International Journal of Allied Practice, Research and Review
Website: www.ijaprr.com (ISSN 2350-1294)

Potential for Urban Water Management in suburbs of Mumbai Metropolitan Region: A Case Study

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Abstract - Badlapur is one of the rapidly growing residential cities of Mumbai Metropolitan Region. With increasing population growth in the city and its associated functions, the demand for water is ever increasing. This paper is an attempt to understand the potential for water security in Badlapur City using system approach. This involves the study of environmental and socio-economic pressures, state of existing water system, impacts on water functions and services and responses in terms of strategies and practices for sustainable urban water management. The present paper attempts to address the issues related to water supply system in Badlapur city and perceptions of end users towards water supply system. Authors also attempt to highlight the projected demand for domestic water supply in the study area and potential for rain water harvesting in the city.

Keywords - Water Management, Minimum Water Requirement, Rain water harvesting.

I. Introduction

At the beginning of this century, the World Summit on Sustainable Development meets held in Johannesburg, South Africa. Apprehensions were voiced about the rapid depletion of fundamental resources including water. Keeping in mind the significance and serious implications of water shortage, the United Nations had declared 2003 as the 'International Year for Fresh Water'. Management of water for domestic use in the cities is an important task in the process of urbanization. The increasing use of fresh water due to increasing population and his activities has produces a number of problems related with the supplies of fresh water. The subsurface water table level is shrinking in all the continents of the world. Agricultural lands are becoming saline, increasing pollution of surface and subsurface waters, nearly 45 crores of people in 29 countries are staying in water deficit regions, large amount of water being used for irrigation has raised conflicts between urban and rural areas etc. As water is highly unevenly it will lead to 'hydro-politics'. If all this continues unabated, then very soon i.e. by 2032 nearly half of the world's population will be facing water shortage problem. The U.N. estimates that by 2025, nearly 1/3rd of the world's population will suffer chronic water shortage with the present rate of water use in the world. It is therefore predicted that in the 21st century the third world war will be on water resources.

The rapid growth of population in the modern world calls for providing safe drinking water and sanitation facilities available in abundant quantities for large urban clusters and mega – cities. India's urban population is 285 million (Census of India, 2001) and number of cities and towns are 5161. The total number of urban centers in Maharashtra is 378 (census, 2001) and growing at a faster pace in terms of size and number. The district of thane is not exception to it. In fact, 72.58% of its total population is urban dwellers (Census of India, 2001) which have exerted intense pressure on existing water sources. The present study is an attempt to study the existing status of availability of water supply for domestic use in the city of Badlapur. The efforts are also made to find out the gap between minimal requirement and supply of water in the study area.

II. The study area

The city of Badlapur is situated at the distance of 68 kms. from Mumbai Metropolis along the Central Railway route and 125 kms. from Pune city. The location of the city in terms of coordinates is 19◦ 9′ 00″ N. latitudes to 19^0 15′ N. latitudes and 73^0 15′ 43″ E. longitudes to 73^0 26′ longitudes. The city is surrounded by the region consist of mountains and is drained by Ulhas river. The elevation of the city is 44m ASL. The population of Badlapur city during 2001 was 1, 40, 917 (Source KBMC) spread over its area of 35.68 km^2. The population growth trend of the city from 1961 to 2001 depicts that the city of Badlapur is growing at a faster pace with the coming up of residential, commercial, service sector and industrial activities, the advantage of being located in the vicinity of Mumbai metropolis. As a result of concentration of various functions in the city, the supply of water in the city has not kept its pace with demand. Hence it experiences severe water shortage during dry season. This problem will get further intensified if the corrective measures are not taken immediately.

Rapid growth of population, mass consumption and pollution of water results in shrinking of per capita water availability. 'It is believed that 40% of world population currently live under the condition of water scarcity' (Hooja R, Arrora R,Parami K.2007)

One of the areas where emphasis is to be given to ensure fresh water supply for domestic, industrial and other commercial purpose in copious quantities to urban clusters is growing both in size and number. The urban centers grew across the world during 19th and 20th century (Hooja R; 2007).

The issues associated with urban water supply have increased since last few years mainly due to unprecedented growth of population in the cities along with the unusual character of the city – a strange mixture of planned and unplanned settlements. According to "By the year 2025, it is estimated that more than two third of the population will be urban dwellers. While the fastest growth of the cities is taking place in the developing world, urbanization is a global phenomenon, closely related with the environmental issues. The rapid growth of urban centers will place tremendous stress on the environment and pose formidable problems of social and institutional change, infrastructure development and pollution control. Water will be one of the key resources for sustainable urban development. It is needed for virtually every human endeavor- for household use, agriculture, industry, leisure – and water also has an important ecosystem function. Provision of adequate water and preventing pollution, of water however are formidable tasks." (Uitto Biswas, 2000: back cover).

Water delivery and disposal in cities is under threat because water is being considered as a commodity and water delivering mechanism is influenced by private water suppliers who supply water at much high prices. Thus there exists a situation of "*de facto privatization*" (Hooja R. 2007).

According to the United Nations Population Fund, 3.3 billion people currently live in cities and this number is expected to rise to 4.9 billion by 2030 (UNFPA, 2007). By 2050, 70 percent of the global population is expected to live in urban areas (UN-Habitat, 2009).

'The goals of urban water management are to ensure access to water and sanitation infrastructure and services; manage rainwater, wastewater, storm water drainage, and runoff pollution; control waterborne diseases and epidemics; and reduce the risk of water-related hazards, including floods, droughts, and landslides. All the while, water management practices must prevent resource degradation. Conventional urban water management strategies, however, have strained to meet demand for drinking water, sanitation, wastewater treatment, and other water-related services. Some cities already face acute water shortages and deteriorating water quality' (Bahri, A. 2012).

Oyebande L. (1978) studied the urban water supply system in Nigeria with reference to the minimum water requirement. According to Oyebande L. (1978) The gap between water need and supply has widened steadily in urban centers despite continuous efforts made to develop the nation's vast surface and groundwater resources.

Ahiablame, L. (2012) conducted a feasibility study through one-time face-to-face interviews to characterize existing water supply systems and obtain public opinion for identifying a model of community-level water supply systems in a suburb of Lomé, the capital city of Togo. This study revealed that the most common water supply systems are bucket-drawn water wells. Other water supply systems include mini water tower systems, rainwater harvesting and public piped water.

Ainuson, K. G., et. al. (2010) elaborated political issues related to water security in Urban areas of African countries. The study revealed that the problem of inadequate water supply is not limited to one SSA country. It is a pervasive problem that permeates all urban centers throughout the developing world.

Rapid growth of population and pollution resulted in shrinking of per capita water availability especially in urban areas. It is believed that 40% of the world's population currently lives under the condition of water scarcity (Hooja R., Arrora R. and Parnami K., 2007).

Even though the rate of urbanization in India is among the lowest in the world, the nation has more than 250 million city-dwellers.

According to Central Public Health Engineering Organization (CPHEO) estimates, as on 31 March 2000, 88 per cent of urban population has access to a potable water supply. But this supply is highly erratic and unreliable.

According to a World Bank study, of the 27 Asian cities with populations of over 1,000,000, Chennai and Delhi are ranked as the worst performing metropolitan cities in terms of hours of water availability per day, while Mumbai is ranked as second worst performer and Calcutta fourth worst (Source: Background Paper - International Conference on New Perspectives on Water for Urban & Rural India - 18-19 September, 2001, New Delhi.)

According to Kinzelbach W. et.al. (2003) a definition of sustainable resource utilization is necessary as a starting point for an assessment of the ground water situation in a catchment.

Kjeldsen T., et.al. (1999) examined the potential for sustainable water conservation in Mupfure catchment a drought prone region of Zimbabwe. The outcome of the study reveals that in order to reach the long-term goal of obtaining a sustainable utilization of the available water resources, which allows users to get a fair share of whatever is available, the present system has to be renewed.

III. Methodology of the Study

The present study deals with the empirical study of the water supply problems and potentials for increasing water supply and methods of water conservation in the city of Badlapur. The study is confined with the water facts in the residential and industrial areas in the city of Badlapur at different localities. The present study is based on both primary and secondary data sources. Secondary data will be collected from various authentic published sources such as Indian Population Census (1971 - 2001), Topographical Maps (Survey of India), Thane District Gazetteer, Annual reports published by Badlapur Municipal Council, Environmental Status Report, reference books, websites, news papers, proceedings of seminars and conferences, research journals and periodicals etc.

The primary data for the study have been collected through field observations, personal interviews and questionnaires. The primary data about issues related to water supply has been collected from households, industries and municipal authorities. A structured questionnaire has been prepared for households, industries and Municipal authorities to obtain relevant data about water sources, supply and issues related with water. Following parameters are selected to examine the status of sufficiency of water in the study area.

1) Duration of daily municipal water supply in the area

2) Other non municipal water sources and their share in meeting the present demand for water

3) Availability of water per person per day in liters

4) Regularity in municipal water supply

5) Seasonal variation in water supply

More over the information confined with water supply department is obtained through interviews of Kulgaon Badlapur Municipal Council officials and representatives. Collected data is tabulated, analyzed and interpreted by using appropriate statistical methods. The collected data is represented by using suitable graphical and cartographic techniques.

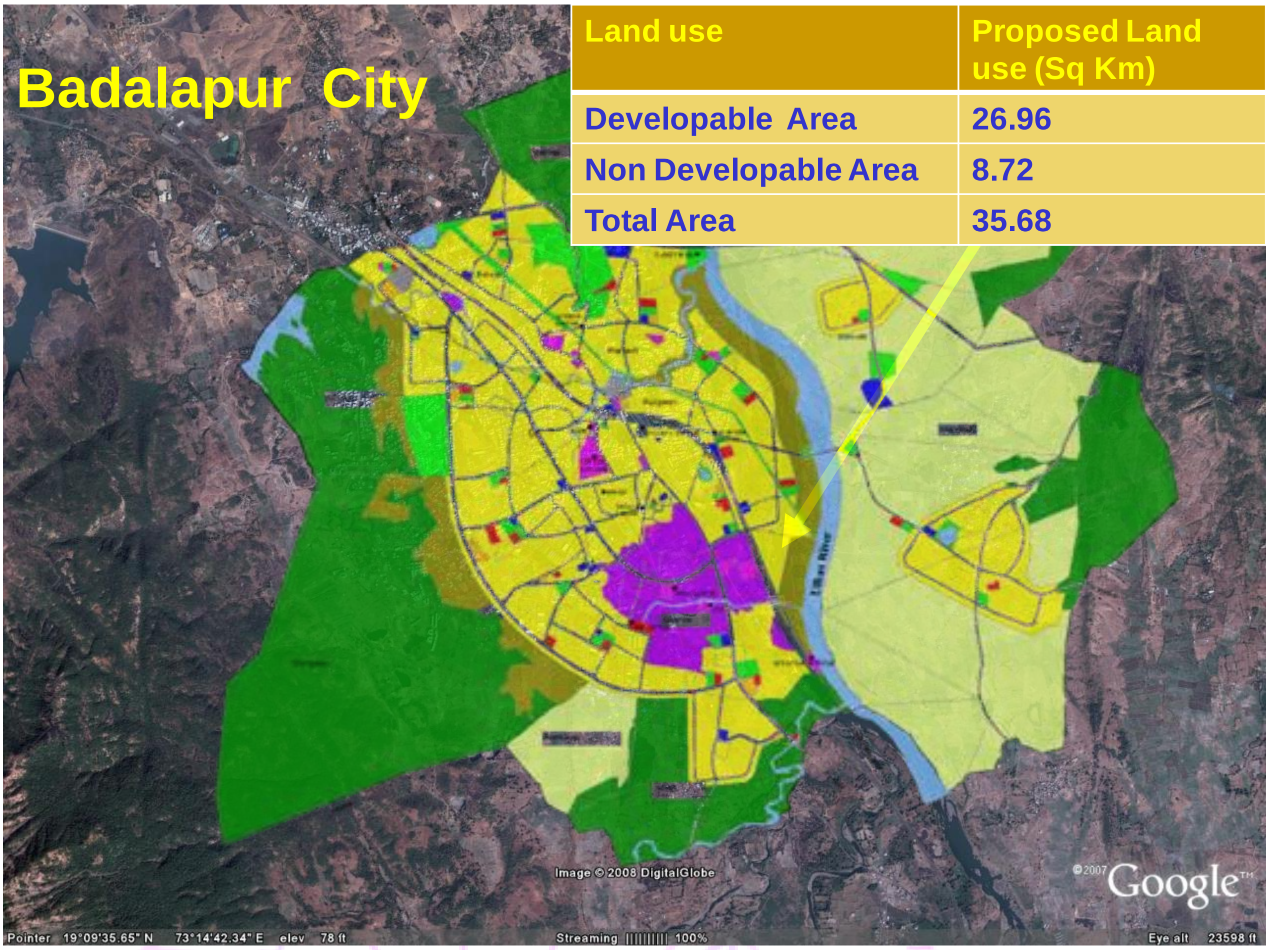
Table 1. Population of Badlapur and Water Requiremwnt (lpcd)

S. No	Population	Persons	AGR	Water requirement (CPHEEO criteria of 135 liters lpcd) in MLD
1	2006	1,66,000	6.29	22.41
2	2011	1,75,516	9.00	23.69
3	2016*	3,49,936	6.50	47.24
4	2021*	4,46,617	5.00	60.29
5	2026*	5,43,378	4.00	73.36
6	2031*	6,29,924	3.00	85.04
7	2041*	7,67,874	2.00	103.66

* Projected population (Source: KBMC)

The population of Badlapur city is growing at a faster rate and will continue to grow in future as well. The estimated water requirement in near future will be far more than that of the present water supply sources. It is therefore the urgent need for water resource management practices to ensure water in copious quantities for growing population of the city.

Fig. 1. Badlapur city overlayed on Google Image



Land use	Proposed Land use (Sq Km)
Developable Area	26.96
Non Developable Area	8.72
Total Area	35.68

(Google Earthpro 2012 and KBMC)

Table 2. Badlapur – Ward Wise Population

Sr. No.	Ward No.	Ward Name	Population (2001)	Population (2011)
1	1	Katrap	7628	6452
2	2	Belawali	2349	5321
3	3	Wadawali	2703	5789
4	4	Ambika Nagar	3658	5723
5	5	Gite Nagar	3997	6234
6	6	Manjarli Gaon	2412	4709
7	7	Hendre pada	6325	6254
8	8	Shani Nagar	3986	5640
9	9	Eranjad Gaon	1453	4321
10	10	Sonivli (east)	2713	5608
11	11	Sonivli (West)	2395	5138
12	12	Badlapur Gaon	1637	5327
13	13	Anjali Nagar	2876	5923
14	14	Sarvodaya Nagar	3211	5736
15	15	Deodhar Market	2354	5248
16	16	Chaitanya Chwk	2162	4823
17	17	Agaskar Tekdi	1287	5443

18	18	Station Pada	3564	5302
19	19	Agar Ali	2364	5265
20	20	Barriage Road	2561	4238
21	21	Saptashrungi	1764	4231
22	22	Subhash Nagar	1566	4336
23	23	Golewadi	2764	5231
24	24	Shivaji Chowk	2380	5257
25	25	Sambhaji Nagar	2643	5248
26	26	Apttewadi	2922	5674
27	27	Yadav Nagar	2143	5185
28	28	Shiragon	2312	3874
29	29	Mankivli	1973	3286
30	30	Datta wadi	3211	5498
31	31	Gavli Wada	3217	4472
32	32	Kharwai	1280	3113
33	33	Rameshwadi	1924	4172
34	34	Bazarpeth	6214	7445
Total Population			97,948	1,75,516

(Source: KBMC, 2001 and 2011)

Due to the high population growth, high land values and congestion, many people working in Mumbai have moved to Kulgaon-Badlapur. Kulgaon-Badlapur Municipal Council (KBMC) was constituted by incorporating 12 revenue villages. KBMC now is a Class-B Municipal council

The rapid growth of population in Badlapur is owned to several reasons. Most of the dwellers in Badlapur are migrated from Mumbai. The migrant population employed in Mumbai cannot afford costly accomodation. Hence, resieds in Badlapur. Secondly, the native Mumbaikars dwelling in chawls are now facing congestion in the house due to increased family size. They, therefore are selling their dwellings that receives a huge amount with which they are able to purchase specious flats in suburb of Bdlapur. This has facilitated them to stay in a joint family besides saving as fixed deposits in banks.

Availability of fresh potable water for domestic purpose is one of the fundamental requirements of every individual. It is therefore the prime responsibility of the local governing body to make water available to dwellers in a copious quantities. According to Central Public Health Engineering Organization (CPHEEO) estimates (2000) for minimum water requirement for healthy and hygienic life for dwellers in class B citys is 135 liters per day per capita. It was felt interested to find out whether the residents in different parts of the Badlapur city are getting access to the minimum water they need. The questionnaire survey was carried out in the study area. The observations of the survey are discussed in the subsections given below.

The population in the city of Badlapur is growing rapidly. The decadal growth rate between 1961 and 1971 was 44.3 % and within a span of 40 years in during 1991 to 2001 it has recorded 87.65 % growth rate.

Sources of water Supply

The supply of water in the city of Badlapur is confined to various sources including private and municipal water supply. As the study is focused on the use and availability of water use to residential areas following sources of water availability were considered. The respondents under study during survey have reported following sources of water used by them for domestic purpose.

Table 3. Overview of water supply and sanitation in Badlapur City

Year	Population	HHs	# slums	Slum pop	# hhs slum	Water supply MLD	Closed drain Km^2	Open drain Km^2	Storage MLD	# Connections	# conn. Slums
2009	183772	45943	18	30168	6557	36.4	15	20.7	35	13023	652
2010	167759	38182	18	26316	6651	49	24	9	35	13023	652
2011	175516	39857	18	26406	6740	51	25	9	35	14137	678
2012	183273	41618	16	29182	6740	35	26	9.5	35	15082	678
2013	185600	45241	16	30311	6740	36	26	9.5	36	15899	712

Source: Annual Performance Assessment Report of Urban water supply and sanitation, Maharashtra, CEPT University, 2008-9, 2009-10, 2010-11,2011-12,2012-13

The major source of water supply for domestic purpose in Badlapur is municipal water distribution system. However, KBMC has no separate water supply system therefore the responsibility of domestic water supply in the city is shouldered by Maharashtra Jeevan Pradhikaran, through public water distribution system. Bore well – Ground water is also an important source of water source for domestic use in the city of Badlapur which constitutes 17.88% of total utilization. It is observed that 22% out of 49 surveyed bore wells are non-active and 47%out of active bore wells do not have sufficient water. It depicts that the supply of water through bore wells is depleting due to shrinking water table.

Besides public water supply system managed by MJP, there are other sources such as public hand pumps, bore wells and dug wells which account for a little share of total water supply in the city. However, the water obtained from these sources are not used for drinking or cooking purpose due to its quality issues as reported by local residents.

Gap between demand and supply of water (lpcd)

According to Malin Falkenmark the minimal requirement of water to maintain adequate quality of life is 100 lpcd. Based on this standard norm the water availability per capita per day in different settlement of the city was obtained with the help data collected through the questionnaire It is therefore essential to find out the gap between demand and supply of water in order to examine the extent of water scarcity.

The data given below in table no 3.4 clearly depicts that the water shortage is increasing with increased in family size. In almost all the settlements in the study area the water availability is less than the minimal requirement in case of family having more than four members. However, the average water availability for five member family in Hendrepada and Shivaji Chowk is 108 lpcd, and 100 lpcd respectively is on the border of minimal requirement. This is a warning signal for the settlement that would experience chronic water shortage in near future. Even the families having four members does not receive sufficient water in the settlements of Sanewadi, Rameshwedi, Subhash nagar, Shivaji

Chowk, Dutta wadi, and Yadav nagar. It may also be pointed out that water availability lpcd is much less in the newly developed areas of the city as compared with its old core city.

Table 4. Demand and Supply of water (lpcd)

No. of family members	No. of HH surveyed	Average Water availability (lpcd)	Minimal requirement	Surplus/ Deficit
02	7	200	135	+65
03	24	173	135	+38
04	46	106.5	135	- 28.5
05	69	79.4	135	- 55.6
6 & more	27	73.7	135	- 61.3
Total HHs.	173			

(Source: Field Survey)

The correlation between family size and water availability per capita daily is found to be near perfect negative correlation (with $R^2 = 0.92$) and also found significant at 0.001 level of significance. The family size determines availability of water supply for domestic purpose. It is therefore advisable to adopt rationing system for domestic water supply so as to rationally distribute water for city dwellers.

According to the international standards of Central Public Health Engineering Organization (CPHEEO), for city dwellers of class B city the requirement of water is 135 liters per person daily. Many localities in the city are fallowing in the category below average minimal requirement of water for domestic use.

Efforts by KBMC for water management

The principal source of water supply to KBMC and its surrounding region is the Ulhas River and its tributaries. The upstream of Ulhas River from Shahad weir is being used as the source of water supply. Ulhas River thus is a perennial and reliable source. The water supplied to the city is 24MLD and the source is located at 69 kms from the city limits. Kulgaon-Badlapur has a water treatment plant, constructed in 1924, to supply 13.5 MLD water to the MIDC at Ambernath. It was later augmented to 27MLD in 1952. The capacity of this plant has been augmented to 34 MLD; however it is running at overloaded capacity of 45 MLD. An additional plant with 18 MLD capacities at Kharvai was established as part of the World Bank aided MWSS project. The total supply is thus around 63 MLD in 1996. The present water treatment capacity is 70 MLD. KBMC has a water storage capacity of 24 MLD pre and post treatment. The storage capacity in the distribution system amounts to 10.4 MLD.

The CDP has pointed out that there are 18 recognized slum pockets with a population of 6557 persons in 1619 households spread over an area of 12.8 acres. In addition to these there are 14 unrecognized slum pockets. The total slum population, including recognized and unrecognized slums, is 10,315 persons (NIUA, 2008).

Supply of water from MJP for Domestic Purpose : Present Situation

The responsibility of water supply in Badlapur is shouldered by Maharashtra Jeevan Pradhikaran. In order to understand the water supply system and strategy of MJP in allotment of new water connections and billing, the officials of MJP civil section, Badlapur were interviewed and data were obtained. The MJP Badlapur civil section established way back in 1923 is a major source of water supply for domestic, commercial and industrial sectors of Badlapur. The barrage was constructed during British period which was broken in 26th July 2005 flood. The new dam is now in work located downstream to the earlier dam. The water is treated in water treatment plant at barrage head water works, the present capacity of which is 78 MLD (Million Liters per Day).

Presently there are two water works functioning in Badlapur. One is Badlapur Head works, Barrage, constructed in 1923 with 36 MLD capacity (overloaded capacity 57 MLD) on gravity basis and another is Kharwai water treatment plant (WTP) at Khrwai, Badlapur (East) established in 1992 with 18 MLD capacity (overloaded capacity 26 MLD) on pumping/lifting basis. There is one MBR 2 GSR and 5 ESRs (distribution tanks) in different parts of the city for water supply. Water is supplied through 454 connections for domestic purpose and 12880 connections for commercial purpose.

Water billing is done based on water usage for which all water connections are metered. The water charges domestic, institutional and commercial purpose are Rs. 7.60/- , Rs. 12/- and Rs. 34.65 per kilo liters respectively which is being revised w.e.f. 1/6/2010 as Rs. 8.35/-, Rs. 38.10/- and Rs. 18.15/- per Kilo Litre. Since the KBMC is a 'B' class municipal council, the standard requirement of water is 135 lpcd, the MJP is trying to improve the water supply capacity to meet the increasing demand.

Currently MJP Badlapur civil section is working on proposed scheme for equal distribution and improvement in water supply system in which 10 no. of ESR along with increase the capacity of water works by 25 MLD. The officials reported that after final approval the scheme will be completed by 2013.

The role of MJP in regulation of water supply in Badlapur is of immense importance. The MJP is trying to increase the capacity of water works in order to keep pace with increasing population and economic activities. However, corrective measures needs to be taken to increase sources of water supply for sustained water management in the city of Badlapur.

Kulgaon Badlapur Municipal council has constantly made efforts for water management. Several projects are undertaken such as Rainwater Harvesting Project and Water Recycling Project for effective water management. Following is the brief discussion about KBMC initiatives for water management in the city.

Rainwater Harvesting

'Till about thirty years back, the areas around our homes and offices used to be unpaved and the rain falling on these areas would percolate into the soil and remain there for being drawn through shallow open wells. With the proliferation of flat complexes, not only have these areas been paved and percolation of rainwater into the soil almost totally stopped, the quantity of water drawn from the soil below has increased manifold. Consequently open wells and not - so - deep bore wells started drying up. The reason is that no sincere attempt is made to replenish the ground water table with rainwater during the monsoon. The Rainwater harvesting is the simple collection or storing of water through scientific techniques from the areas where the rain falls. It involves utilization of rain water for the domestic or the agricultural purpose. The method of rain water harvesting has been into practice since ancient times. It is as far the best possible way to conserve water and awaken the society towards the importance of water. The method is simple and cost effective too. It is especially beneficial in the areas, which faces the scarcity of water' (Worm, J., 2006).

People usually make complaints about the lack of water. During the monsoons lots of water goes waste into the gutters. And this is when Rain water Harvesting proves to be the most effective way to conserve water. We can collect the rain water into the tanks and prevent it from flowing into drains and being wasted. It is practiced on the large scale in the metropolitan cities. Rain water harvesting comprises of storage of water and water recharging through the technical process

It was very difficult to imagine few decades before that you will require to buy drinking. The use value of water was never undermined, but its about time that even its exchange value is given due importance. Fresh water today is a scarce resource, and it is being felt the world over. More than 2000 million people would live under conditions of high water stress by the year 2050, according to the UNEP (United Nations Environment Programme), which warns water could prove to be a limiting factor for development in a number of regions in the world. About one-fifth of the world's population lacks access to safe drinking water and with the present consumption patterns; two out of every three persons on the earth would live in water-stressed conditions by 2025. Around one-third of the world population now lives in countries with moderate to high water stress—where water consumption is more than 10% of the renewable fresh water supply, said the GEO (Global Environment Outlook) 2000, the UNEP's millennium report. Pollution and scarcity of water resources and climate change would be the major emerging issues in the next century, said the report. These issues would be followed by problems of desertification and deforestation, poor governance at the national and global levels, the loss of biodiversity, and population growth, said the report - The Observer of Business and Politics, 12 October 1999.

Millions of people throughout the world do not have access to clean water for domestic purposes. In many parts of the world conventional piped water is either absent, unreliable or too expensive. One of the biggest challenges of the 21st century is to overcome the growing water shortage. Rainwater harvesting (RWH) has thus regained its importance as a valuable alternative or supplementary water resource, along with more conventional water supply technologies. Much actual or potential water shortages can be relieved if rainwater harvesting is practiced more widely.

People collect and store rainwater in buckets, tanks, ponds and wells. This is commonly referred to as rainwater harvesting and has been practiced for centuries. Rainwater can be used for multiple purposes ranging from irrigating crops to washing, cooking and drinking.

Rainwater harvesting is a simple low-cost technique that requires minimum specific expertise or knowledge and offers many benefits. Collected rainwater can supplement other water sources when they become scarce or are of low quality like brackish groundwater or polluted surface water in the rainy season. It also provides a good alternative and replacement in times of drought or when the water table drops and wells go dry. One should, however, realize that rainfall itself cannot be managed. Particularly in arid or semi-arid areas, the prevailing climatic conditions make it of crucial importance to use the limited amount of rainfall as efficiently as possible.

The collected rainwater is a valuable supplement that would otherwise be lost by surface run-off or evaporation. During the past decade, RWH has been actively reintroduced by local organizations as an option for increasing access to water in currently underserved areas (rural or urban). Unfortunately decision-makers, planners, engineers and builders often overlook this action. The reason that RWH is rarely considered is often simply due to lack of information on feasibility both technical and otherwise. During the past decade the technology has, however, quickly regained popularity as users realize the benefits of a relatively clean, reliable and affordable water source at home.

In many areas RWH has now been introduced as part of an integrated water supply, where the town water supply is unreliable, or where local water sources dry up for a part of the year. But RWH can also be introduced as the sole water source for communities or households. The technology is flexible and adaptable to a very wide variety of conditions. It is used in the richest and the poorest societies, as well as in the wettest and the driest regions on our planet.

Rainwater harvesting in urban settlement is one of the most effective tools of water management. KBMC successfully attempted several projects for Rainwater Harvesting (RWH) in the city. Initially, KBMC officials carried out awareness campaign in all wards to motivate people to get involved in large scale projects on Rainwater Harvesting. Lab experiments were carried out to assess the utility of RWH structures. KBMC constructed six small RWH structures of Rook Rainwater Harvesting at Radhanagari Society, Shiv Ganga Society, Ramnagar Shirgoan, Swami Darshan Society, Sai Niwas, Shree Ram Kunj Society at Dattawadi in KBMC area.

After successfully completion of these projects, a mass project of Roof Water Harvesting was prepared for 40 buildings at Shiv Darshan Society in KBMC area under MMRDA funded project.

Rainwater harvesting is done at various locations based on slope and elevations below ground surface to inject rainwater in natural inlets (e.g. Joints and Fractures in rocks). The project came out with a grand success through 200 m^3 availability of water per day!

Future Water Demand and Supply situation in the study area

As per the data obtained from field survey and subsequent analysis with standardized method of water requirement, it is found that inspite of the sincere efforts by local municipal authorities yet more than 82% of the city's population is still facing problem of water scarcity. This is due to ever-increasing population growth where the authorities are not in a position to keep pace with respect to water supply and water demand. Presently, the population of Badlapur city has crossed 2 Lakh mark, and so the water supply situation is bound to worsen as the capacity of existing water supply system has not kept pace with increasing population.

Moreover, increasing concentration of commercial activities and industrial establishment in the area is adding extra burden on available water resources. There is thus a dire need to minimize the widening gap between supply and demand of water for residents of the city. Scientific management of the existing water resources and search for alternative additional sources of fresh water is needed for future water demands in the study area.

The future water demand and supply is depicted in table 7.1 and fig. 7.1. The data clearly shows that existing water supply system has limited resources to make sufficient water available for domestic purposes. Moreover, the existing pipeline system looses up to 30% of total water through leakages in pipeline. Contamination of groundwater also limits the utility of bore well and open well water usage for domestic purposes. Therefore, the need of the hour is to find out sustainable measures to solve the problem of present and future water crisis.

The existing capacity of water supply system is not keeping pace with the growing demand for fresh potable water. Even if about 40% of the total fresh water supply is considered for domestic purpose, still there is a gap between water demand and supply. Presently there is a deficiency of 20% fresh water supply for increased population of the city of Badlapur. The demand for fresh water is going to increase with growing population. Hence, there is a need to increase the capacity of public water supply system by means of construction of new water reservoirs and also installation of modern water conservation techniques.

Table 5. Estimation of Future Water requirement for Badlapur city

Year	Population	Water requirement for domestic purpose (MLD) (considering 20% loss due to leakage)	Capacity of water supply system (MLD) (considering 40% of total water for domestic use)
1961	12, 527	2.03	13.6
1971	18, 077	2.93	14.4
1981	31, 460	5.1	16.0
1991	52, 197	8.46	24.0
2001	1, 40, 917	22.72	26.8
2011*	2,39,558	38.81	30.8
2021*	3,23,403	52.39	40.8

* Projected figures (Source: MJP civil section, Census of India)

The implementation of Roof Rainwater Harvesting projects on large scale would definitely help in mitigating future water demands of the city. Certainly, with increase in number of urban settlements, the roof area would also increase and so would be the potential for roof rain water harvesting. A rough estimate is made by calculating the roof area of the city with the help of updated Google Earth Satellite Image. It reveals that nearly 32,40,000 m^2 area is currently available for rainwater harvesting. Thus, even if 50% of this roof area is brought under RWH structures, it would then help to store water not less than 369.69 million liters every year. This will definitely solve the problem of water shortage at present as well as in the future.

IV. Recommendations

- Rainwater Harvesting Need to be made mandatory: The region receives heavy rainfall during monsoon season as depicted in the table 7.2. Hence it should be made mandatory to all the institutions and societies to harness the roof rainwater through rainwater harvesting programmes so that, to some extent, other uses of water demands can be fulfilled and stress on drinking water would be minimized to a great extent.

- Rainfall – Rainfall in a particular watershed is a major source of fresh water for various uses. It is therefore essential to study the temporal variation in rain fall over the years to find out the trend of natural water supply in the study region and accordingly manage the available water resources.

- The climate in the region is of monsoon type with uneven distribution of rainfall over the year. Hence during dry period (summer season) there is chronic shortage of water particularly in the months of March, April and May.

- Most of the wells and bore wells are either going dry during summer or its water is not potable. Recharging these wells with rain water would not only increase the underground water table level but would help in improving the quality of subsurface e water.

- All the institutions and residential areas should implement roof rain water harvesting programme on war footing so that it will ensure sufficient and improved quality of water supplies in the city. Those who fail to implement this project should be penalized and stringent punishments be adopted to tackle the situation of water scarcity.

- It is important to increase green cover in the city so as to moderate the micro climatic effect and attract precipitation besides gaining other advantages of green cover.

- Installation of water meters with different slab structure rates depending upon the amount and type of water usage.

- Installation of waste water treatment and water recycling should be made applicable to all new structures in the city. Institutions adopting such projects need to be provided with incentives in tax payments.

- Alternative source of water supplies by increasing reservoirs and rejuvenation the lakes, ponds and wells in the city should be taken on priority basis.

As per the data obtained from field survey and subsequent comparison with standard water requirement, above 82% of the city's population is still facing problem of water scarcity despite sincere efforts of local municipal authorities. Therefore, the need of an hour is to find out sustainable measures to solve the problem of present and future water crisis. Effective Rainwater Harvesting can solve the problem of water scarcity. With increase in number of households and establishments in Badlapur, the roof area also increases that provide high potential for roof rain water harvesting and recharging of ground waters sources.

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