ASSESSMENT OF FUTURE WATER DEMAND OF DHAKA CITY

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ABSTRACT

Dhaka, the capital of Bangladesh, is one of the fastest growing cities of the world. It remains a great challenge to ensure uninterrupted water supply in the city with adequate quantity and quality round the year. Necessary measures are undertaken to meet the growing demand of water supply which is presently dependent on abstraction of groundwater. It appears that no further abstraction is feasible as the groundwater level is declining very fast. To reduce the overwhelming dependence on groundwater resources, surface water in the vicinity of the Dhaka city can be utilized. The study includes water demand and population projection upto 2035.

1.0 INTRODUCTION

Forecasting of water demand is a crucial component in the successful operation of water supply system. Accurately forecasted water demand either in short-term, or medium-term, or long-term time horizons can be very useful for capacity planning, preparation of maintenance, cost effectiveness and optimization of the operations of a water system. In addition, adequately forecasted water demand will be a basis for the strategically decision making on future water sources selection, improvement of the available water sources. Future water demand will also help in designing of the abstraction options so that water resources are not exhausted. All users in Dhaka have the right to access to available resources both surface water and ground water in near future. This chapter describes the existing progression of population and prediction of future water demand for Dhaka city. The estimation of future water demand addressing the uncertainties associated to the existing supply scenario and growth of population has been illustrated in the following sections.

2.0 PRESENT SITUATION OF GROUND-WATER DTWS IN DHAKA CITY

Over the years the number of DTWs has been increased enormously in Dhaka city. A graph showing the increasing number of DTWs is shown in Figure 1. At present 78% of the total supplied water is provided from 750 wells which were more than 88% before the introduction of Saidabad Phase II SWTP. Every year more numbers of new DTWs are installed to meet the increased demand of the city. Over the years, the increasing trend of DTW in Dhaka city is shown in Figure 1:

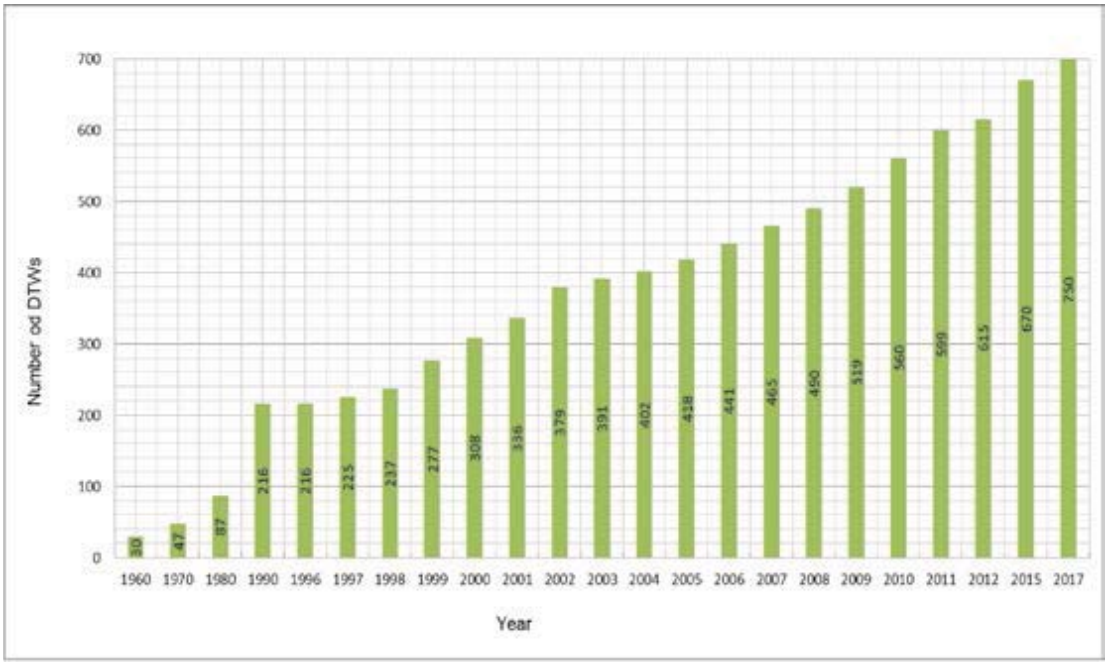

Fig 1. Increasing trend of DTWs over the years

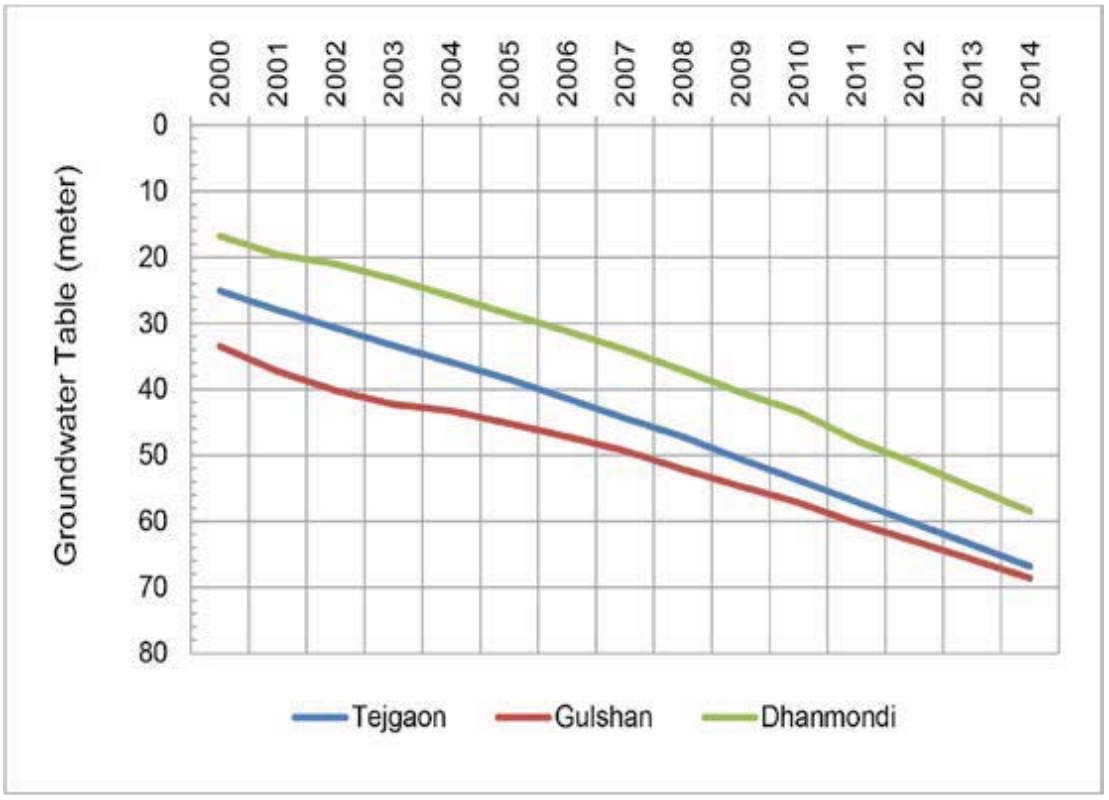

Fig 2. Groundwater depletion state in Tejgaon, Gulshan and Dhanmondi

The gradual mining depth of groundwater table for water extraction is shown at Figure 2. It was shown that mining depth for groundwater table is an increasing trend. For instance, in 2000 the depth was 20 m and in 2017 the depth reaches to 70 m. Some DTWs are used to extract water from a depth of 750 meters which is an alarming situation.

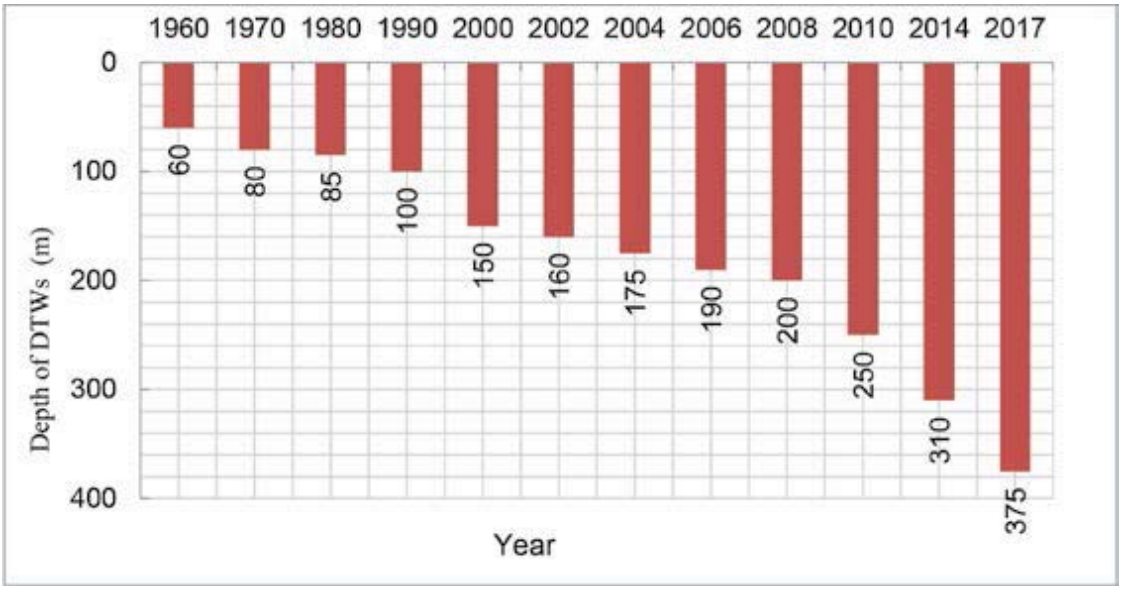

Fig 3. Gradual increase in mining depth of DTWS

Though it was found that, pumps operated more than 20 hours a day, most of the pumps are operating more than the recommended time. As a result, the aquifer is not getting minimum required time for recharging. Again, the rate of groundwater depletion varies in different areas of the city. The rate of groundwater depletion in different areas of the city is shown at Table 1, Figure 2 and Figure 3.

Table 1. Groundwater depletion state in Lalbag, Motijheel, Cantonment, Mirpur, Tejgoan and Dhanmondi

Year	Groundwater depletion state in m						
	Mirpur	Lalbagh	Motijheel	Tejgaon	Gulshan	Cantonment	Dhanmondi
2000	29.9	27.0	38.8	25.1	33.5	20.8	16.8
2001	32.5	29.2	42.7	28.0	37.3	23.6	19.6
2002	35.4	32.3	45.5	30.7	40.2	27.0	21.0
2003	38.1	35.5	48.0	33.4	42.3	30.1	23.3
2004	41.2	39.0	50.6	35.9	43.3	32.9	25.9
2005	44.2	42.7	53.4	38.5	45.2	36.1	28.6
2006	47.3	46.3	56.5	41.4	57.2	39.0	31.2
2007	50.5	50.0	59.7	44.4	49.3	41.6	34.0
2008	53.75	53.7	62.6	47.2	52.1	44.5	37.1
2009	57.1	57.0	65.7	50.6	54.7	47.5	40.5
2010	60.5	60.3	68.8	53.8	57.2	50.8	43.4
2011	64.0	63.8	72.0	57.1	60.3	54.2	47.8
2012	67.4	67.0	75.0	60.3	63.0	57.5	51.2
2013	70.9	70.9	79.0	63.6	65.8	60.9	54.9
2017	74.3	73.5	83.0	66.8	68.6	64.2	58.5

(**Source:** DWASA 2014)

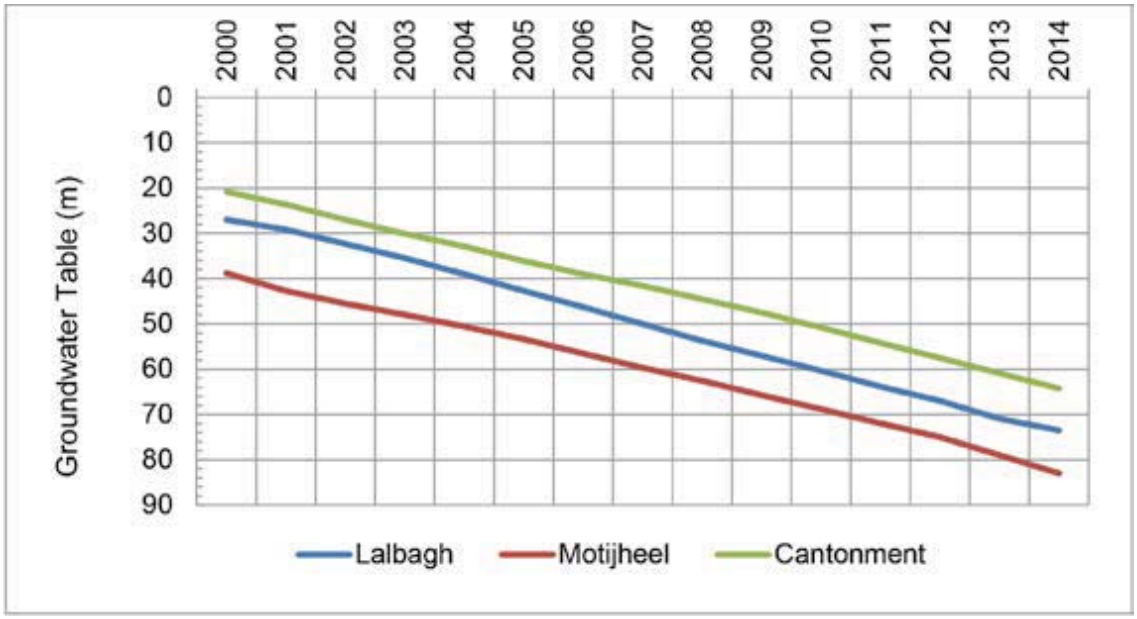

Fig 4. Groundwater depletion state in Lalbagh, Motijheel and Cantonment

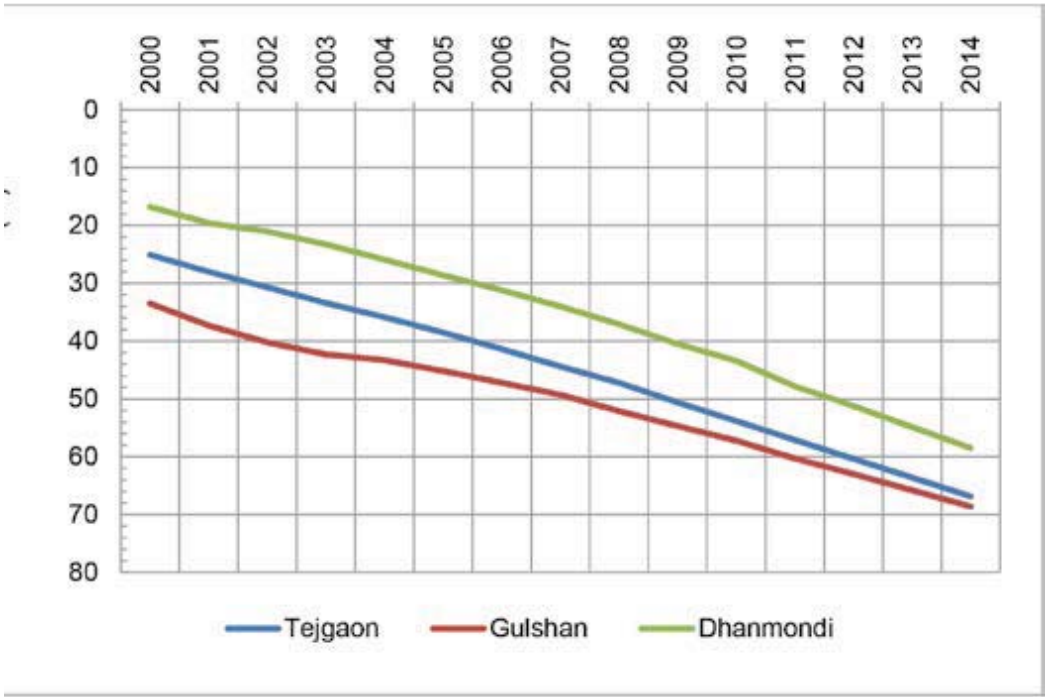

Fig 5. Groundwater depletion state in Tejgaon, Gulshan and Dhanmondi

Groundwater depletion is one of the prime causes of fresh water crisis which is directly related to over extraction triggered by increased demand of the city. Premature well failure is another challenge of DWASA which also affects the overall water production capacity. The expected life time of a pump is considered to be 30 to 40 years but every year 40 to 60 DTWs are being replaced just after an average life span of 2 to 3 years. Clogging due to over extraction and small particles from aquifer, poor design and improper construction supervision are a few major causes of these premature well failures. SWTPs cannot produce at their optimum capacity due to non-availability of surface water. Surface water pollution is another cause of fresh water crisis of the city. Due to industrial waste, solid waste and sewage disposal the surface water of Dhaka City is getting exceedingly polluted. The pollution level has gone so high that in many cases the water is unusable in the SWTPs.

3.0 SURFACE WATER TREATMENT PLANTS (SWTP) OPERATED BY DWASA

In order to collect the information regarding the treatment capacity, production, quality parameter and cost effectiveness on the water supply situation numbers of visits have been conducted to existing SWTPs (Saidabad, Chadnighat, Godnail, Sonakanda) from 15 November to 25 November 2017. The officials informed that SWTPs cannot produce at their optimum capacity due to unavailability of raw surface water. Production capacity reduces more during dry season due to less flow of water. For example, Chandnighat SWTP has a capacity of treating 39 MLD but produces only 3 MLD on an average during dry seasons due to low water level in Buriganga River. The use of chemicals for the treatment of raw surface water in these SWTPs is increasing significantly. It was also reported that if the intake water quality deteriorates more, it will not be possible to treat any more. As a result, due to increased demand and deteriorating water quality of peripheral rivers, supplying water from Padma and Meghna River is an utmost need. At present DWASA has 4 SWTPs with total production capacity are given at Table 2.

Table 2. Details of SWTPs

Serial	Name of SWTPs	Capacity (MLD)	Coverage Area
1.	Saidabad Water Treatment Plant (Phase 1 and 2)	450	Mods Zone 1, 2, 3, 4, 5, 6, 7
2.	Chadnighat (Dhaka) Water Works	39	Mods Zone 2, 3
3.	Narayanganj (Godnail) Water Works	33.17	Narayanganj west
4.	Sonakanda Water Works	1	Narayanganj east

(**Source:** DWASA 2017)

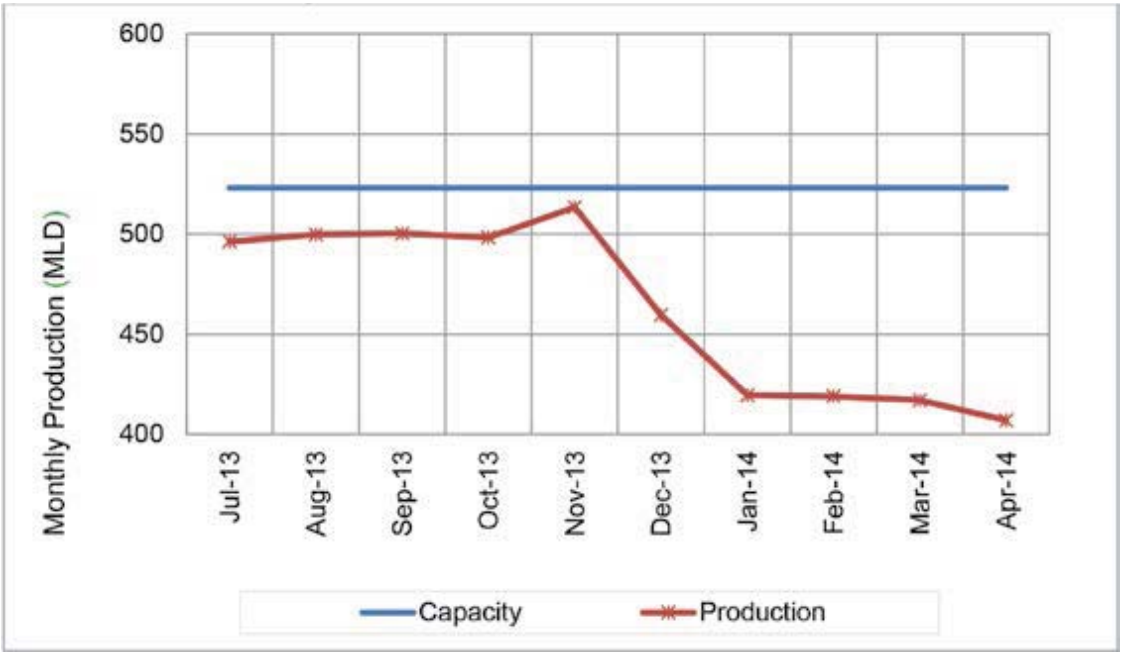

Fig 6. Seasonal variations in monthly production of SWTPs

4.0 WATER SUPPLY AS SURFACE WATER FROM RIVER SOURCES

In a personal communication of DWASA, was revealed that the actual fresh water production of DWASA is around 2196 MLD whereas the demand is more than 2300 MLD. It was revealed that the maximum production capacity of DWASA is 2486.47 MLD, but it can utilize 88.34% of maximum level due to various reasons discussed earlier. As a result, there is continuous shortage of 100 MLD or even more fresh water in wet season. This shortage becomes more during dry season stated in article. Around 80.56% of the supplied water of Dhaka comes from DTWs and rest 19.44% is obtained by treating surface water. Due to lowering of groundwater table neither it is possible to increase the rate of production nor is it feasible to dig more numbers of wells. All these conditions necessitate the requirements of exploring alternative options of water supply for meeting the present and future demand of the city.

5.0 POPULATION PROJECTION

The population data has been collected from Bagladesh Buraeu of Statistics (BBS-2011) for the years 1975 to 2010. Best fit curve has been obtained and to be extrapolated for future prediction.These data has been plotted as shown in Figure 6.

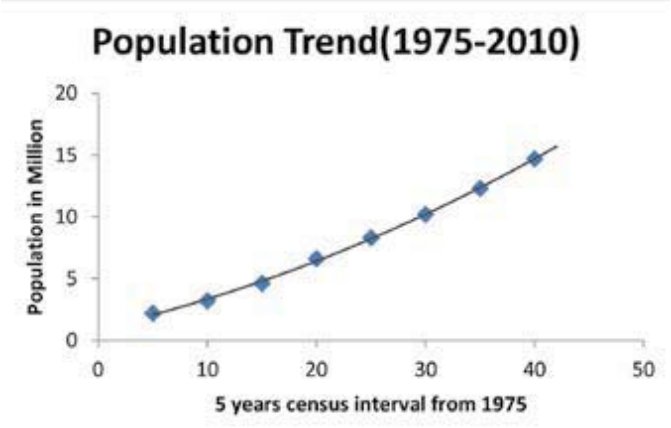

Fig 7. Population trend of Dhaka from 1975 to 2010

Based on the data and trend of graph the following equation was obtained

$y=0.0035x^2+0.2011x+0.9768$ - - - - - - - - - (1)

Here in equation (1) y is the population in million and x is the census interval in 5 years. In order to estimation and projection of future population a graph has been generated and obtained the population upto 2060 as shown in Table 3.

Table 3. Projected population upto 2060

Year	Projected Population in Million
2020	19.78
2025	22.62
2030	25.64
2035	28.84
2040	32.20
2045	35.75
2050	39.46
2055	43.36
2060	47.43

6.0 FUTURE WATER DEMAND ASSESSMENT

Future water demand has been calculated as per the population projection shown in Table 3. Water demand is divided into three main categories i, e, residential demand, non-residential demand and fire fighting requirement. System losses in water demand are also considered as percentage of these main categories.

6.1 Residential Water Demand

The present area of Dhaka city is 404 sq km. In 2035 the area will be 617 sq km and in coming future it will be even more. The breakdown of indoor household water consumption was estimated from the survey conducted in the year 2012, 2014 and 2016 for sample size 50, 45 and 60 numbers of families respectively. The amount of water consumed per person for personal washing (showering, ablution and face/hand washing), clothes washing and floor washing seems to be logical in many cases as found from collected data. The residential consumption rate is considered 150 lpcd; non- residential (other) consumption is around 12%, fire fighting 5 lpcd and system loss is assumed as 8%. Breakdown of all possible water consumption as resulted from survey is shown in Table 4.

Table 4. Breakdown of indoor household water consumption

Feature	Collected Data in 2012		Collected Data in 2014		Collected Data in 2016	
	lpcd	%	lpcd	%	lpcd	%
Personal Washing	75	36%	70	45%	72	25%
Toilet Requirement	25	17%	30	20%	28	19%
Washing Apparatuses	26	16%	25	17%	24	13%
Clothes Washing	25	21%	17	13%	20	12%
Drinking	2	1%	2	2%	2	1%
Cooking	3		3	2%	4	18%
Floor washing	3	9%	2	1%	3	12%
Other Uses	1		1	0%	1	0%
Total	160	100%	150	100%	155	100%
Sample size	50		45		60	

(**Source:** DWASA 2014)

6.2 Non Residential Water Demand

Non-residential water consumptions such as consumptions in government/institutional, commercial, industrial and community buildings have been considered as a percentage 12% to 20% of total residential consumption.

6.3 Total Future Water Demand

Future demand assessment incorporates the key water demand factors such as population projection, per capita daily consumption and other residential and non-residential demands. The water requirement has been used to assess future demand for different scenarios up to 2035. The required production capacity was estimated for each of the scenarios based on different rates of system losses. The population has been projected based on previous inter-census growth rates and future urban development plans. Per capita daily consumption rates are based on the household survey findings for different structure types, possible reductions in poverty levels in the future, expected responses to tariff re-structuring and projections of changes in housing structure types.The proportion of non-residential (other) water demands has been based on urban development plans and possible composition of economic activities in Dhaka. The different rates of system losses have been based on expected implementation of existing and new Dhaka service areas and assumptions on improved operation and maintenance of water supply infrastructures. It is expected that the projected water demands can be updated as part of regular census in expanded urban development plans. The extent of service area of Dhaka expanded to part of Tongi and Gachcha in the North West, Kaliganj in the north east, Rupganj in the west, Keranigonj in the south west and Bandar in the south east. Population density and existing and expanded Dhaka city is shown in Figure 7.

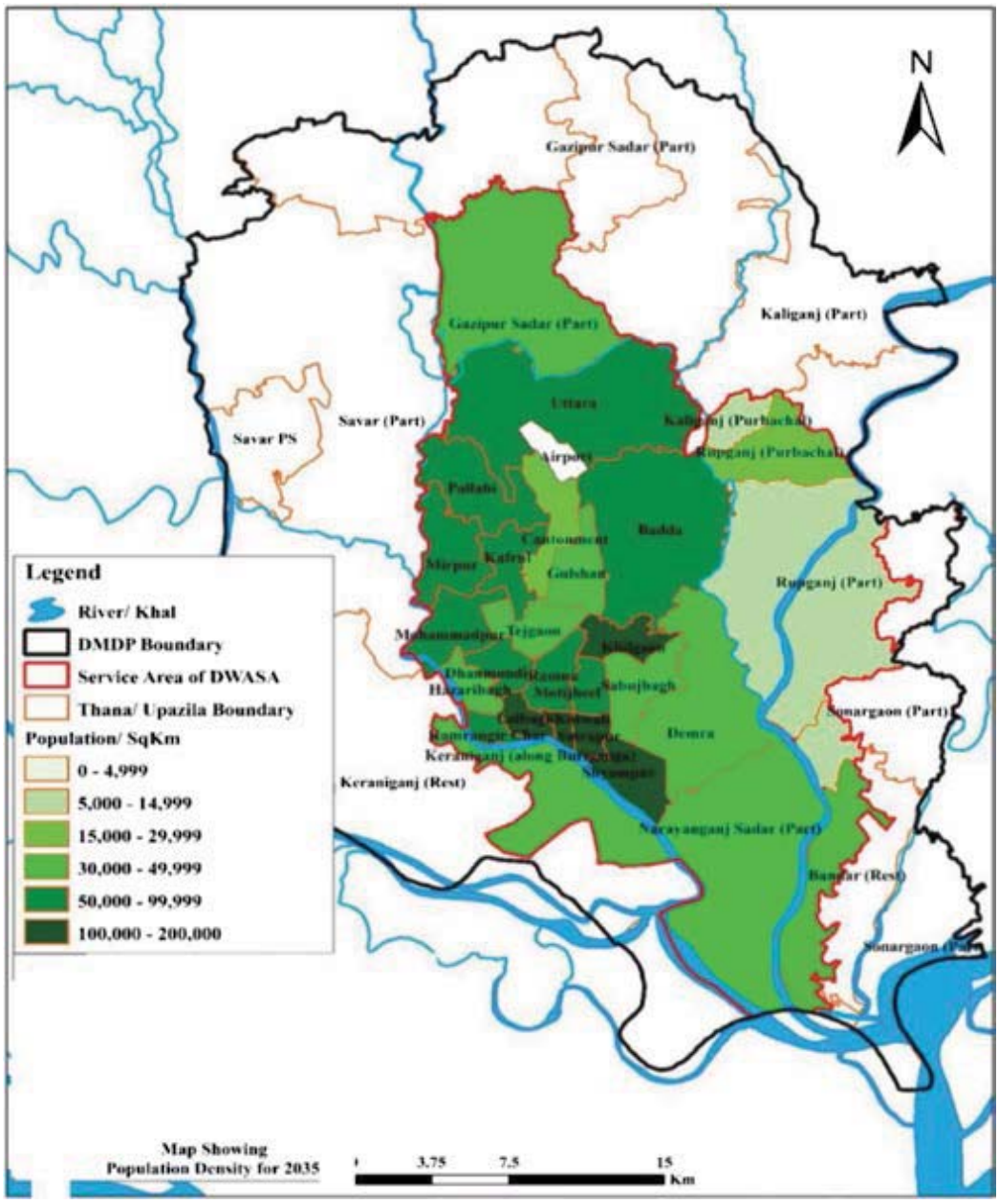

Fig 8:.Map showing population density of Dhaka city

Notes:

a. Initial residential consumption rate based on household demand survey

b. Area expansion in 2020 includes Purbachal, Tongi, Gachcha and part of Keraniganj and Rupganj

c. Area expansion in 2030 includes parts of Rupganj, Sonargoan and additional parts of Keraniganj.

A calculation was carried out to determine the future water demand of the city. In 2017 the estimated population is 18 million, residential consumption rate is 150 lpcd and considering other consumption, fire fighting, loss the total demand stands 2727 MLD. At present, 8% loss considered in the system where it is expected to improve further with the development of technology and infrastructure. Therefore, the gradual decrease of system loss upto 2% has been considered in this study. Likewise calculation upto 2035 year have been estimated and found around 5105 MLD can be seen in Table 5. The coverage area will increase with the time.The coverage area will be increased to 617 km2 by 2025 km2 and will be increased after the year 2045 to area upto700 km2 with more population and expansion of area (DWASA, 2016). A calculation has been made for the same scenario upto the year of 2060 and demand was estimated around 7091 MLD has been shown in Table 6.

Table 5. Estimation of projected water demand from 2017 upto 2035

Year / Item	2017	2020	2025	2030	2035
Coverage Area (Sq km)	404	497	617	617	617
Estimated Population Served (Million)	18	19.78	22.62	25.64	28.84
Resedential Consumption Rate (Lpcd)	150	150	150	150	150
Residential Consumption (MLD)	2250	2654.4	3059.1	3460.6	4009.2
Percentage of other Consumption (%)	12%	14%	16%	18%	20%
Other Consumption (MLD)	270	371.616	489.456	622.908	841.932
Total Consumption (MLD)	**2520**	**3026.016**	**3548.556**	**4083.508**	**4851.13**
Fire Fighting Requirment (MLD)	5	7	8	9	11
Total Demand (MLD)	**2525**	**3033.016**	**3556.556**	**4092.508**	**4862.13**
Percentage of Loss%	8%	7%	6%	5%	5%
Total Loss (MLD)	202.00	212.31	213.39	204.63	243.11
Required Production Capacity (MLD)	**2727.00**	**3245.33**	**3769.95**	**4297.13**	**5105.24**

Table NB 6: Estimation of projected water demand from 2040 upto 2060

Year / Item	2040	2045	2050	2055	2060
Coverage Area (Sq km)	617	700	700	700	700
Estimated Population Served (Million)	32.20	35.75	39.46	43.36	47.43
Resedential Consumption Rate (Lpcd)	150	150	150	150	150
Residential Consumption (MLD)	4291.25	4570.8	5048.4	5327.95	5594.6
Percentage of other Consumption	22%	21%	22%	23%	24%
Other Consumption	944.075	959.868	1110.65	1225.43	1342.7
Total Consumption	**5235.325**	**5530.67**	**6159.05**	**6553.378**	**6937.3**
Fire Fighting Requirment	12	12	12	14	15
Total Demand	**5247.325**	**5542.67**	**6171.05**	**6567.38**	**6952.3**
Percentage of Loss	4%	3%	3%	2%	2%
Total Loss	209.89	166.28	185.13	131.35	139.05
Required Production Capacity	**5457.22**	**5708.95**	**6356.18**	**6698.73**	**7091.3**

Final outcome of Table 1.6 is the total production capacity required for the Dhaka city which is 2727 MLD in 2017 and 5105 MLD in 2035. In the same process the demand will increase around 7091 MLD in 2060 which is very high compared to present population.

7.0 CONCLUSIONS

In this paper, prediction of future population and demand has been assessed to meet the future water requirement of Dhaka City. The causes of water crisis of the city are the rapid groundwater depletion, extreme surface water pollution and untreated surface water sources. It is apparent that present amount of water supply and its infrastuctural arrangement are not sufficient to meet the future water requirement of the Dhaka city. There is a necessity to explore surface water sources to solve the water crisis. The Dhaka area is expected to expand from the current 404 km2 to about 617 km2 by 2035. During this period, the total population in the 617 sqkm area is expected to increase from 16 million in 2011 to 29 million by 2035. The total demand is expected to increase from about 1500 MLD in 2011 to 5105 MLD in 2035. Beyond 2035, there is likely to be around 50% increase in total demand by the year 2060. Water consumption in Dhaka city is showing a rising trend as the population and urban development are being expanded. This consequence needs due attention with proper estimation and evaluation of the surface water sources for future demand of Dhaka City.

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