Drinking water supply management in municipal corporations of Maharashtra

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Abstract- **This paper measures the demand and supply of drinking water in Municipal Corporations in Maharashtra. The demand for drinking water is continuously increasing due to growth of population, industrialisation and commercial units. Drinking water is not provided on a sustainable basis in the municipal corporations. Water has price in terms of time, space, quality and quantity. But water tariffs are not high and uniform across the municipal corporations. They do not have funds to invest in water supply projects. The whole water supply systems are not efficiently and regularly managed. The alternative policies such asroof rain water harvesting, reducing leakages, increasing tariff and metering, water use laws, and private investment in water supply will reduce the future drinking water supply deficit.**

I. INTRODUCTION

Safe drinking water is essential for human existence. Hence, the right to adequate drinking water is considered as fundamental human right (Ramachandraiah C. (2001), Kanmany J.C. (2003)). The proportion of urban population of India is projected to increase from 28 per cent of the total population to about 38 per cent in 2026.The current state of supply of core services in the urban areas, viz, water supply, sewerage, solid waste management and street lighting, is inadequate by any standards. The higher growth of urban population will add further pressure on provision of these services (MoF 2009). The growth of urbanisation is higher in Maharashtra. The government has promoted industrialization due to such policy automobile, engineering, electronic, information technology (IT) and biotechnology industries have grown fast. Such industries have created huge employment opportunities in the state. Therefore immigration of the indigent rural labour and qualified professionals from other states took place. Along with the production and manufacturing, the growth of services sector also occurred in the state. The BPO, call centres', banking, insurance companies have opened their corporate offices and grown significantly in terms of numbers. The abandoned industrial sights are getting converted into residential locations. Township planning and low cost affordable housing is developed for growing population. Urbanisation is putting more pressure on the existing civic amenities in all the municipal corporations. The policy of 24*7 drinking water supply is beyond the limit of all the Municipal Corporations in Maharashtra. Drinking water is provided for few hours with lower pressure. The water received by the households is depending on the time, number of connections in the area, water leakages, repairing season etc. There are large inequalities in the drinking water supply where richer households are getting more water and . poorer are getting less. The reasons are faculty pipeline, inadequate distribution system, transmission and distribution losses, storage capacity etc. The richer households have more water storage facilities but the poor households are struggling to get basic necessary water supply. If the distance of drinking water tap is more then it is a forceful activity for women and children to carry water. Most of the women are working in industrial and services sector units. Children are studying in various municipal and private schools. Women and children do not have time to stand in a long queue and carry drinking water from longer distance. It is not only affecting on their day to day activities but such time has high opportunity cost for future development. The study of Mehta L.et.al (2007) shows that better and easier access to water makes more time available for economic activities and keep children in school thus improving human capital. It also helps for income generation. Most of the women can take part in income generating activities because piped water availability in the house increases time for household chores, leisure and learning. Women involved in the informal sector have to work hard to get enough drinking water. They have to wake up early in the morning, stand in a queue and carry drinking water from longer distance for whole family. If the distance is higher and beyond the limit, then household has to pay an extravagant price for safe water. Reliable safe drinking water supply is a scarce commodity across the Municipal Corporations in Maharashtra. Safe drinking water can be brought at substantial cost. The amount for water which a poor family use is depending on the family members including children's, family income, habits and cleanliness, distance and price of water etc. If the price of safe drinking water is higher then poor household reduces its use. After all, the poor households are spending large proportion of their income for few litres of drinking water every day, which is necessary to sustain life in the cities. The poorer households are affected more because of the lower quality and quantity of water supply. They have to pay higher direct and indirect cost due to water washed and water borne diseases. The direct cost include transportation, consultation fees, medicines, loss of wage but the indirect cost such as travel time, standing in a long queue, time spend in hospital, travel and visiting time of relatives is also important. If the recovery period due to the water washed and water borne diseases is more or repeated visits are occurring then poorer households have to borrow money from different sources. Such burden of diseases on poor household is difficult to measure. The poor households are not insured against such

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diseases. Drinking water supply project is highly capital intensive activity. The initial cost comprises as building dam, pipeline, storage and filtering system, water distribution system, metering and bill collection system etc. Municipal corporations do not have money to invest in water supply projects. The grants received from the central government under JNNURM are not enough. Water tariffs in various municipal corporations are different and they are too low. Water bills for actual use of water are not paid regularly by the consumers. Water supply is not charged according to the actual use and water meters are not installed. Lack of complete coverage of safe water supply on sustainable basis is an important challenge for Municipal Corporations in Maharashtra.The first part of the paper deals with research methodology and drinking water supply system. The second part of the paper deals with drinking water demand estimation in Municipal Corporations in Maharashtra. The third part of the papers deals with regression results and policy implications.

II. Data and Methodology

Data for this study is mainly brought from various sources. For Greater Mumbai, the ward wise data of population, industrial and commercial units is available on the Municipal Corporation website. The MMRDA reports are referred for water supply schemes and investment. The city development reports of Pune and Pimpri-Chinchwad are referred. The environment status report and storm water plan report of Pune city has given the major insight to study the drinking water supply system. Thane district has six municipal corporations. The Thane, Navi Mumbai, Ulhasnagar, Mira-Bhayandar, Bhiwandi-Nizampur and Kalyan-Dombivali Municipal Corporation's city development report is referred. In Maharashtra, there are Amravati, Kolhapur, Nanded-Waghala, Nagpur, Nasik and Nagpur Municipal corporations. The city development report of these municipal corporations is also referred. For this study, the water supply schemes of United Kingdom, World Bank projects particularly Nepal, Sri Lanka, are also studies. The Asian Development Bank's project proposals by various SAARC countries are alsoreferred. The proposals on drinking water supply submitted by various municipalities to HUDCO are studied. Few water conservation experts are interviewed.

We have calculated water demand for domestic, industrial, commercial and institutional units based on the water demand norms. Total deficit of water is calculated as total demand of drinking water minus total supply of drinking water within a particular year for each Municipal Corporation. We have used Tobit and ordinary regression model for each and group of municipal corporations. The data is processed in STATA@10 software.

III. Drinking water supply systems

Mumbai city is grown from seven islands that are Mahim, Warali, Parel, Girgaon, Mazgaon, Little Colaba and Upper Coloba. Over the period of time, these islands were acquired by series of reclamations. Due to wide business opportunities in Mumbai city, the communities like Gujarathi, Parsi, Boharas, Jews and Bania came to Mumbai. The continuous expansion of infrastructural facilities and establishment of mills, commercial units in the city, the massive employment was generated. Many people from western Maharashtra, Kokan and other states came to Mumbai in search of employment. Therefore continuous migration was resulted into congestion in the city. The population of Mumbai city was ten thousand in 1661 and it increased up to sixty thousand in 1675. For drinking water, the city population was depending on number of tanks such as Mumba Devi, Manamala, Babula, Govaliam Gilder, Banganga etc. The people of city were fetching water from the wells and shallow tanks. These sources tended to dry up in summer and quality of water used to get deteriorate. The local residents had complaint against the shortage and bad quality of water. Therefore this was the beginning to search sources of water to meet the city's demand. Further expansion of education facilities and technical advancement in the city, the larger work force was attracted from all over the country. There was urgency to establish water supply system to Mumbai city. The valley of river Mithi located near Vihar village was chosen for creating water source to Mumbai city. The work was started in the year 1856. The Vihar lake was completed in the year 1860. This was the first piped water supply to the Mumbai city. The quantity of water supplied was 32 Million Litres a Day (MLD). The population of the city was 644405 in 1872. During the year 1872, the height of Vihar lake was increased in order to supply more water to city. The water supply from this lake was increased up to 68 MLD. Because of acute water shortage in 1879, Tulsi dam was constructed across the Mithi river. Through this dam additional 18 MLD water was brought to the city. In order toprovide the additional water supply, an emergency measure was undertaken in 1891. Pawai lake on a tributary of Mithi river was developed. It added 4 MLD water supply. Instead of continuous efforts and investment in water supply system, the potable water was not sufficient to growing city. Tansa scheme of water supply was developed in four stages. The first stage was completed in 1892 by constructing a Masonry dam. The quantity of water supply added to the city was 77 MLD. In 1906, the population of Mumbai city was 977822. During 1915, Tansa-II was developed. It added 82 MLD water supply. In spite of tapping all these resources, the water supply to the growing population in the city was not adequate. Therefore Tansa-III was developed after raising the dam height on river Tansa. It additionally supplied 98 MLD water to city. After independence, the Tansa–IV was completed. The storage capacity was increased by providing 38 flood gates. The water supply was further increased by 198 MLD. In 1948, total water supply for the two million populations was 541MLD. Dam on Vaitarna and tunnel between Vaitarna and Tansa lake was completed in the year 1957. It supplied additional 490 MLD water to Mumbai city. In 1967, the water supply added by Ulhas river was 90 MLD. During 1973, additional upstream dam was constructed on Vaitarna river. It provided additional 554 MLD water to city. Bhatsa water resource was developed in

three stages. Bhatsa-1 was completed in 1981. It supplied additional 455 MLD water to city. In 1989, additional 455 MLD water was supplied to city by Bhatsa-II. During 1998, drinking water was insufficient for city therefore Bhatsa –III was developed. It supplied additional 455 MLD water. The total water supplied by all sources is 3350 million litres per day (MLD). Following table shows the water sources and water yield from various sources.

Table 1 Water sources to Mumbai city.

Sources	Yield (MLD)	Percent
Tulsi	18	**0.54**
Vihar	110	**3.28**
Tansa	417	**12.45**
Upper Vaitarna	1025	**30.60**
Bhatsa	1650	**49.25**
Mumbai-III	150	**4.48**
Sub-total	3350	**100**
En-route supply	120	**-3.58**
Total water supply	**3230**	**96.42**

Source: Kashid, Sukhdeo (2003)

For Greater Mumbai, the Bhatsa scheme is imporantant because it supply 1650 MLD drinking water. The second source is Upper Vaitarna where city gets 1025 MLD water. The lowest water supply is available from the Tulsi lake and it is 18 MLD. Water is also supplied to en-route villages. It is 120 MLD. Therefore the total water available for the entire city is 3230 MLD. It is continuously provided through out all seasons to the Greater Mumbai. Water supply gets fluctuate because of rainfall in the catchments area. If the rainfall in the catchments area is low or drought like situation arises, then Brihanmumbai Municipal Corporation (BMC) and Government of Maharashtra (GoM) announces the water cuts in the city. The municipal corporation confirms the water level in the various lakes. If it is satisfactory then water is regularly supplied to the city. The level of the water is regularly observed during the monsoon and summer season.

In Thane district, each municipal corporation has its own independent source of drinking water supply. Thane Municipal Corporation (TMC) was use to get the drinking water supply from the state owned organisations such as Maharashtra Jeevan Pradhikaran and Maharashtra Industrial Development Corporation (MIDC). But in 2002, the municipal commissioner of Thane took up a first step of setting up of a 100 MLD water supply project from Bhatsa dam. The project was self funded by Thane Municipal Corporation. Water from such dam began to flow in to the city from 2003. The cost of the project was much cheaper as compare to the other water supply projects. The second big step in this direction took place in 2003 when the state government proposed to turn STEM into a joint stock company between the TMC and two other civic bodies as well as Zilla Parishad, Thane. The TMC has a biggest share of assets in the first joint stock water firm of a country. The corporation effectively took up the responsibility and made STEM turn round the corner. Thane city is getting around 127mld water from such firm. The third major step towards making the city self reliant in water supply took place in late 2007 when commissioner decided to launch the 110 MLD water project. Other than these schemes, Brihanmumbai Municipal Corporation (BMC) is supplying 30 MLD as a raw and 30 MLD as pure drinking water. MIDC is also supplying 75 MLD drinking water to Thane Municipal Corporation. From all sources, Thane Municipal Corporation gets 362 MLD drinking water supply on a regular basis. The new drinking water supply project has further added 110 MLD water. TMC began to make the city independent of state owned water suppliers.

The New Mumbai Municipal Corporation (NMMC) has its own new water supply system. The Government of Maharashtra has transferred the water supply system to New Mumbai Municipal Corporation in 1998. But such water supply system was inadequate and insufficient for rising population of a planned city. Therefore in 2005, NNMC decided to purchase the water from Morbe dam. The official ownership of the Morbe dam is transferred from the government of Maharashtra to NMMC.A Kalyan-Dombivali Municipal Corporation is depending on the Ulhas and Kalu river for drinking water. Around 255 MLD water is supplied from such scheme (NIUB 2008a). The residents of the Mira-Bhayandar get only 91MLD drinking water supply. Before two years ago, MIDC promised 30MLD drinking water supply but Mira-Bhayandar Municipal Corporation has received five to eight million litres a day drinking water supply (NIUB 2008b).

In Ulhasnagar, the water supply system is very old. In 1948, the drinking water was supplied to military camp from Badlapur barrage head work. It was 18 diameters tapping from 24CI line. Total water supply was 1.59 MLD through Balkan-si-Bari GSR. Total nine distribution mainlines were laid from supplying water to camp one to five. Total water supply was inadequate to the rising population. Therefore in 1967, a special pipeline of 15 MLD was developed at Shanti

nagar. Similarly pump house of 0.9 million litres capacity was constructed for supplying water to camp number four. In 1978, the water demand was higher for growing population. The old water supply system was not yielding adequate water. Therefore water from the Badlapur barrage system was stopped. Total water was supplied from the Shahad water works and Barvi dam. The population growth for a year 1991 was forecasted as 3.66 lakh. The water supply for the growing population was designed as 55 MLD. In 1995, Kirloskar Company prepared a 51crores water supply scheme to the Ulhasnagar city from Barvi and Shahad reservoirs. Such water supply is managed by the MJP and MIDC. Total 112 MLD water is supplied to the whole Ulhasnagar city. Thane district gets water from the Andhra dam. Barvi dam is located in the Ambernath tahasil. Water from both the dam is sent in Ulhas river. Such water is provided to Kalyan-Dombivali, Thane, Mira-Bhaynder and Ulhasnagar Municipal Corporation (BMRDA 1995).

In Pune city, drinking water supply system is very old and it exists since 1750. Pune city received first piped drinking water supply from Katraj via Amboli odha, Shanivarvada. After the first scheme, the Swargate water work came in existence in the year 1873. Such scheme is planned to treat raw water and supply to Pune city. Such water supply scheme is on Mutha right back cannel and it is picked up at Swargate. Total water supply was inadequate for rising population and commercial activities in the city. Therefore when Pune city reached at a status of the municipal corporation in the year 1950, a project of 45 MLD was developed on the Mutha right back cannel. Such scheme has provided water to the Pune city and Cantonment. Other than two major water supply schemes, Pune city gets drinking water from the Holkar water works. It is constructed in 1919 on Mula river. It is supplying 22 MLD water to Pune city and Khadki Cantonment. The Warje water work is constructed in 1999 which added 23 MLD drinking water. Such scheme is built on Khadakwasla dam. The capacity of Khadakwasla dam is 56 million cubic meters. The Wagholi water work is built on the Pavana dam in the year 2000. It added 23MLD drinking water. Such scheme is planned to provide water to the villages on the boundary of Pune city. Due to merger of the villages in the Pune Municipal Corporation, the villagers are obliged to provide the drinking water. Total installed capacity of five water supply schemes for Pune Municipal Corporation is 793 MLD.

For Pimpri Chinchwad Municipal Corporation (PCMC), Pavana dam is a major source of drinking water. It is constructed in 1972. Intake works are constructed in the river bed 150 meter upstream of the existing Punawale weir near Ravet village. It is six kilometre away from the city. Around 91 percent of the stored water is utilised for the non irrigation purposes. Drinking water is mainly supplied to Talegaon, Dehu Road cantonment, and Pimpri Chinchawad township. Every day 350 MLD (51 per cent) raw water is lifted from Pavana dam and supplied to Pimpri Chinchwad Municipal Corporation area. The Pawana dam has capacity of 241 million cubic meters. A Kolhapur Municipal Corporation gets 128 MLD drinking water supply from two independent sources. Nearly 120 MLD water is obtained from the corporation and 8 MLD obtained as ground water source. The ground water is supplied through 809 wells. For the piped water Kolhapur city is depend on three rivers. The Bhogavati river is a first source and it is eight kilometre away from the city. Secondly, Panchganga river via Bawada, which is six kilometres away from the city. Third source is via Singapore, which is eleven kilometres and the Kalambatank is three kilometres away. At present, Kolhapur Municipal Corporation is unable to run Bawada water work. Therefore there is shortage of drinking water in the city.

In Nagpur Municipal Corporation, old Gorewada scheme of drinking water was developed in 1911. The band of river Pali is located eight kilometres of North east of Nagpur city. In 1921, nearly 16.50 MLD drinking water supply was planned from Ambazari and Gorewada. For 145000 populations, drinking water supply was inadequate and a daily litre per capita was only 114. In order to solve the water scarcity in 1941, Kanhan river thought as a new source of water for rising population. But it added only 37.5 MLD drinking water to the total stock. The litre per capita daily was increased up to 149 but water supply was inadequate. The population of Nagpur city became almost double within two decades. During August 1961, the municipal corporation decided to develop Kanhan source for drinking water. It added 35 MLD drinking water which was not sufficient. Drinking water was the need of 644000 and still rising population. The litres per capita daily came down up to 124. Therefore third time in August 1981, the Kanhan source was repaired. It added only 45 MLD drinking water. Total stock did not increase much and therefore litres per capita daily were remained low. The dam on river Pench-I and Pench-II was developed. It added further 245 MLD drinking water to total stock. In 2001, the population of the Nagpur city was 2150000. In the same year, the number of commercial units that is hotels, restaurants, small and large industrial units, cinema halls and garages was increased. Therefore nearly 100 MLD drinking water supply was developed through Pench-III dam. But it was still insufficient. From the Old Gorewada, another 16 MLD drinking water was withdrawn. From different sources, Nagpur city gets 470 MLD drinking water supply.

For Amravati Municipal Corporation, the river Wardha is a major source of drinking water. A Nal-Damayanti dam at upper Wardha is constructed at Simbhora. It supplied around 95 MLD drinking water. Other than this dam, bore and tube wells are the sources of drinking water. The plant is functioning below the overall capacity of 95 MLD. In Nanded city, water supply system is developed over the long period of time. In 1936, first drinking water supply was planned to city. Such scheme was designed for the projected population of fifty thousand for the year 1966. The head water work was located at old Dunkin near Govardhan Ghat on the bank of river Godhavari. The water treatment plant with a capacity of 9 MLD was located at Fort. Due to rising population and industries, such water was inadequate. Therefore in 1969, the second drinking water supply scheme was designed and commissioned for a population of one lakh. Butrising demand for water forced Municipal Corporation to construct bandara on river Godavari at

Govardhan Ghat in 1976. At present, Godavari river is a major source of drinking water to Nanded City. City gets 27.50 MLD drinking water from Vishnupuri dam. Such dam is located nine kilometres away from the city. Apart from this source, Municipal Corporation pumps water from Godavari river in the city through Jack wells dug on the banks of the river at new pump house. Other than this source, the municipal corporation has 91 bore wells. They are located at different locations but they provide water to local population in specific pockets. The total quantity of water drawn from various sources is 54.40 MLD. For Aurangabad city, there are two water supply systems. An old water supply pipeline of 700 mm diameter provides 42 MLD drinking water. The new water supply pipeline line of 1400mm diameter provides 88 MLD water in the city. Therefore total 130 MLD water is provided to the Aurangabad city. At present, Nasik Municipal Corporation gets 280 MLD drinking water supply. Such water is provided from the two sources. The Gangapur dam water is a first source. It is 1200mm diameter pipeline. The municipal corporation has developed their own source of drinking water over the period of time.

All the municipal corporations are regularly supplying water to respective area. Water supply get fluctuate due to small repairing, joining pipeline etc. If there is drought like situation arises in the state then all the Municipal Corporations cut the drinking water supply at some extent. It is precautionary measure adopted by the municipal corporations. If the monsoon arrives on time and there is enough water in the lakes, then water supply is regularly maintained.

IV. Water Demand in urban local bodies

We have calculated the drinking water demand in all the municipal corporations and regions for the year 2008-09. Such water demand is comprises as water used by different units for different purposes. The number of units and standard use of water is available in the literature. Therefore, we have calculated future growth of units in each Municipal Corporation and region and calculated with water supply norms. Such water demand is presented in the following table.

Table 2 Water demand according to the regions in Maharashtra (2008-09)

Regions	Type of municipal corporation or area	Water demand (MLD)
Greater Mumbai	Zone 1	603
	Zone 2	766
	Zone 3	854
	Zone 4	789
	Zone 5	454
	Zone 6	501
	Total	**3967**
Thane district	Thane	378.77
	Kalyan-Dombivali	238.16
	Ulhasnagar	121.31
	New Mumbai	228.53
	Mira-Bhayandar	121.87
	Bhiwandi-Nizampur	117.69
	Total	**1206.33**
Pune Metropolitan Region (PMR)	Pune	531.94
	Pune cant	13.30
	Khadki cant	12.35
	Rest of PMR	23.43
	Pimpri-Chinchwad	239.32
	Total	**820.34**
Rest of Maharashtra	Aurangabad	208.52
	Nasik	299.40
	Amravati	113.20
	Nagpur	438.34
	Nanded-Waghala	110.00
	Kolhapur	115.50
	Total	**1284.96**

Source: Computed from data

The water demand in the Greater Mumbai is 3967 MLD for the year 2008-09. The water demand from the zone three is 854 MLD. Such area has higher density of population, small and large industries, hotels and slums. Therefore water is demand by different units for different purposes is higher. In the Zone five, water demand is only 454 MLD. It is lowest as compare to all other zones in the city.

In Thane district, the water demand of the Thane Municipal Corporation is highest and it is 378.77 MLD. It is followed by the Kalyan-Dombivali Municipal Corporation, where water demand is 238.16 MLD. In Thane Municipal Corporation water demand is higher due to rising population. Thane city is well connected to the financial capital of country through road and railway network. It is also an immediate proximity to Mumbai city. Most of the industrial sites are getting converted in to residential areas in Thane city. Thane Municipal Corporation (TMC) has restructured its water supply system in the new residential areas. TMC has built new MBR and put additional new water supply system. Small industrial units in Wagale estate and surrounding area require water but it is in small quantity. The water demand in the Ulhasnagar and Mira-Bhayandar is almost similar. The lowest demand of drinking water in Thane district is observed by the Bhiwandi-Nizampur Municipal Corporation. It is mainly because density of population is very low. Most of the cotton and garment units are located in the Municipal Corporation area. They hardly use drinking water for different purposes. The water demand by six municipal corporations in Thane district is calculated as 1206.33 MLD for the year of 2008-09.

Water demand in the Pune Municipal Corporation is consists of water demand by Pune municipal Corporation area, Pune and Khadki cantonment and rest of Pune Metropolitan Region. The water demand in this Pune Municipal Corporation is 581.02 MLD. The water demand in the Pimpri-Chinchwad municipal corporation area is 239.32 MLD. It is an industrial area in Pune Metropolitan Region. Density of population is very low; therefore water demand is also low. In Pune city, numbers of malls, theatres, shops, garages, hotels are demanding more drinking water. The water demand by the population is continuously rising in the corporation area. The total water demand in Pune Metropolitan Region is calculated as 820.34 MLD.

Among the six municipal corporations in Maharashtra, the water demand of Nagpur Municipal Corporation is 438.34 MLD. Since 2001, population industrial and commercial units are significantly grown in the city. In each Municipal Corporation area, population, industrial, commercial units, institutions are different. The water demand by the Amravati and Kolhapur Municipal Corporation is low. In Nanded-Waghala Municipal Corporation, the water demand is calculated as 110 MLD. It is lowest among all the Municipal Corporations. The total water demand in all the six Municipal Corporations in rest of Maharashtra is calculated as 1284.96 MLD.

V. Water use by different units

Drinking water is not only used for drinking and cooking purposes but it is used for variety of purposes by different units. We have identified some units and their water use in different Municipal Corporations or regions. It is shown in the table.

Table 3 Water demand according to units (MLD)

Type of unit	Greater Mumbai	Thane District	Pune Metropolitan Region	Rest of Maharashtra
Population	3463.64	859.9	672.00	975.40
Small and large Industries	297.41	310.83	41.14	121.00
Hotels, Restaurants Shops	101.8	6.09	61.14	11.00
Garages	13.92	10.90	10.93	76.60
Theatres and malls	1.18	3.49	0.52	4.18
Public and private Hospitals	10.45	2.49	1.71	1.60
Fire stations and hydrants	55.95	6.71	8.10	1.70
Educational institutions	21.56	1.66	24.28	83.42
Parks and gardens	0.64	3.92	0.43	10.10
Total	3966.55	1205.99	820.25	1285.08

Source: Computed from data

The demand of drinking water by population is 3463.65 MLD in Greater Mumbai. The demand is higher due to density of population. The water demand by slums is also higher inGreater Mumbai where sixty percent population live in slums. In Thane district, the water demand by population is 859.9 MLD. Among the six Municipal Corporations, the water demand by population is 975.4 MLD. Water demand by the industrial units is highest in the Thane district and it is 310.83MLD. In the Kalyan-Dombivali, Bhiwandi-Nizampur, Ulhasnagar and Navi Mumbai Municipal Corporations, there are many small and large industrial units located. They are demanding drinking water for various purposes. Water demand by the hotels, restaurants and shops in Greater Mumbai is 101.8 MLD. The number of shops, restaurants and hotels and their use of water for drinking, cleaning and washing are higher. In Thane district, water demand by shops, restaurant and hotels is only 6.09 MLD. Water demand for garages is 76.60 MLD in the six Municipal Corporations of Maharashtra. In Greater Mumbai it is only 13.92 MLD. In Mumbai, Public transport is available but the use of private vehicles is higher in Mumbai city. Therefore vehicles require much of water for cleaning and washing. But it is much less as compare to Municipal Corporations in rest of Maharashtra. The water demand by theatres, Cinema Halls and multiplexes is 3.49 MLD in Thane district. In Municipal Corporations in rest of Maharashtra, it is 4.18 MLD. It is higher because water is provided at lower tariff. In Mumbai city, the water demand is only 1.18 MLD because higher tariff is higher and it is continuously increasing. Water demand by the public and private hospital is calculated as 10.45 MLD in Brihanmumbai Municipal Corporation. The numbers of public and private hospitals are more and their use of water for different purposes is also higher. In Thane district, it is only 2.49 MLD.

The water demand by the fire stations and hydrants is 55.95 MLD in Greater Mumbai. It is only 6.71 percent in Thane district. This is mainly because every municipal corporation has only one fire station. Water demand by the schools and colleges is 83.50 MLD in six Municipal Corporations in rest of Maharashtra. In Greater Mumbai, water demand by educational institutions is only 21.56 MLD. The reason is that in Mumbai, there is no adequate space for schools and colleges therefore there are no gardens for schools and colleges. Water is only used for drinking, toilets and cleaning purposes. In Brihanmumbai Municipal Corporation, parks and gardens are concerned then the water demand is 0.64 MLD. The drinking water demand for parks and gardens in rest of Maharashtra is 10.10 MLD. The total water demand in the Greater Mumbai is calculated as 3967 MLD and it is highest as compare to all other Municipal Corporations and regions in Maharashtra. In Thane district, Municipal corporations have 1206MLD drinking water demand. The water demand in Rest of the Municipal Corporations in Maharashtra is 1285MLD.

VI. Water distribution system

Drinking water which is brought by the pipelines requires treatment before it gets distributed to the consumers. Water treatment is necessary because of water contamination by various sources at the different points. In Greater Mumbai, the raw water is regularly treated and then it is transferred to Bhandup and Pawai master reservoirs. The Bhandup Master Balancing Reservoir supply water to eastern and western suburbs. It provides water to A, C, D, K and H ward. The H east ward is partly served by this reservoir. The Pawai reservoir supply water to F/N and F/Sward. It is also provided water to M, N and L ward. They are partly served by this reservoir. Water distribution system is very complex in the Greater Mumbai. The water transmission (650 kilometre) and service pipes (3200 kilometre) are covering entire city. Water supply to each ward is difficult to measure and it changes according to total water availability. The water pressure is also gets affected due to total stock, leakages, repairing etc. The numbers of household, commercial, small and large industrial units are also matters (MCGM 1995). Drinking water supply distribution system for Pune and Pimpri-Chinchwad Municipal Corporation is different. In Pune city, water supply operation is divided into seven zones. Each zone has its specified area and water supply service. In some part of the city water is pumped and in some part water is distributed through gravity. It is also depending on the zone reservoirs. Water is distributed through pipes consist of different diameters. The lowest size of the pipe is 80mm and highest diameter is 1600mm. Total length of the network of pipeline in the city is 647.18 kilo meters. Total length of the distribution of drinking water pipeline is 2474 kilo meter. It also includes the 24 kilo meter transmission line. In Pune city, water supply pipeline is mainly located near road. Some roads have more than one water supply pipeline. The reason is that they are put at different time. Total length of roads in Pune city is 1750 kilo meter (ESR 2008, PMC 2006). In Pimpri-Chinchwad Municipal Corporation, the distribution network covers length of 722 kilo meters. It is 95 percent of road length. The water supply system in Pimpri-Chinchwad Municipal Corporation covers whole developed area including slums. The newly added areas are catered by the tanker supply. Total water storage capacity is 74million litres and it is only 32 percent of installed capacity of the system. Therefore the reservoirs in Pimpri-Chinchwad Municipal Corporation are filled more than two times a day. The water supply is distributed by gravity and pumping zone in the city. The gravity zone covers west side of Mumbai-Pune highway and railway line. There are 24 Elevated Service Reservoirs (ESR's) in the gravity zone. The pumping zone comprises areas north of ridge and slopping towards the Indrayani river. They are subdivided in to eight water districts. Each water district is served from the local ESR. There are total 15 ESR's in pumping zone. It is also depending on the water supply system in that particular ward. In Pune city, water supply operation and maintenance, pumping of water treatment, distribution is taken care by municipal corporation staff. Due to wide service area and connections, total 1650 person's including technical staff is employed by the Pune Municipal Corporation. In Pimpri-Chinchwad municipal area, water supply distribution network and service area is small. Therefore only fifty persons are

employed. The contractors are involved in distribution and maintenance at the boundary level (PCMC 2006).In Thane Municipal Corporation, the length of the water supply is 42 kilo meters. The distribution network is spread on 369 kilo meters. The whole Thane Municipal Corporation area is divided into three major zones and 44 water districts. Each zone has provided the water by separate source. It is further supplied to the ESR in respective area. The central zone has 13 water districts. It gets 100 MLD water from STEM. The northern zone gets 100 MLD water from STEM and it has 14 water districts. Eastern part of the Thane city gets water from MIDC source. It has seven sub districts. All the zones are regularly supply water to different water districts (TMC 2006). In New Mumbai Municipal Corporation, the drinking water is supplied from Morbe dam. The supply system network is spread in CBD Belapur, Nerul, Sanpada, and Vashi. Water is regularly supplied to all the households, commercial and industrial units in the municipal area. (NMMC2006). In Ulhasnagar Municipal Corporation, due to topography, the water supply system is divided into 16 water zones. Out of these zones, the southern and northern part of the municipal area is further divided in to seven zones (UMC2006). Water supply in Kolhapur Municipal Corporation is divided in to A to E wards. Drinking water is supplied through the network pipeline which consists of reservoirs and distribution system. The main transmission runs around 57 kilo meters. Drinking water transmission and distribution losses are 20 percent to total supply. The city has five ground level storage reservoirs with a capacity of 15million litres and 16 Elevated Storage Reservoirs (ESR's). It has storage capacity of 22.05 million litres (KMC 2006). In Nagpur Municipal Corporation, there is old Gorewada and another two working pumping schemes. At Pench-II, there are three working pumps but their capacity is very high. At 17 location's, there are 28 service reservoirs. Such service reservoirs are supplying the water to the entire city. These service reservoirs are divided into seven water supply zones. Pure water is supplied to the Master Balancing reservoirs. There are only two MBR's such as Seminary Hills and Guest House. These two major reservoirs supply water to 28 reservoirs. The seminary Hill reservoir receives water from Pench WTP and old Gorewada WTP. There are two GSR's with a capacity of around 27.97million litres. It also includes the old GSR of 3 million litres capacity. The old GSR gets water from old Gorewada water treatment plant whereas the new GSR gets water from Pench I and II. Both these reservoirs are supplying the water to different regions (NMC 2006).

In Amravati, the water treatment plant is maintained by the Maharashtra Jeevan Pradhikaran (MJP). The raw water is pumped in Master Balancing Reservoir (MBR). In the AMC, there is only one MBR. The water is further pumped in to the ESR. There are three GSR's and eight ESR's in the AMC. Total length of the pipe line is about 550 kilo meters (AMC 2008). In 1977 additional distribution system of Nanded town was completed due to growth of population in the city. Similarly in 1979, ESR's was constructed at Chouphala of 2.27 millon liters. During 1983-85 number of water supply related tasks were completed. New ESR at Gandhi Putala (18.20 MLD), railway station (6.8 MLD), work shop (22.70 MLD) was developed. In 1997 new pump house at Kotithirth was developed. In 1997, new WTP with capacity of 60 Million litres is also established. From 1998 onward numbers of water supply projects are planned. The first 13 ESR's and 2 MBR's were completed. The entire water supply scheme is planned to supply at least 135 litres per capita daily water to urban population. The open bore and tube wells are constructed in an authorised and unauthorised layouts and slums to cater the local needs. Some pipe network has not reached in such area. The ground water resource needs to be protected for present as well as future generation. In Nanded Municipal Corporation, water treatment facilities are located at three places. The Kabra nagar WTP is located 9 kilo meter away from city and it is commissioned in 1997 on Vishnupuri dam. It is a sand filter and Chlorination type of treatment with installed capacity of 60 MLD. But at present, it is used as 24 million litres. The CIDCO, WTP is located five kilo meters away from city and the source of water is Vishnupuri dam with special installed capacity of 12 MLD. It has used
capacity of 10 MLD. It is sand filter and Chlorination type treatment plant. The last Dankin WTP (New and old) is located in the Nanded city. The installed capacity is 27 MLD but only 20 MLD capacity is used for water transmission. The water is distributed separately for two different zones. They are serviced through 10 Elevated Storage Reservoirs (ESR's). The total capacity of all reservoirs is 15.35million litres. The distribution system in the Nanded city is 526 kilo metes. In 1936, total 30 kilo meters distribution system was laid. In 1966 to 1975 total 300 kilo meters pipe line was laid. During 1980 to 1996 another 30 kilo meters was laid and rest was laid in1997 to 2004 (NWMC 2006). In Aurangabad Municipal Corporation, the water supply was inadequate for rising population. Total 675 kilo meter pipeline is distributed in the city to supply water (AMC 2006). At present, Nasik Municipal Corporation provides drinking water through 1200mm diameter ms pipeline. After filtration, water is supplied to CIDCO and Satpur area. Water pumping main is located in Gangapur dam and it supply water to Nasik, Gandhinagar, Panchavati and Nasik road WTP (NMC 2008). In each municipal corporation water supply network is developed over the period of time and it is bigger in Size.

VI. WATER TARIFF

Drinking water is a merit good. All individuals in each Municipal Corporation have a right to an adequate, reliable, affordable supply of potable water. Water supply must be priced in such a way that which will cover the capital cost such as operating and maintenance cost. Drinking water has economic value in terms of space, time, quantity and quality. But its uncertainty and quality increases further cost. Water tariffs are different in different Municipal Corporation. The water pricing is depending on density of population, small and large industries, commercial units and how the raw water is purchased.

Table 4 Water Charges for Different Purposes in Greater Mumbai (per 1000 Litres)

No.	Category	2007	2006	2002
1	Slum area, Stand post, Residential chawls	2.50	2.25	**2.25**
2	Dharmashala, Asylum, Women's hotels, Balwadi, hotels, All residential premises, Bungalows, Row houses, Offices of trade unions, Educational institutions, Gardens.	3.50	3.50	**3.50**
3	Halls for religions and social functions, Hospitals, Dispensaries, Piggeries, Coaching classes, Playgrounds Swimming Pools.	10.50	10.50	**10.50**
4	Industrial establishments, Dhobi-ghats, Ice factories, Photo studio, Xerox shops.	18.00	18.00	**15.00**
5	All shops, Mall, Stores, Parlors, Training Centres, Schools , Colleges , restraints , All hotels , Cinema halls, Multiplex-warehouses, Petrol pumps, Workshops , Garages, Swimming pools, Ice cream factories, Studios.	38.00	25.00	**22.00**
6	**All three star hotels, Aerated water factories, Manufacturers of bottled water.**	**38.00**	**38.00**	**38.00**

Source: Brihanmumbai Mahanagar Palika, Hydraulic engineer's Department

In Brihanmumbai Municipal Corporation area, water for residential chawls, slums is charged for Rs.2.50 per thousand litres in 2007. But for all residential premises it is Rs.3.50 per thousand litres. Drinking water for hospitals, playgrounds, and swimming pools is costlier and it is Rs.10.50 per thousand litres. The water rates for such use are not increased since 2002 by Municipal Corporation. Water for shops, malls, parlours, cinema and multiplexes and swimming pools is Rs 38 per thousand litres. Such water tariff is higher and Municipal Corporation has increased tariff in the city. Certainly, the poor people are not visiting to these places. Water for three star hotels and manufacturers of bottled water is available at Rs38.00 per thousand litres. The water tariff is same over the period of time. In Thane Municipal Corporation, water from the source is available at different prices. The STEM and raw water received from BMC is charged at Rs.4 per thousand litres. The water received from the MIDC is Rs.7.50 and pure water received from BMC is charged at Rs.8 per thousand litres. The water received from the PISE is cheap and the rate is Rs.2.50 per thousand litres. In Thane city, water meters will get installed in few months. The civic body charges water at a flat rate on monthly basis. It is irrespective of the quantity of water used. The charges for water are set to be Rs.5 for every thousand litres for first 18000 litres per month per flat. It is Rs. 6 per thousand litres for consumption between 18000 and 24000 litres (Rode S.2009b). In NMMC, tariff for water is based on consumption categories ranging from Rs.3.75 to Rs.4.65 for domestic metered connections. Water tariff for the non metered connection is Rs. 60 to Rs.100 per month. The rate of tariff for the commercial consumers is Rs.30 per thousand litres. The NMMC does not supply water to industries in MIDC area. It supplies water to slums through public stand posts.

Few wells are provided in slum pockets of Airoli, Digha, TTC and Dahisar ward. In Pune municipal corporation area, thousand litres of drinking water is provided at Rs.3. For Pune and Khadaki cantonment, it is Rs. 5. For commercial and industrial unit, the rate is Rs.21 per thousand litres. Households in slum have to pay Rs.365 per annum. Water for stand post is free of charge. In PCMC, domestic water supply connections are charged at Rs.3.30 per thousand litres. Non domestic connections are charged Rs 28 per thousand litres. Unmetered domestic connections are charged a minimum of Rs. 792 per annum. Commercial and industrial unmetered connections are charged of Rs. 652 per annum to Rs.11358 per annum depending on the diameter of connection. In PCMC the water charges are different for different apartments and years. In 2004-05, per apartment the water tariff rate was Rs.872 but in 2007-08 it was reported as Rs.1160. It means every year per apartment, one percent water tariff has increased (Rode S. 2009a). In Kolhapur city, the water tariff for domestic purposes is Rs7 per thousand litres and for commercial connections it is Rs. 20. For industrial purposes water charges is Rs. 4 per thousand litres. Such water tariff rates get revised every year. In Amravati, for residential purposes, the water tariff rate per thousand litres is Rs.10.20. Water for non residential purposes is charged as Rs.46.20. For institutions, it is Rs.19.65 paisa per thousand litres.

VII. Regression Results

The water demand is increasing in all the municipal corporations but it is difficult to identity which units are contributing to such increase in water demand. Population and commercial units are important but some units are also showing the decline in the use of water. Therefore in order to examine the correlation with the units, we have used Tobit and ordinary least square regression model

(Wooldridge, J.M. 2003, Greene 2003,Baltagi Badi H. 2008). The Tobit model is defined as follows,

$Y^*i=x'i\beta+\varepsilon i$

Where $Y^*i>0$

The results are presented in the following table.

Table 5 Regression results for Municipal Corporations and regions

Variables	Greatermumbai Municipal Corporation		Thane district		Pune Metropolitan Region		Rest of Maharashtra	
	(Tobit)		(OLS)		(OLS)		(Tobit)	
	Co-efficient	Z test	Co-efficient	Z test	Co-efficient	T test	Co-efficient	Z test
Population	0.00* (0.00)	257.69	0.29*** (0.11)	2.58	1.00* (0.00)	2143.75	1.93* (0.00)	401.85
Hotel and restaurants	0.20* (0.00)	21.89	208.88* (18.66)	11.07	3.17* (0.05)	58.29	-	-
Cinema house and theatres	0.02* (0.00)	9.62	-	-	1.32* (0.20)	6.59	-	-
Educational institutions	0.00 (0.00)	0.93	94.22** (32.50)	2.90	4.42* (0.04)	94.00	-	-
Small and large Industrial Units	0.03* (0.00)	4.59	0.99* (0.00)	771.11	-	-	-	-
Fire stations	-0.02* (0.00)	-4.05	-	-	-	-	-10.04* (3.33)	-3.02
Constant	0.49 (0.28)	1.75	-59.36 (0.67)	-87.64	-0.20 (0.26)	-0.79	-2.30 (1.54)	-14.95
	L RChi^2=221.75 Prob>chi^2=0.00 Log Likelihood =-330.54		R square =1.00 Adjusted R square =1.00 Root MSE=0.04		R square =0.99 Adjusted R square =0.99 Root MSE=1.88		L RChi^2=221.75 Prob >chi^2=0.00 Log Likelihood = -330.54 P seudo R^2=0.25	

- Figures in Parenthesis shows standard errors
- *Significant at 1 percent **significant at 5 percent *** significant at 10 percent

Water demand by population is positive and significantly correlated in all the municipal corporations. It is observed that because of urbanisation, population in all the municipal corporations is growing. Therefore rising population requires more water for different purposes. The demand of water to the hotels, restaurants is positively co-related in the Brihanmumbai Municipal Corporation, Thane district and Pune Metropolitan Region. The population in the municipal corporations often visit to such places. Therefore water is used for cleaning, washing, drinking and food preparation etc. Water demand of cinema and theatres is positively co-related in Greater Mumbai and Pune Metropolitan Region. In both regions, people visit cinema houses to watch movies. They use different recreational facilities at such places. The water is used for drinking, food preparation, cleaning and toilets etc. Water demand by educational institutions is positively correlated in the Pune Metropolitan Region and Thane district. The demand of water by educational institutions is statistically insignificant in Greater Mumbai. The water demand by the industrial units in Brihanmumbai Municipal Corporation and Thane district is positively correlated and statistically significant. The water demand by the fire hydrants/stations is negatively correlated in Brihanmumbai Municipal Corporation and Municipal Corporations in rest of Maharashtra. The possible reason is that, there are few fire related cases reported in municipal corporation area.

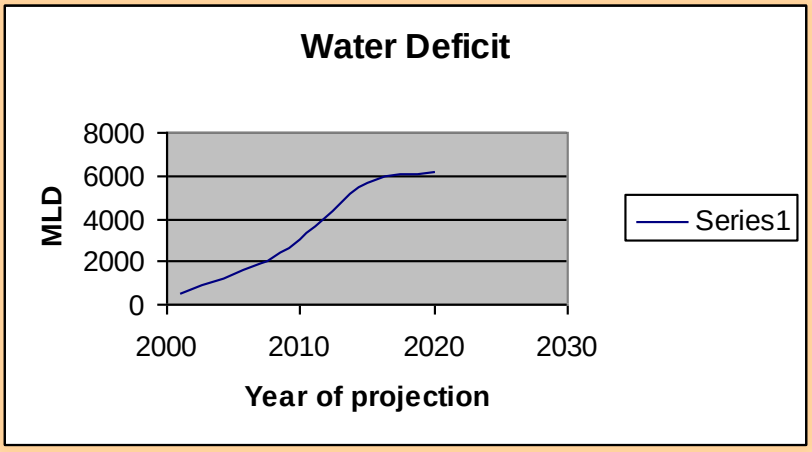
Therefore water demand by fire hydrants/stations is low. It is negatively correlated and statistically significant.

VIII. Future Water Demand and Supply Estimation

Water demand is increasing in the each municipal corporation area due to the growth of the population and commercial units. But the supply is stagnant and it increase at once. It is the local urban body which decides on the available and distribution of drinking water supply. But it is difficult to ensure the adequate water to the population on a sustainable basis. We have calculated the growth of the different units and the requirement of drinking water. The water demand is sharply increasing in the Mumbai city but supply is stagnant. The deficit of drinking water is increasing and it is calculated as more than 6000 million litres till 2021. The supply of drinking water schemes are planned till 2021. Municipal Corporation will able to keep

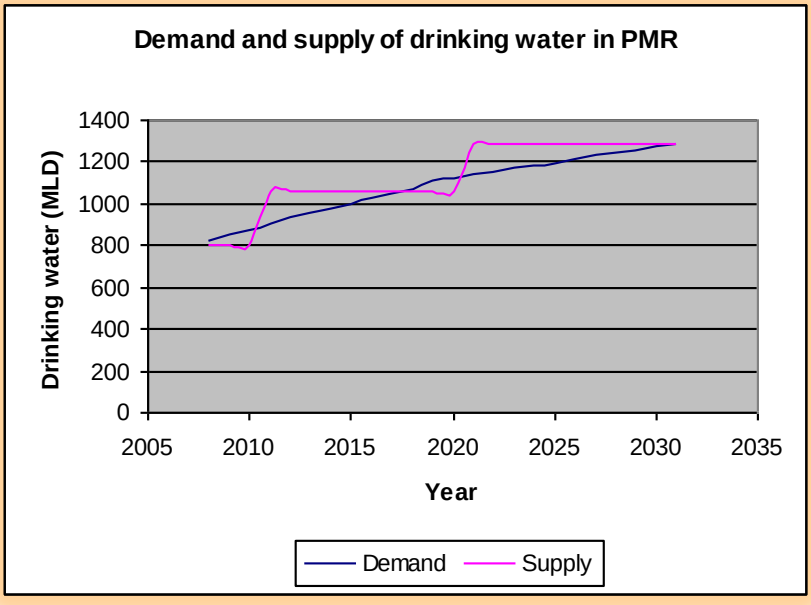
the deficit of drinking water at constant rate but it will not decline.

Figure 1 Water deficit in the Greater Mumbai



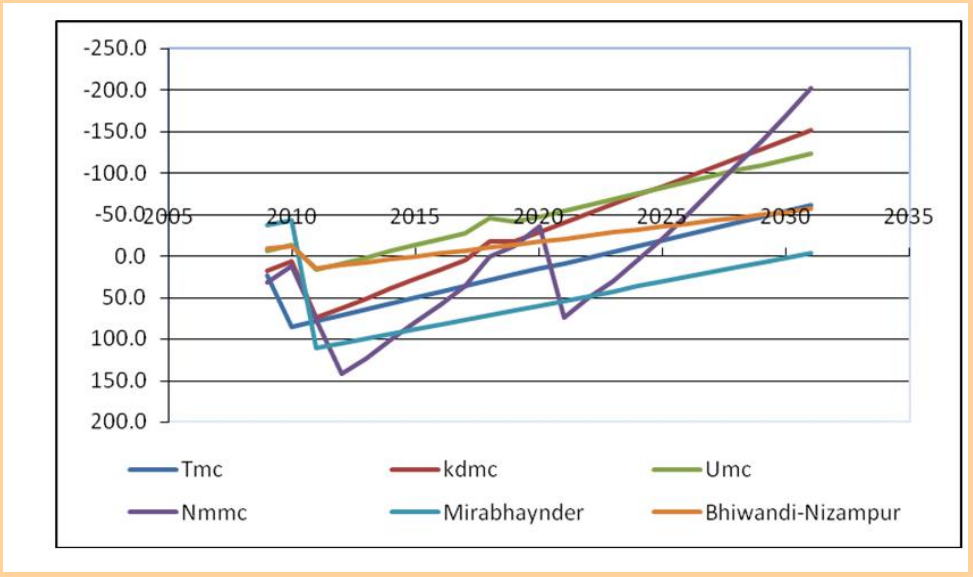
The water supply projects are announced and completion of such projects is expected till 2021. We have calculated the water supply and demand situation in Pune Metropolitan Region. In Pune metropolitan region, water demand and supply is increasing. The numbers of water supply schemes are planning along with the growth of the population in the region.

Figure 2 Water demand and supply in PMR



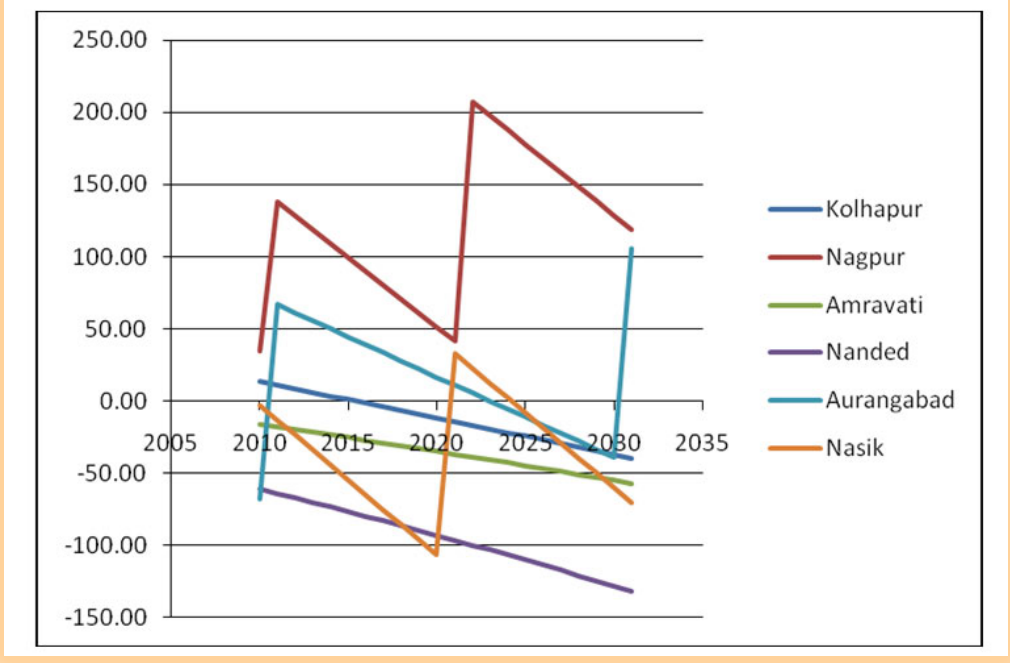
Therefore deficit of the drinking water is not observed in the city till 2031. But it is also depend on how the water supply schemes get completed. If they are not completed on time then water demand will rise but supply will not. Similarly, there are different small and large industries located in Pune metropolitan area. They have their own arrangement of water supply. In Thane district, Thane Municipal Corporation is completely becoming independent in terms of water supply. The demand of drinking water is continuously increasing but supply schemes are not announced. The deficit of drinking water till 2031 is 50 MLD. It is small deficit in drinking water and it is required to adjust with new water supply scheme.

Figure 3: Deficit of drinking water in municipal corporations in Thane district (MLD)



Water deficit in New Mumbai Municipal Corporation is rising fast and in the year 2031, the water deficit will be 200 MLD. It is a planned city and therefore population, commercial units, malls and theatres are continuously increasing. The New Mumbai Municipal Corporation has to increase the supply of water in future through announcement of water supply projects. Water deficit in the Ulhasnagar Municipal Corporation is also increasing and in the year 2031, the water deficit will be more than 125 MLD. Water deficit in Kalyan-Dombivali Municipal Corporation is also increasing and it will be more than 150 MLD till 2031. Water supply schemes are not announced by the Municipal Corporation and few schemes are not enough to cater the need of rising population. In Mira-Bhayandar, water deficit is not observed till 2031. The water supply schemes are planned according to future growth of population. In Bhiwandi-Nizampur Municipal Corporation, the water demand is rising but the deficit is very low. In such municipal corporation, density of population is very low. Such Municipal Corporation area is not well connected through rail and highway. Therefore water demand is very low. But in future monorail is planned from the corporation which will increase population and other units. Therefore water demand may increase in future. We have also estimated the water demand of six Municipal Corporation of rest of Maharashtra.

Figure 4: Deficit/surplus of drinking water in Municipal Corporations in rest of Maharashtra (MLD)



Water supply is surplus in Nagpur city. In 2011, water supply schemes will add 200 MLD water to total stock. In Future, water supply is planned according to the rising population and other units. Therefore there is surplus in the drinking water supply in the Nagpur Municipal Corporation. It is similar case for the Aurangabad Municipal Corporation. The water supply scheme of 2031 will add 150 MLD water. Therefore surplus of 100 MLD is observed at the year of 2031. At present, drinking water deficit is not observed in Kolhapur city. In the year 2031 the water deficit is observed as up to 50MLD. For Kolhapur city, not a single water supply scheme is planned. For Amravati Municipal Corporation, the deficit is not observed at current period. But in future water deficit will increase. There is not a single water supply scheme which is planned for city. The water deficit in the year 2031 is observed as more than 50 MLD. In Nanded city,in current year more than 50 MLD drinking water deficit is observed. In the year 2031, the water deficit is observed as more than 140 MLD. For Nanded city, not a single water supply scheme is planned. In Nasik Municipal Corporation, water supply schemes are announced but the rising population and the industrial and commercial units, the announced water supply schemes are not enough. Therefore the water deficit of 50 MLD is observed at the year of 2031.

IX. Policy Implication

India has made gains after independence but the fact remains that more people are vulnerable to water related diseases. (Biksham G.and Hajara S. 2005). In Maharashtra, demand for drinking water is continuously increasing. The growth of population in urban centres is more because of higher employment opportunities and infrastructure services.Population growth is a challenge because it is not growing uniformly across the state. Some municipal corporations are facing the problem of provision of urban services to its population. Population is increasing but the supply of drinking water is constant.The future growth of schools, shops, commercial, industrial units, garages isvery high. The deficit in drinking water will increase. Therefore municipal corporations must plan water supply with rising population and commercial units.In Pune Metropolitan Region, Aurangabad and Nagpur municipal corporation water supply is planned according to the future water needs. In order to tackle the water supply deficit, the municipal corporations must make the roof rain water harvesting system compulsory. Rainwater harvesting is an old method of capturing run-off rainwater from the terrace. It is important to examine whether the rainwater harvesting technique is efficient, functional, and sustainable. Rainwater harvesting system increases ground water level and it provides ready and natural source of water. It is also helpful to reduce the salinity in groundwater. Tanks, lakes and wells are the natural sources of water. Time has come to use these natural sources more effectively and efficiently because of higher water demand. Tanks in the corporation area can be repaired and reused. Water for toilets must be provided through wells and ponds. Municipal corporations must reduce the leakages and theft of water in their area. Wastewater can be treated and reused for different purposes. It can be recycled from the different residential buildings, commercial establishments, factories, and institutions. Such recycled water can be used for flushing, gardening, car washing etc. The water demand can be managed through increase in water use efficiency, recyclining and promotion of water saving technologies (Reddy V.R. 2001).In the present juncture, the city population is using potable water for flushing, gardening etc. There are alternative sources of water and they can be substituted for different use. In each Municipal Corporation, water leakages are occurring at several points due to various reasons. The major loss of water is seen at the time of water treatment, distribution and pumping. In Brihanmumbai Municipal Corporation, unaccounted water is almost 20 percent. 15 percent leakage is considered as acceptable in a distribution system because further reductions are not cost effective. Suchreduction in the leakages through immediate measures will add 162 MLD water in the city (Rode S.2008). When water is supplied to consumer, it is wasted during washing cloths, drinking and brushing etc. It is visible that most of the people keep tap running while brushing. Rich people regularly like tub and shower bath. Women keep tap running while washing clothes. People drink half glass of water and half glass is thrown in the drainage. Potable water is wasted during all these activities. Proper awareness and advertisement could save drinking water wastage. There is need to prepare small advertisements of running tap, washing cloths, potable water thrown in drainage etc. Television programs and small advertisements can save few million litres of potable water in the state. Municipal Corporations can reduce water theft through proper laws and legal actions. Water theft across the pipelines can be reduced through protective walls and compounds. Sometime the water supply is by and large limited by natural availability, technologies for harnessing, recyclining and reusing can enhance supplies but only to a limited extent. The crux of water management lies in managing demand (Krishnan R. 2003).Water tariff can satisfy three objectives. It helps to discourage water use for particular activity or category. It is a useful method to reduce the water wastage. Higher water tariff is useful to generate more money for future projects and maintaining present water supply system. At present, water supply systems are not effectively managed. Total collection of money of water bills is low because of irregularity of water bills, errors in readings and invisible water reading. There is need for efficiency in water supply system. The water tariff needs to be revised in the all the municipal corporations. Present flat system of tariff needs to be replaced with marginal pricing of water. It will help to achieve long term efficiency in deploying water resource. In the short period it will affect water demand but it will promote efficiency in the long term. In a competitive economy, prices of goods and services are always decided on the basis of demand and supply. The water charges can be framed on the basis of standard use of water. Such water tariff must be high enough to meet the different expenses. Regular revision of water tariff structure will certainly help to increase the financial resources. If the cost of water is not

covered, municipal corporations may drag on the limited resources. (Shah C.H. 2005).The water supply system can be made efficient, transparent, and functional. The resources can be used for further investment. There is also need to provide technical training to Municipal Corporation staff about the computerized billing system and simple method of water bill collection. The public water supply needs modernization and technical up gradation. At present, investment and building a new dam
is time-consuming process and sometimes it takes 10 to 15 years. It needs to take clearance from forest and environment department. Rehabilitation of project-affected villages/people is another problem. Because of all these reasons, cost of the project continuously increases. Sometimes the new water supply schemes cannot be managed because they are the most capital intensive and expensive ones. Major costs incurred are costs of planning, water storage and rehabilitation of villages; establishproduction capacity, maintenance of storage, new pipeline, transmission and distribution network. The water supply scheme has fixed cost and returns are low over the period of time. The schemes are announced when there is acute shortage of water supply. It takes maximum time to get funds, clearance from various departments and actual work of the project and supply of water. After a huge investment in water supply schemes, the recovery is very low because of low tariff, water wastage, leakages etc. The whole water supply system suffers from mismanagement and lack of modern system and equipments. In order to avoid all the above problems, government can introduce the public private partnership in water supply system. There are many advantages of this partnership, it can help to complete time bound projects, meeting water quality standards, resource mobilization, and ensuring speedy recovery. Public private partnership is helpful to build reservoir and treatment plants. Through this partnership better water supply management, modern techniques for repairing, and leakages can be managed. This partnership is useful to provide regular, reliable and affordable water supply to all citizen. There is need of private sector participation in water related investment. Such investment can be converted as technological investment in water supply system (Thomas Wipperman, 2007). The private sector should not allow fixing the tariff structure. Municipal Corporations must monitor the service of the private companies. Water supply system needs more capital and such capital can be generated through private companies. There is need to see the entire water supply system in terms of the modern water supply distribution system. It will help households to improve health and education through reduction of diseases burden.Progressive and sustained expansion of access to safe water supplies among disadvantages urban dwellers will contribute greatly to reducing under five mortality (Fotso J.E. et al. 2008). Such efforts are also important for sustainable drinking water supply in the municipal corporations.

X. References

1) AMC (2008) “Environment status report of Amravati city, 2008-09” Amravati, Maharashtra.
2) AMC (2006) “Aurangabad Municipal Corporation City Development Plan”, April 2006, Aurangabad.
3) BMRDA (1995) “Draft regional plan for Bombay Metropolitan region 1996-2011”Bandra, Mumbai - 51
4) Baltagi Badi H. (2008), ,,Econometrics’ Fourth edition, Springer-Verlag Berlin Heidelberg.
5) ESR (2008),’Environment status report 2007-08’ Pune Municipal Corporation, Pune
6) Fotso, J.E., Ezeh A.C, Madise N.J, Ciera J. (2008) “Progress towards the child mortality millennium development goal in urban sub-Saharan Africa” UN/pop /EGM –URB) 2008/12, New York.
7) Greene, William H. (2003): “Econometric Analysis” fifth edition, Pearson Education Private, Ltd, Indian Branch, Delhi, India.
8) Gujja, Biksham and Shaik Hajara (2005) “A Decade for action: water for life, when India will cover the uncovered?” Economic and political weekly, March 19, 2005. PP 1086-1089.
9) KMC (2006) “Kolhapur Municipal Corporation City Development Plan”, April 2006, Kolhapur.
10) Krishnan, Rekha (2003) “Swajaldhara: More empty promises?” Economic and political weekly, March 8, 2003, PP937-939.
11) Kanmony, J.Cyril (2003) “Drinking water in Kanyakumari” Economic and political weekly, August.30, 2003, PP3633-3636.
12) Kashid, Sukhdeo (2003) “Water” Municipal Engineers Association, Mumbai and Brihan Mumbai Licensed Plumbers Association ,OM Sai Printers, Vile-Parle (E) ,Mumbai-57
13) Mehta, L., Marshall F. ,Movik S., Stirling A. , Shah E., Smith A. and Thomson J. (2007) “Liquid dynamics challenges for sustainability in water and sanitation”, STEPS working paper 6, Institute of Development Studies; University of Sussex Brighton BN1 GRE U.K.
14) MCGM (1995) “Mumbai City Development Plan 2005-2025” Mumbai.
15) MoF (2009) “Thirteen Finance Commission 2010-2015” Ministry of Finance, Government of India, December 2009, Vol.1.
16) NIUB (2008a) “Appraisal of city development plan Kalyan-Dombivali” June 2008, New Delhi.
17) NIUB (2008b) “Appraisal of city development plan Mira- Bhayandar” July 2008, New Delhi.
18) NNMC (2006) “New Mumbai Municipal Corporation City Development Plan”, April 2006, New Mumbai, Maharashtra.
19) NMC (2006) “Nagpur Municipal Corporation City Development Plan”, April 2006, Nagpur
20) NMC (2006) “Nasik Municipal Corporation City Development Plan”, April 2006, Nasik.

21) NWMC (2006) "Nanded-Waghala Municipal Corporation City Development Plan", April 2006, Nanded.
22) PMC (2006) "Pune City Development Plan 2006-12" Volume 1, April 2006, Pune
23) PCMC (2006) "Pimpri Chinchwad City Development Plan 2006-12" Volume 1, April 2006, Pimpri Chinchwad, Pune
24) Ramachandraiah, C. (2001) "Drinking water as a fundamental right" Economic and political weekly, Feb.24, 2001, PP619-621.
25) Rode, Sanjay (2008) "Public private partnership in drinking water supply of Greater Mumbai" Working paper /urban studies/Rode Feb-2008.
26) Rode, Sanjay (2009) "Sustainable drinking water supply in Pune Metropolitan Region: Alternative Policies" Theoretical and Empirical researches in Urban Management, Number 1S, April 2009, PP 48-59.
27) Rode, Sanjay (2009) "Equitable distribution of drinking water supply in municipal corporations of Thane district" Management research and practice, Vol.1 Issue 1, December 2009, PP14-25.
28) Reddy, V.R (2006) "Declining social consumption in India" Economic and political weekly, July 21, 2001 pp-2750-51.
29) Shah, C.H. (2005) "Economic analysis of a drinking water project in Andhra Pradesh" Economic and political weekly, January, .29, 2005, PP474-481.
30) Thomas, Wipperman (2007) "Crisis, what crisis? Challenging the urban water challenge of the twenty first century" DPU working paper no.133 London WC1H 9EZ, U.K.
31) TMC (2006) "Thane Municipal Corporation City Development Plan", April 2006, Thane.
32) UMC (2006) "Ulhasnagar Municipal Corporation City Development Plan", April 2006, Ulhasnagar
33) Wooldridge, J.M. (2003) "Introductory Econometrics: A modern approach" Thomson south- western division, 5191 Natorp boulevard, Mason Ohio 45040, U.S.A.