastewater reuse by constructing wastewater recycling plants. The study's major goal is to ensure the sustainable water consumption practices. Sustainable water consumption is beneficial for both consumers and suppliers. It also saves a lot of resources for both parties. Non metered connections should be removed and the fixed priced policy should not be practiced anymore. People should pay for the amount of water they've used, this will obviously change everyone's perspective, people will be more concerned before wasting water. Also, the authority has many flaws, they should work on those things and make sure to supply consumable water to every houses. The analysis result and discussions of the research work concludes us to these observations -

(i) The research shows that the per capita water consumption of a person for domestic usage is 128 LPCD in our study area.

(ii) People with higher economical condition consumes more water compared with people of lower economical condition. Highest monthly consumption of a family was 45450 liters, the same family has the highest monthly income of 1,00,000 BDT.

(iii) Flashing toilets use more water than non-flushing toilets. Users of shared toilets use less water than individual toilets. Users of shared toilets consume less water than users of individual toilets.

(iv) Use of water saving appliances in faucets, sinks, toilets can reduce water consumption, and the reuse of grey water can save up to 71.5 LPCD water.

(v) Research shows the variance in water pricing policy and irregular connections of that area. The family which uses the highest amount of water pays only 500 BDT per month whereas the lowest consumed family pay almost the same, 400 BDT per month.

(vi) Research indicates 54% of domestic water can be recycled for non-drinkable and outdoor usages.

References

Afzal, H.A.K.M., Siddiqui, S., and Sadek, S., (2000) "Groundwater Resources Assessment and Management for Dhaka City", Unpublished paper.

Ahmed, M.F., and Rahman, M.M., (2000), "Water Supply& Sanitation: Rural and Low-Income Urban Communities"

Aitken, C. K., H.Duncan, and T. A.McMahon (1991), A cross-sectional regression analysis of residential water demand in Melbourne, Australia, *Appl. Geogr.*, 11, 157– 165.

Amy Vickers (2001), Handbook of Water Use and Conservation.

Anwar, Md. Shibly. "Potentials for Water Conservation in Dhaka city." university thesis, December 2010: 5-6.

Arbués, F., M. A. Garcia-Valinas, and E. Martinez-Espiñeira (2003), Estimation of residential water demand: A state-of-the-art review, J. Socio Econ., 32, 81–102, doi:10.1016/S1053-5357(03)00005-2.

Cardoso ML (2013) Modeling Portuguese water demand with quantile regression. Doctoral dissertation, University Institute of Lisbon

Carter**,** David W., and J. Walter Milon. (2005). Price Knowledge in Household Demand for Utility Services. 2: 265-83.

Corral-Verdugo, Victor & Armenta, Martha & Gonzalez-Lomelí, Daniel. (2003). On the Relationship Between Antisocial and Anti-Environmental Behaviors: An Empirical Study. Population and Environment. 24. 273-286.

DWASA, "Management Information Report", 2018.

Dube, E. and Van Der Zaag, P. (2003) Analysing Water Use Patterns for Demand Management: The Case of the City of Masvingo, Zimbabwe. Physics and Chemistry of the Earth, 28, 805-815.

Kamal, A.M. (2003). Attitude and opinion of the profile regarding water supply: A case study of Slum dwellers. Water and sanitation for Cities, World Habitat Day 2003 Souvenir, Bangladesh Institute of Planners (BIP) & Center for Urban Studies (CUS), Dhaka, Bangladesh.

Mayer PW, DeOreo WB, Opitz E, Kiefer J, Dziegielewski B, Davis W, Nelson JO (1999) Residential end uses of water. American Water Works Association Research Foundation, Denver, CO.

Mia, Md & Zakir, H. (2014). Water Quality Evaluation of Tongi Area in Bangladesh: An Impact of Industrialization. Journal of Chemical Biological and Physical Sciences. 4. 1735-1752.

Nauges C, Thomas A (2000) privately operated water utilities, municipal price negotiation, and estimation of residential water demand: the case of France. Land Econ 76(1):68–85.

Okubo, K., Khan, M.S.A., and Hassan, M.Q., (2008), "Hydrological processes of adsorption, sedimentation, and infiltration into the lake bed during the 2004 urban flood in Dhaka city, Bangladesh"

Population Stat. Dhaka, Bangladesh Population (2022) - Population Stat

Population Hub - www.population-hub.com/en/bd/population-of-tongi-2194.html

Rahman, M. Feroze Ahmed and Md. Mujibur. water supply and sanitation. Dhaka: ITN-Bangladesh, June 2000.

Rahman, M.Feroze Ahmed and Md. Mujibur. water supply and sanitation rural and low-income urban communities. Dhaka: ITN Bangladesh, June 2000.

Rhoades SD, Walski TM (1991) Using regression analysis to project pumpage. J Am Water Works Assoc 83:45–50

Shaw, D. T. and Maidment, D. R.: 1987, 'Intervention Analysis of Water Use Restrictions, Austin, Texas', *Water Resources Bulletin* 23 (6), 1037–1046.

Shiklomanov, I. (1993) World Fresh Water Resources (Water in Crisis: A Guide to the World's Fresh Water Resources). Oxford University Press, New York.

The Four Assumptions of Linear Regression - Statology

Tanvir ferdous Saeed, Abdullah Al-Muyeed. Environmental Sanitation, Wastewater Treatment and Disposal. Dhaka, november 2013.

Western Regional Climate Center (2005) WRCC: Comparative Table (dri.edu)

Western Resource Advocates, (2003) - www.westernresourceadvocates.org

WHO (2003). The Right to Water, WHO Geneva.

YABIKU, SHARON L. HARLAN AND SCOTT T. "Household Water Consumption in an Arid City." Society & Natural Resources, February 2015: 4-5.

Appendix A

Table A1 Survey Questionnaire

Survey data	Write/Tic the correct data			
Road, House address:				
Area of plot:				
No of flats:				
No of people:				
Earning members in each family				
Source of income:	◯ Job		◯ Business	
Water supply from regular source	◯ Municipal Supply		◯ Groundwater	
Amount of water bill:				
Water supply nature:	◯ Regular	◯ Mostly Regular	◯ Irregular	
Quality of water:	◯ Good	◯ Moderate	◯ Poor	
	Reason behind poor or moderate: ◯ Taste ◯ Color ◯ Odor			
Sanitary system	◯ High comed		◯ Pan	
Types of kitchens	◯ Individual - Inside home	◯ Individual –Outside home	◯ Shared- Inside home	◯Shared– Outside home
Bathing facilities	◯ Individual - Inside home	◯ Individual –Outside home	◯ Shared- Inside home	Shared– Outside home
Water usage for bathing: (LPCD)				
Water usage for cleaning: (LPCD)				
Water usage for drinking: (LPCD)				
Water usage for wastage: (LPCD)				
Livestock or poultry: (LPCD)				
Home gardening: (LPCD)				
Personal vehicle: (LPCD)				
Waste water disposal system:	◯ Drain	◯ Septic tank	◯ Both	