Drinking Water Supply Management through Innovative Methods and Finance in Municipal Councils of Mumbai Metropolitan Region

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ABSTRACT

Drinking water is a basic need of human being. Adequate, continuous and safe quantity of drinking water supply reduces the burden of diseases and improve standard of living of people. The water demand is continuously increasing with urbanization in Mumbai Metropolitan Region. The supply of drinking water is inadequate due to more demand by different units. The demand of drinking water is higher by population, commercial units, health care, educational institutions and industry. The deficit in supply of drinking water supply is observed in all the municipal councils of Mumbai Metropolitan Region. The Tobit regression shows that the water demand is positively co-related to the population, malls and theaters in all councils. Therefore the policies of public private partnership will bring good result in water supply infrastructure. The municipal councils should be allowed to issue municipal bonds to raise long term capital. The water use laws and awareness among people about scarcity of water will reduce water waste and improve its effective use. Government and municipal councils should look long term solution to reduce water scarcity in metropolitan region.

KEYWORDS: *Equality, Health, Tariff.*

JEL CLASSIFICATION *D1, H7, I1, Q5*

INTRODUCTION

Water is essential for human existence. The right to adequate drinking water is considered to be the most fundamental of human rights. The adverse impacts on public health from poor water supply have long been recognized in both developing and developed countries (Howard & Bartram, 2005). Therefore governments everywhere feel called up on to give top priority for programs to provide safe drinking water. But the question of whether this has been done efficiently in third world countries remains to be answered (Kanmony, 2003). In India, millions of people do not have access to safe drinking water. It has been estimated that out of the 37 diseases responsible for most deaths in developing countries, 21 are related to water and sanitation. About 1.5 million children under the age of five are estimated to be dying in India each year due to such diseases. It is also estimated that about 200 million person days are lost annually due to such ailments. It is the poor and weaker sections who bear the brunt of these diseases and suffer loss of earnings (Ramachandran, 2001). But still the importance of adequate quantity and quality of water is not given by government.

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In Mumbai Metropolitan Region, there is continuous migration from rural to urban and urban to urban area. The rural skilled and unskilled migrants find employment in region. They easily adopt with employment opportunities and housing. Metropolitan region has good connectivity of railway and roads. The people from Mumbai and Mumbai suburbs are migrating to Thane and Raigad district due to affordable housing, good environment, regular transport system and other civic amenities. The municipal councils such as Panvel, Ambernath and Badlapur are growing in terms of population and other units. Local trains are providing the good connectivity to Mumbai city and neighboring areas. The businessmen have invested resources in real estate, commercial units such as malls, shops etc. The state government and municipal councils have invested money in public utilities such as electricity, water supply, recreation, sewage collection and local transport. Due to massive investment, Mumbai Metropolitan Region has witnessed as transformation in overall infrastructure. The population, commercial units, manufacturing units, educational and health care institutions have grown significantly. They put pressure on the existing civic amenities of municipal councils. Municipal councils have lack of resources to finance the infrastructure and civic amenities. It has resulted into scarcity of different civic amenities and services. The rising population is continuously demanding more amenities in Mumbai and Municipal Corporations of Thane district. Such inadequate civic amenities such as water supply, housing, transportation, health care, solid waste, sanitation is affecting on quality of life. It has further resulted into traffic, slums, inadequate water supply, untreated sewage and power cut in municipal council area. The adequate drinking water is not provided on regular basis. Poverty is evidently an aggravator of water-related stress. The poor households have inability to invest in water collection, storage or purification (Krishnan, 2003). The women and children are required to carry drinking water from far places. At some places, water is available only a few hours a day and few days a week. Many people in slum areas are forced to buy water from vendors at prices that are up to 10 to 20 times higher than prices for tap water (Gonzalez de Asis et al., 2009). The poor women are required to wake up early in the morning and carry drinking water for family. They do not have choice because water is scarce and it does not easily available in slums. Women and children stand in a long queue and carry few liters of water which is required for family. The opportunity cost of women and children is much higher. Most of the women are working as daily wage earners and children are in school. The water borne and water washed diseases affects on poor of these councils. If a child fall sick then the woman need to wake up early and stand in a long queue at public health care facility. The direct cost such as loss of wage, medicines, transport cost is much higher for poor households. The indirect cost such as waiting in queue; time of family members, time spent in hospital is also much higher for poor family. The indirect cost due to water borne and water washed diseases is much higher for poor people in all councils. The studies have shown that the rich family have fall under debt trap and vicious cycle of poverty due to water related diseases. Water supply related investment is urgently required in each municipal council. Water supply must be provided on 24*7 basis to people in all councils. The investment is required in dam construction, pipelines to GSR and ESR, storage tanks, metering of connection. The poor households must get the adequate water supply on regular basis.

1. IMPORTANCE OF STUDY

In order to have planned development across the Mumbai city, MMRDA has been set up on 1st March 1975. In the North, it is extended up to Vashi. To the east side, some parts of Thane district comes under metropolitan region. It comprises as Kalyan, Bhiwandi and

Ulhasnagar cities. In the North side, the Vasai tahasil is the boundary of region. The Southern boundaries have been extended up to Pen and Alibag tahasil of Raigad district. The Southern part of metropolitan region is Panvel, Karjat, Khalapur, Pen, and Alibag tahasil. There are eight municipal corporations in region such as Greater Mumbai, Thane, Ulhasnagr, Navi Mumbai, Nizambur Bhiwandi, Mira Bhayander, Vasai Virar and Kalyan Dombivali. Other than these municipal corporations, there are 15 municipal towns and seven non-municipal urban centers. In metropolitan region, total 995 villages are located. The Mumbai Metropolitan Region (MMR) is one of the largest urban agglomerations in India. It accrues tremendous revenues to the central and state government (Pethe et al, 2011). Mumbai Metropolitan Region has witnessed a high economic growth due to services and manufacture sector. It is most vibrant region because most of the modern facilities such as transport facilities, recreation, health, education facilities are located in this region. The head quarters of banking institutions such as RBI, non banking financial institutions, National Stock Exchange (NSE), Bombay Stock Exchange (BSE), Security Exchange Board of India (SEBI) is located in Mumbai city. Some commerce related trading offices; headquarters of banks and industry are located in this region. The growth of services sector such as finance, IT, telecom, tourism, entertainment, advertising, communication is higher in region. Metropolitan region provides various services on 24/7 basis. In Mumbai Metropolitan Region, urbanization, population, industrial, commercial unit growth is higher. Mumbai city is planned as an international financial center. Services sector provides enormous employment opportunities to people. But the problems of civic amenities are not studied in region. Most of the people do not get the quality services and it affects on the standard of living. The economic growth of the region is depending on number of civic amenities provided to people. This paper examines the water related issue in all municipal councils in Mumbai Metropolitan Region.

2. DATA

The population related data for this study is mainly collected from census 2001, 1991 and 2011. We have referred the council development plans. The city development plan of Mumbai, Thane, Ulhasnagar, Vasai-Virara, Bhiwandi-Nizampur, Navi-Mumbai has been referred. We have also referred the environment status report of different cities and development plan of Mumbai Metropolitan Region. All these reports helped to measure the number of health care, educational units, vehicles and commercial units. Such statistics is used for measuring water demand by each unit in different municipal councils.

2.1 Econometric model

We have estimated total water demand in each municipal council. The water demand by each unit in metropolitan region is also estimated. Such water demand is estimated for nine municipal councils in Mumbai Metropolitan Region.

(1)

Total water demand in metropolitan region is equal to the water demand by the each municipal council.

(2)

Total water demand in each municipal council is a function of different type and number of units.

Where

P: Population of each municipal council
S: Shops in particular municipal council
H: Health care institutions in municipal council
E: Educational institutions in council
C: Commercial units such as malls and shops
G: Garages in municipal council
I: Industrial units in particular council

$$\sum_{i=1} W_u = N_u * S_n \quad (3)$$

Total water demand by any type of unit is equal to the number of units ((N_u) and standard norms of water demand (S_n).

3. DRINKING WATER SUPPLY

In municipal council, the piped water is supposed to be the most reliable, safest and easiest source of drinking water. Hand pumps and tube wells are more labor- and capital-intensive, respectively, though they are relatively safe after piped water (Reddy, 2001). All municipal councils supply drinking water to population and other units through piped supply. The water is supplied in respective area only. Each municipal council has its own water supply system and network. We have explained the water supply by each municipal council in Mumbai Metropolitan Region.

Table 1. Drinking water supply in municipal councils

Municipal council	**Water supply(MLD)**	**Percent**
Ambernath	540	38.52
Badlapur	35.50	25.32
Karjat	1.20	0.86
Khopoli	6.20	4.42
Matheran	1.40	1.00
Panvel	26.78	19.10
Uran	3.50	2.50
Alibag	5.50	3.92
Pen	6.11	4.36
Total	140.19	100

Source: Author's calculation

The Ambernath Municipal Council gets 43 MLD water from Barrage head works. It is 8 kilometer away from city. The second source is Chikhloli dam. It is 5 kilometer away from city and it is supplying 6 MLD water to city. The third source is MIDC tapping point. It is 3 kilometer away from Ambernath city. The daily quantity lifted is 5 MLD. There are 255 bore well in city, which supply 0.2mld water. There are 27 dug well which supply 0.025mld water. Therefore from the entire sources city gets 54mld water supply. The

Badlapur city gets water supply from Barrage head works on Ulhas. The distance from city is 3 kilometer. The tub well and hand pump are 189 and they supply 0.2mld water supply. The bore well supply 0.6mld water and they are 192 in number. There are 14 dug well and they supply 0.2 MLD water. The water supply to city from this source is 35.5mld. The Karjat Municipal Council gets water supply from Pej River. The distance from city is 10.6 kilometer. The quantity of daily water supply is 1.2mld.The Khopoli Municipal Council provides water supply from Patal Ganga River. It is 0.35 km away from city. Other than this, there are 244 bore well which supply 1.5mld water. The quantity of daily water supplied to city is 6.2mld. The water supply to Matheran is done through Ulhas River, Kumbhe. The distance from council is 10.2 km. Total 0.8 MLD water is supplied to city. The Charlotte lake of Matheran is another source of water supply. The distance of this lake is 1.2 km and it is supplying 0.6 MLD water. There is no any other water supply to city. Total water supply from all the sources to city is only 1.4mld. The population density is less in this council. Therefore water supply is also lower. The Panvel city gets water supply from Dehra dam. The distance is 16 kilometer from city. Total 12 MLD drinking water gets supplied to city from this dam. Maharashtra Jeevan Pradhikaran (MJP) tapping provides 4.71 MLD water. It is 1 km away from city. MJP tapping two provides 2.07mld drinking water. It is 0.03 kilometer away from city. MIDC taping one and two, each provides 3 MLD water to council. MIDC tapping three provides 1.5 MLD water. It is 0.003 km away from city. Total 26.78mld water is provided to city from all the sources.

The source of drinking water to Uran Municipal Council is MIDC. The water source is 0.5 km away from city. Total 3.5 MLD water is supplied to city. In the normal season that is July-February, 115 lpcd water is provided. In summer season, 105 lpcd drinking water is provided. Total water supply from all the sources is 3.5mld. The Alibag Municipal Council gets water supply from different sources. The area of city is 1.93 square kilometer. There are 17 wards in city. The MIDC tapping provides 5.5 MLD water to city. It is 4.8 km away from city. There are 16 bore wells and 7 are dug wells to supply additional water to city. From all the sources, treated water is provided to city. Therefore there is no additional need to treat drinking water. In both normal and summer season, total 135 lpcd water is provided. In Pen Municipal Council, there are 18 wards. The city gets water from Bhogawati River which is 1 km and 6 MLD water is supplied. The Ambegaon dam supply 15mcft liter water. The Hatwane dam is new proposed dam which is 10 km from city. It is planned to supply 2.50 MCM water. There are 107 tub wells and hand pumps in city. They supply 0.05 MLD water to city. The bore wells are 66 in city and they supply 0.05 MLD water. In normal season that is July-February, around 90 lpcd water is supplied. In summer season that is March-June; nearly 70 to 80 lpcd water gets supplied to population. Operation and maintenance is done by council itself. Total 140.19 MLD water is supplied in all nine municipal councils by different sources.

3.1 Water treatment and storage

In Ambernath Municipal Council, the water treatment plant is located at Barrage Badlapur with capacity of 55 MLD. The water treatment unit is unconventional in nature. The second water treatment plant is located at Ckikhloli. Such water treatment plant has capacity of 6mld. This water treatment plant is conventional in nature. Total 29 thousand households are provided drinking water in council. Nearly 135 liters water is provided to each member of household. The water supply to each household varies as per season. From July to February, it reaches up to 156 lpcd. In summer season, 125 lpcd drinking water is provided. Maharashtra Jivan Pradhikaran (MJP) is operating and maintaining the entire water supply

system for this council. As far as storage reservoirs are concerned then Bhendi Pada GSR has 2.70 lakh liters capacity. The Sai section GSR has 1.50 thousand liters capacities. Another Sai section GSR has 1.10 thousand liter capacities. Navre Nagar GSR has two lakh liters capacity. The transmission main from Belivali MBR to Vadolgaon, the transition main line is seven thousand meters with 700 diameters. From Belivali MBR to ordinate sump, the length of transmission main is 6700 meters and the diameter is 600mm. Third transmission main is from Chikhlioli WTP to Navare Nagar. It is 4300 mm in length and the diameter is 355 mm. The distribution of water is mainly done through 50 to 400 meter length pipes. In Badlapur Municipal Council, water is treated conventionally in Kharvai conventional plant. Total capacity of water treatment plant is 18 MLD. In the normal season (July to February), total 192 lpcd water is provided. In summer season, 154 lpcd water is supplied in council. The MJP is responsible for operation and maintenance of entire water supply system. All domestic and institutional consumers get water supply through different size of pipes. The consumer water meters vary from 50 to 600 mm size. There are 5 storage reservoirs in this council. The Shirgaon ESR has 3.55 thousand liter capacities and staging height is 25 inches. The Kharvai ESR has 12 thousand liter capacity. The Gandhi chowk ESR has one lakh liters capacity. The Badlapur gaon ESR has 50 thousand liters capacity. The Belivali ESR has 4.50 thousand liters capacity. The transmission main from Barrage sum to Belivali MBR is 700mm and length is 3450 meter. The second transmission main is from Barrage sump to Belivali MBR. The diameter of this pipeline is 711 mm and total length is 3450 meters. From the Kharvai WTP to Shirgaon MBR, the length is 610 mm line and total length is of this line is 1500 meter. From TM Kharvai WTP to Kharwai ESR, the diameter is 250 mm and the total length is 3200 mm. The transmission main from Belivali MBR to Saigaon, the diameter of transmission main is 100 mm. Total length is 1900 meter. The transmission main from Belivali MBR to Eranzad is 200 mm. The total length is 3100 mm. The last transmission main is from Belivali to Barrage road. The diameter is 450 mm and total length is 4500meter. The distribution system varies from 40-610 meters. In Karjat, the water treatment plant is located at Dahivali. It is unconventional type of water treatment plant. The capacity of this plant is 8.52 MLD. The standard norm of water supply is 135 lpcd. But in normal season (July–February), around 115 lpcd water is supplied. The Karjat Municipal Council (KMC) operates and maintains the entire water supply system. There are six storage reservoirs in municipal council. The Wajarwadi ESR has 80 thousand liter capacity. The Dahivali GSR has 1.80 thousand liter capacity in this council. The Karjat ESR has 15.50 thousand liter capacity. The Akrule ESR has 1.80 thousand liter capacity. The Gundaje ESR has 4.50 thousand liter capacity. Similarly, the Bhisegaon GSR has 5 lakh liter water storage capacities. The length of the distribution system line is from 100 to 500 meter. In Khopoli Municipal Council, the water treatment plant is located at Kajuwadi. It is unconventional type of water treatment plant. Total capacity of this plant is 4.8mld. The water supply in entire year is 100 lpcd. An operation and maintenance of water supply system is done by municipal council. There are 4821 domestic and 443 non-domestic consumers in this council. Total numbers of stand post are only 79. The numbers of group connections are 70 in this council. The numbers of unauthorized connections are 30 in municipal council. Total three storage reservoirs are located at Kajuwadi. The first GSR has 7.50 thousand liter capacity. The second Kajuwadi GSR has 8 lakh liters capacity. The third Kajuwadi GSR has 1 lakh liter capacity. The transmission line is available from Patalaganga River to Jack well one. The Shiv mandir line has 500 diameter lines and the length of this line is 350 meters. The jackwell to WTP has 300 mm diameter and the length is 755 meter. The third Jack well to WTP has 400mm diameter and length is 670meters. The length of the

distribution system varies from 50 to 400 meter length. In Matheran, the unconventional water treatment plant is located in council area. It has capacity of 1.37 MLD. In normal season, 100 lpcd water is supplied to population. In summer season, nearly 90 lpcd water is supplied in council. The operation and maintenance of water supply system is done by MJP. The stand posts are 22 in this council. The WTP one GSR storage reservoir has 4 lakh liter storage capacities. The other WTP storage reservoir has 7 lakh liter storage capacities. The Olympia race course ESR has 50 thousand liter storage capacity. The transaction main from Charlote Lake to WTP Matheran is 200 mm diameter line with 1200 meter length. The second transmission is from Ulhas River. The Kumbhare-Neral to WTP Matheran has 200 diameter mm transmission lines with 10200 meter length. In Panvel city, the conventional water treatment plant is located at ST stand. The ST stand is a central part of city. It has capacity of 16 MLD. At ST stand ESB has 6.52 thousand liter capacity. At Shivaji chowk, the ESR has 9 lakh liter storage capacities. The Patel Mohalla has 650 thousand ESR capacities. The transition from Hariom Nagar ESR has 5.50 thousand liter capacities. The transmission from Hariom Nagar to Thana Naka SDO office has 350 diameter lines with 11570 meter length. Behind ST stand to Ridhi-Sidhi society, it has 300 mm line and total length is 28 meter. From Patel Mohalla to Kacchi Mohalla, the diameter is 400mm. Total length is 2200 meter. From ST stand to GNE-hospital, the diameter is 300 mm. Total length of pipeline is 31meter. From Podi ESR to Podi one, the diameter is 150mm and total length is of this line is 500meter. The Uran Municipal Council operates and maintenance the entire water supply system. There are 616 domestic and 117 non domestic consumers. There are 28 stand posts in council. As far as storage reservoir is concerned then Sarvodayawadi GSR has 11.32 thousand liter capacities. The Sarvodayawadi -2 GSR has 6.25 thousand liter capacity. Sarvodayawadi-3 GSR has 10 lakh liters capacity. Town hall GSR has 8 lakh liter capacities. The transmission main from town hall to Sarvodayawadi is of 300mm diameter line and the total length of this line is 519 meter. From ESR to Ganapati Mandir, the diameter is 400 mm with total length of line is 480 meter. In Alibag Municipal Council; the Ramnath ESR has 3lakh liters capacity. The Koliwada ESR has 3lakh liters capacity. The Shree bag ESR has 6.75 thousand liter capacity. The gravity transmission main is located from RCF to Vidyanagar. The diameter is 600mm. Total length of pipeline is 4800meter. Rising main transmission is located from sump to MBR and diameter is 250mm. Total length of this line is 50meter. Gravity main from BPT to sump has 457 diameter lines and total length is 900meter in council. The gravity main from BPT to existing ESR has 350 diameter lines and the length is 900m. The gravity main from BPT to existing ESR has 350 diameter lines. Total length of line is 700 meter. Gravity main from Mahesh talkies to Ramnath ESR has 200 diameters and length is 900meter in this council. In Pen Municipal Council, the ESR has capacity of 7.25thousand liters and the height is 5 meter. The Pirdongary ESR has 7 lakh liter capacities. Tare Ali ESR has 3lakh liter capacity and height is 16 meters. The raw water rising main from jack well to pimpaldoh has 355.6mm diameter. The total length is 1.24 meter. Additional raw water rising main from Jack well to Pimpal doh is 406 diameters and total length is 1.24 meter. Raw water rising main from Ambeghar dam to Jack well to Pimpal doh has 300 diameter lines. The total length of this line is 3.8 meter. The pure water rising main from WTP to MBR near WTP has 250 mm diameter and it is located in city itself.

3.2 Water tariff and recovery of bills

The water tariff is charged differently in different municipal council. Some council have tariff per thousand liters for month and some councils have yearly tariff. Few types of council have tariff based on diameter of pipeline. In Ambernath city, the average tariff for domestic purposes is 7.60 Rs/kl. For non domestic purpose, the tariff is 34.65 Rs/kl. For special consumers, the water tariff is 16.5 Rs/kl. The average recovery of billing was 98.81 percent in 1998-99. In Badlapur Municipal Council, the tariff for domestic purpose is Rs.7.6 Rs/kl. For non-domestic purposes, it is 34.65 Rs/kl. The billing and recovery rate is 100 percent in this council. In Khopoli Municipal Council, the domestic tariff is different for different type of pipelines. The water tariff for 15mm pipe line is Rs.806 per year. For 20mm pipe line, it is Rs.1800. In this municipal council for 25mm water supply pipe line, tariff is four thousand rupees per year. For non domestic purposes, the tariff for 15 mm line is Rs3580 per year. For 20 mm water supply pipe line, the tariff is Rs.7138 per year. For 25mm pipe line, the tariff is Rs. 16152 per year. Recovery of the bill is only 60 percent in this municipal council. In Matheran Municipal Council, the domestic tariff for 'A class' type is Rs.30 per month. The non domestic tariff is Rs86.90 and Rs75 respectively. For B class, water tariff is Rs.69.30 to Rs.60. For C class, water tariff is Rs 58.30 to Rs.50. For commercial purpose, the water tariff is Rs.19.65 per month. The billing and recovery was 93 percent in 2009-10. In Panvel Municipal Council, the domestic tariff is Rs.7 kl. Nondomestic tariff is 8 Rs/kl. For commercial purpose, the tariff is Rs.25kl. Water is also provided for industrial purpose. It has a tariff of Rs.25kl. The recovery rate was 87.18 percent in 2008-09. In Alibag Municipal Council, the recovery rate of water bills was 68.22 percent in 2008-09. In Uran Municipal Council, the tariff for the domestic purpose is 9 Rs/kl. For non domestic purpose, it is 15.55 Rs/kl. For commercial purpose, the water tariff is 20 Rs/kl. For industrial purposes, it is 29 Rs/kl. The recovery of bill was 62 percent in 2008-09. In Karjat Municipal Council, the recovery of billing was 100 percent in 2008-09. In Pen, the billing and recovery was 68.22 percent in 2008-09. The recovery is different in each municipal council.

4. DEMAND OF DRINKING WATER

We have calculated the water demand in each municipal council based on above methodology. Such water demand is based on different types of units and norms of water demand. Such drinking water demand is presented according to municipal council in the following table.

Table 2. Current water demand in municipal councils

Municipal council	Water demand (MLD)	Percent
Ambernath	63.48	31.07
Badlapur	43.34	21.21
Karjat	7.74	3.79
Khopoli	17.18	8.41
Matheran	1.52	0.74
Panvel	46.33	22.68
Uran	8.93	4.37

Municipal council	Water demand (MLD)	Percent
Alibag	5.78	2.83
Pen	9.99	4.89
Total	204.3	100.00

Source: Author's calculation

The water demand in municipal council of Ambernath is 63.48 MLD. It is 31.07 percent of the total water demand of all municipal council. Water is demanded by household, industrial and commercial units. The demand of drinking water in Badlapur Municipal Council is 43.34 MLD. It is 21.21 percent of total water demand. It is third highest as compare to other municipal councils in Metropolitan Region. In Karjat Municipal Council, the water demand is 7.74 MLD. It is 3.79 percent as compare to total demand. In Khopoli Municipal Council, the water demand is 17.18 MLD. The water demand is low because of physical feature of this municipal council. Water demand is 8.41 percent of total demand. In Matheran Municipal Corporation, the water demand is 1.52 MLD. Matheran is a tourist place and most of the people visit this place regularly. The drinking water demand for current period is estimated as 0.74 percent of total demand. In Panvel Municipal Council, the water demand is 46.33 percent. The water demand is second highest as compare to the other municipal council. Population and other units are continuously growing in this municipal council. Water demand is estimated as 22.68 percent of total demand. In Uran Municipal Council, present drinking water demand is 8.93 percent. It is 4.37 percent of total demand. Such water demand is lower but in future it will increase fast. There are few railway projects and one international airport is planned in this area. Therefore connectivity to surrounding area will rise. It will further lead to increase in population. The water demand in Alibag Municipal Council is 5.78 MLD. It is 2.83 percent of total demand. Alibag is a tourist place in Mumbai Metropolitan Region. Most of the people visit Alibag at weekend. The water demand is slightly higher in this Municipal Council. In Pen Municipal Council, the water demand is 9.99 MLD in current period. It is 4.89 percent of total demand. We have estimated total 204.30 MLD drinking water demand in all municipal council of Mumbai Metropolitan Region.

4.1 Drinking water demand according to different use

We have calculated the demand of drinking water according to different types of units. The water supplied is inadequate in each municipal council. Some units get more drinking water whereas some units get less water. The demand of drinking water is calculated to each unit based on norms. Such demand is added as total water demand of each municipal council in Mumbai Metropolitan Region.

Table 3. Drinking water demand according to type (MLD)

Municipal Council	Population	Theaters / Mall	Shops	Garages	Health	Education	Industry
Ambernath	37.37	1.82	7.56	2.6	0.37	8.37	5.4
Badlapur	25.55	1.54	5.28	1.32	0.25	5.72	3.69
Karjat	4.38	0.65	0.69	0.34	0.06	0.97	0.63
Khopoli	10.31	0.85	0.35	1.72	0.15	2.3	1.49

Municipal Council	Population	Theaters / Mall	Shops	Garages	Health	Education	Industry
Matheran	0.77	0.28	0.11	0.06	0.01	0.17	0.11
Panvel	26.19	1.62	7.55	1.06	0.27	5.85	3.78
Uran	4.10	1.13	1.32	0.8	0.07	0.91	0.59
Alibag	3.20	0.89	0.31	0.15	0.05	0.72	0.46
Pen	5.59	0.73	1.37	0.16	0.08	1.25	0.81
Total	117.46	9.52	24.55	8.2	1.32	26.27	16.97

Source: Author's calculation

The water demand by population in Ambernath Municipal Council is 37.37 MLD. Population demand water for different purposes therefore the demand of drinking water is more. The water demand by population in Panvel municipal council is 26.19 MLD. The lowest water demand by population is in Matheran Municipal Council. It is 0.77 MLD. The density of population in Matheran is lower. Total water demand by population in nine municipal councils is calculated as 117.46 MLD. The malls and Theaters demand of water is 1.83 MLD in Ambernath Municipal Council. It is followed by Panvel Municipal Council where water demand is 1.62 MLD. In both the municipal councils, the number of malls and theaters are more in quantity and increasing. Therefore the demand of drinking water is also more. The lowest water demand by malls and theaters is found in Matheran Municipal Council, where it is observed as 0.28 MLD. There are few theaters and malls in this council. The water demand by shops is 7.56 MLD in Ambernath Municipal Council. Shops demand water for cleaning and drinking purposes. The lowest water demand is found in Matheran Municipal Council which is only 0.11 MLD. The water demand by the garages in Ambernath Municipal Council is 2.6 MLD. The vehicles demand more water for washing and cleaning purposes. The lowest water demand is found (0.06 MLD) in Matheran Municipal Council. It is located at mountain area. Therefore there are few vehicles in this council. In Ambernath Municipal Council, the water demand by health care institutions is 0.37 MLD. In Matheran Municipal Council, water demand is only 0.01 MLD. The water demand by educational institutions is 8.37 MLD in Ambernath Municipal Council. In Matheran Municipal Council, the water demand by educational institutions is only 0.17 MLD. The water demand by the industry is 5.40 in Ambernath Municipal Council. The old and new industries demand water for different purposes. The workers also demand water for toilets, cleaning and drinking purposes. In the Matheran Municipal Council, the water demand by industry is 0.11 percent. In Matheran, there are no large and medium industries therefore the water demand is low. Total water demand in all municipal council is calculated as 204.30 MLD. Such water demand is calculated for 2014-15 period.

5. REGRESSION RESULT

We have used Tobit regression (Greene, 2003) to find the co-relation between dependent variable and different independent variables. The difference in demand of water by municipal council is because of population density, slums, industrial units and commercial establishments. The Tobit model is suitable because of sum of drinking water demand in municipal corporations in Mumbai Metropolitan Region. The quantity of water demand in each municipal council is a mixture of discrete and continuous figure. The other regression

model shows the multi-co linearity problem. Therefore Tobit model helps to identify significant water demand by domestic, industrial and commercial units.


Where $Y_i^* > 0$ (4)

The ordinary least squares estimates are smaller in absolute value than the maximum likelihood estimates. The regression results are presented in the following table.

Table 4. Tobit regression result

Variables	**Co-efficient**	**Standard error**	**T test**
Population	1.69*	0.086	19.63
Theaters and malls	0.96*	0.040	23.91
Constant	-8.64*	11.31	-0.76
Pseudo R^2=0.47	LR chi^2=162.77	Prob>chi^2=0.00	Log likelihood=-91.43

1. * Significant at one percent

Source: Author's calculation

Above table shows that the total water demand is positively co-related to the population, theaters and malls in all councils. The population in all the municipal council is increasing. The increasing population requires the water for drinking, cooking, bath, cleaning purpose. Therefore the water demand by population in each municipal council is positively co-related and statistically significant. The people of all municipal council are visiting the theaters and malls. They spend time for purchase of different goods and watch movies. The water is demanded for different recreational activities. Therefore water demand is positive and statistically significant.

6. DEFICIT OF DRINKING WATER

We have calculated the total water demand by all the units in each municipal council. Such demand of water is calculated for all the municipal council from 2014 till 2041. The water is supplied by municipal council in respective area. The current water supply is minus from the total demand.

$$D_t = \sum dd_t - \sum ss_t \quad (5)$$

Where

D_t = Deficit of water in the t period
dd_t = Demand of water in period t.
ss_t = Supply of water in period t.

The deficit is calculated based on available figures. The deficit in drinking water supply is shown in the following figure.

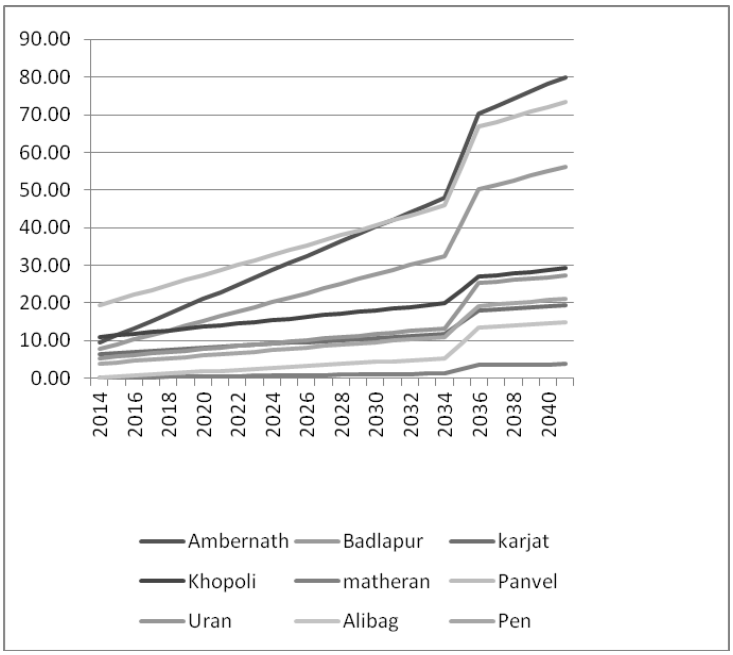

Figure 1. Deficit of drinking water supply in municipal councils (MLD)
Source: Author's calculation

The current deficit of drinking water supply in Ambernath Municipal Council is observed as below 10 MLD. But in 2035, it is observed as 70 MLD. Population and number of other units in this council will rise. The water deficit will cross 80 MLD in 2041, if the water supply projects are not announced. In Panvel city, the deficit in water supply is observed as 20 MLD in current year. The population, shops, educational and health care institutions are rising fast in the municipal council. The water deficit is observed as 45mld in 2035. Few water supply projects are announced by council. Therefore the water supply will rise in future. But more water supply project announcement is required at this point. The water deficit in Badlapur city is observed as 8 MLD in current period. In the year 2036, the water deficit is observed as 50 MLD. It will touch 60 MLD in 2041, if the water supply projects are not announced. In Uran and Khopoli, the water deficit will touch 30mld in 2041. There is need of additional water supply projects. In Karjat and Pen city, water deficit will be 20 MLD in 2041. In Alibag city, the water supply deficit will be 15 MLD in 2041. The lowest deficit in water supply is observed in Matheran Municipal Council. The water deficit will be less than 5 MLD till 2041. It is lowest deficit as compare to all other municipal councils in Mumbai Metropolitan Region. The Matheran is a tourist destination and in future there will be less chance that the population and other units will grow. But in all other municipal councils, the water demand will rise with increase in number of units. The growing number of users is required larger quantities with every passing year. The need is to increase quantities of available water (Chauhan, 2006). Successive governments in Maharashtra have continued to pour money into schemes ranging from digging new wells to piped supply, yet the numbers of habitats threatened by scarcity continue to rise (Kumar, 2002). Therefore some innovative methods are required for sustainable development of water supply.

CONCLUSION

Water supply deficit is observed in all the municipal councils. It has different effects on health of population. The poorly maintained distribution system is a cause of drinking water below acceptable levels and it poses serious health risks. The deficiencies are caused by the failure to disinfect water or maintain a proper disinfection residual; low pipeline water pressure; intermittent service; excessive network leakages; corrosion of parts; inadequate sewage disposal; and inequitable pricing and usage of water (Lee & Schwab, 2005). It is evident from the study that access to water has significant benefits for human health and well-being. The studies highlighted the complementarities that exist in water, sanitation, energy, agriculture, hygiene, education and health care (Krishnan et al., 2003). The water demand is continuously rising with increasing population in municipal councils of Mumbai Metropolitan Region. The demand of water by malls, theaters, shops, health care institutions, garages and industry is higher in Ambernath Municipal Council. The water demand by different units is lowest in Matheran Municipal Council. The population in all the municipal council will demand more water in future. Similarly the demand of drinking water by theaters and malls will be higher. The deficit of drinking water is higher in Ambernath, Badlapur and Panvel Municipal Council. The lowest deficit in drinking water is observed in Matheran Municipal Council. Therefore the policies of more investment in drinking water supply are required in all the municipal councils. The underlying fact is that the supply capacity has to be increased without compromising the quality in order to keep pace with the rapid urbanization and the resultant spurt in demand. Acute shortage of disposable capital for the extension of service and the negligible or partial recovery of operating costs of providing the service are major underlying constraints to increasing coverage of access to safe drinking water. This has led to nothing but an exceedingly uneconomical and consumer impassive water distribution network, with no financially viable water pricing mechanism in place (Roy et al., 2004).The public private partnership in drinking water supply will reduce the deficit in drinking water supply. Awareness of drinking water use through mass media will definitely yield good results. The water use laws by each municipal council will reduce the deficit in drinking water supply. Municipal council must reduce water leakages through innovative methods. They must be allowed to issue the municipal bonds to raise the long term capital. Water is the need of every human being. The poor spend more time and energy for collection of water. Municipal council must fix the tariff based on actual use of water. It will help to raise more resources for water supply system. It is important to acknowledge that demand-driven and cost-sharing features will not really secure the right to water for all. In fact, it can be argued that with so many people dependent on daily wage labor, imposition of costs for drinking water provision amounts to a violation of the right to water (Sampat, 2007). Therefore the tariff rates for drinking water for poor in slums should be lower. The water crises are developing because the government and people are not looking beyond temporary, non-sustainable measures to alleviate scarcity (Gujja & Shaik, 2005). It is argued that the government should provide community drinking water supply systems as a matter of policy. The community should assume the responsibility for the maintenance of such assets. In course of time even the capital costs of expansion of the assets could be decided, managed and implemented by the community itself with limited state intervention. This is the best option for the sustainability of common assets (Veerashekharappa, 2000; Rode, 2009). Therefore alternative policies are required to ensure regular and adequate supply of drinking water in municipal councils of Mumbai Metropolitan Region. The state government and municipal councils should work together to find number of alternative policies for water supply. Safe

and regular drinking water supply has multiple effects on human health and standard of living.

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