WATER EFFICIENCY AND AUDIT OF A HIGH-RISE RESIDENTIAL BUILDING IN PUNE

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Abstract – *Water is the necessity of the hour and residential sector is one of its major consumer of all time. Green building rating systems across the globe guides the measures to reduce, reuse and recycle water. The paper highlights the weightage of water efficiency in some of these rating systems by comparing them. LEED, IGBC, GRIHA and GREEN MARK were compared for water efficiency on the basis of their distribution of credit score between each vertical. As a result of which IGBC was found to have more weightage, followed by GRIHA, GREENMARK and LEED.*

The high-rise residential building selected in this case is already under possession, has already applied for pre certification of IGBC and is successfully practicing most of its standard guidelines. The paper highlights the loopholes that needs to be taken care of even after green building certification. These areas of potential wastages were identified by conducting a water audit for 20 days. The findings have shown a massive volume of non-revenue water. Measures to tackle the same have been recommended.

Key Words: Water efficiency, Green building rating systems, Residential sector, High rise building.

1. INTRODUCTION

The earth's surface is covered with 70% water, of which 97.5 % is salt water & 2.5 % is fresh water. Of the 2.5% of the fresh water, 69.5% is locked away in glaciers and 30.1% is in the form of ground water. Only about 0.4% is surface water, which is available for human consumption. Hence, every drop of water is precious and to be used diligently [12].

Water is a limited resource, and in many areas—especially those plagued by drought—future water supplies are so uncertain that many worry whether usable water will be exhausted. If water supplies were depleted, the impact on economic and social interests would be profound: businesses would likely fail, agriculture would dry up, and many towns might end up like ghost towns of the Old West [8].

According to the Second UN World Water Development Report, if present levels of consumption continue, two-thirds of the global population will live in areas of water stress by 2025. Increasing human demand for water coupled with the effects of climate change mean that the future of our water supply is not secure. As of now, 2.6 billion people do not have safe drinking water. Added to this, are the changes in climate, population growth and lifestyles. The changes in human lifestyle and activities require more water per capita. This tightens the competition for water amongst agricultural, industrial, and human consumption [15].

The paper highlights the importance of water efficiency, ways to its improvement and maintenance. This includes the study of various green building rating systems, highlighting the weightages of water efficiency in each system, identification of water wastages in the residential building, measures to overcome the same.

1.1 Problem Statement

Water losses and Non-revenue water has been a major problem faced post possession in high rise residential buildings, though there are enough green building facilities, equipments and measures already being installed and practiced at the site.

1.2 Scope of Project

The project purpose is to identify the potential wastages of water in a high rise residential building and recommend appropriate solutions to improve its overall water efficiency.

1.3 Objectives

a) To study and compare various green building rating systems on the basis of water efficiency.

b) To collect the site details and determine the water consumption pattern of all the installed facilities.

c) To prepare a water audit over a stipulated time to monitor the day-to-day flow of water.

d) Analysis of the audit, find and implement solutions that are acceptable and feasible.

2. LITERATURE REVIEW

According to Rishabh G. Saigaonkar et.al. (2014) LEED, BREEAM, GREEN STAR, GREEN MARK and HK-BEAM are not specific in assessment criteria and hence a rating system was planned and suggested. The unique rating system devised by the author provides almost important and equal weightages to all the sub heads namely site aspect, water efficiency, energy efficiency, materials and resources, indoor environmental quality, transportation, pollution control, innovation. This includes major focus on indoor air quality, water and energy efficiency and materials and resources concluding to a total credit score of 150. As per the author unique aspect as regards mandatory compliance and motivational aspect for innovation and maintenance of green

features, as suggested would promote more green construction.

Yueming Qiu, Matthew E. Kahn (2019), found that due to data limitations regarding collecting consistent electricity consumption data for the same buildings over time, it has been very difficult to study the energy efficiency gains from green buildings. By merging detailed administrative data from a major Phoenix electric utility along with several other data sets, they have been able to create a long term large longitudinal data base for tracking commercial real estate electricity consumption over time. Using a fixed effects estimation strategy combined with an occupant matching approach, the researchers have generated new estimates of the effects of energy certification programs. They found a modest effect of the Energy Star program in reducing occupant energy consumption. While their sample only includes commercial buildings in Phoenix metropolitan area, the results are likely to generalize to other populous "sun cities" such as Los Angeles, Dallas, and Houston. These other cities share similar warm climate and have also experienced fast population growth in recent years

Pooja Choudhary, Jagriti Gupta, Dr. Bharat Nagar (2018), have focussed on the necessity and requirement of a green building. As per the study conducted by them on a residential 4 storey building with ground floor parking which is located in Jaipur, Rajasthan many of the parameters were found existing in the building. But it is found that certain aspects were not fulfilled like: rain water harvesting and efficient solid waste maintenance. The researchers have considered LEED rating system as a standard to convert existing building into green. The parameters which were considered, designed and estimated in monetary terms were:

A.) Vertical gardening

B.) Vermin composting

C.) Grass pavers

D.) Aluminum paint

E.) LED lighting

F.) Solar power plant

Which then results in earning a total of 64 credits (49+15)

Aishwarya Kodnikar, et.al. (2018), carried out analysis of green retrofitting in existing building, and for that purpose they selected a residential building – Swami krupa, Pune. They analyzed the existing energy and water consumption of the total 6 flats – 3 no. of 2 bhk and 3 no. of 1 bhk. They have used LEED rating system as a standard guideline and by implementing it they can transform an existing building into green building which will save approximately 20-22% energy consumption. These concepts conform with the IGBC norms for existing green building and helps the building get a LEED recognition.

According to Jamal Al-Qawasmi et.al. (2019), the coverage of social-related water subcategories are fewer compared to the environment-related water subcategories in most of the SB rating systems. The study involved 11 prominent SB rating systems to examine the coverage of water efficiency and management aspects with the help of comprehensive coverage analysis approach. According to them, the approach is efficient enough to enable a representative and comprehensive list of criteria to ensure water efficiency in buildings while developing or designing new SB rating systems.

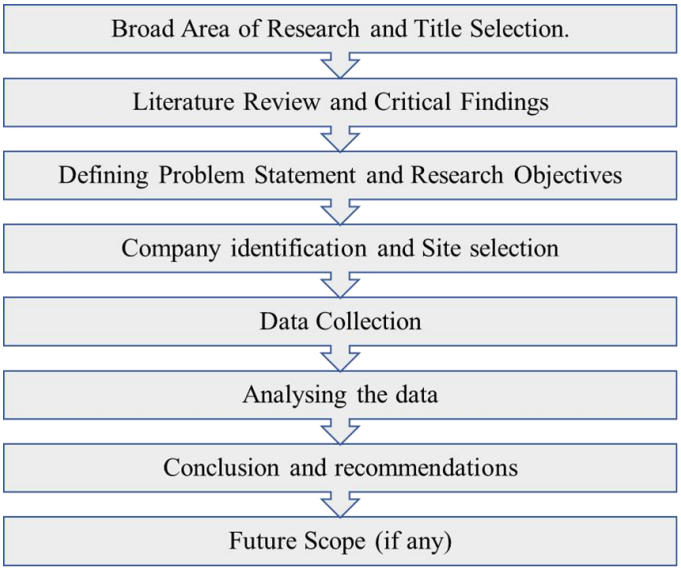
Luay N. Dwaikat, Kherun N. Ali (2018) have addressed the economic benefits associated with energy saving in green building by analyzing the actual energy performance of a green building in use. For an elapsed time period of 7 years, he actual economic performance of a green building was analyzed and quantified, then based on current building performance, the economic benefits associated with reduced energy consumption were analyzed and quantified along the whole life cycle of the building. It was empirically found that the current building saving in the investigated green building is 71.1% in comparison to the industry baseline.

Peng Wu and Sui Pheng Low (2010) presented that Green building is a holistic solution to achieve the concept of sustainable development in the project life cycle including project planning, designing, constructing, and operating. Although this life-cycle concept is adopted by a majority of the professionals, most concentration has been focused on design and technical related areas that can be applied in the design and construction stage. However, by comparing LEED 2.2 published in 2005 with the Green Globes and BCA Green Mark 3.0, which were both published in 2008, there is a trend that project management process can offer a low-cost low-barrier avenue. Through the comparison of the three rating systems, this research is able to address the importance of project management, in terms of both the practice and the process, which is allocated around 20% of the credits.

In the predesign stage, defining and planning sessions are organized to take as wider a range of interests as possible into consideration to prevent the green baton phenomenon from happening. Brainstorming and periodic meetings serve as the internal process to achieve the green objectives. In addition, periodic meetings are a precautionary measure to make sure that the building is resilient enough for changes. The execution strategies to achieve the green agenda in the construction stage are currently the focus of the construction industry and is allocated with most of the credits in the project management section in both LEED 2.2 and BCA Green Mark 3.0, 78.6% in LEED 2.2 and 71.4% in BCA Green Mark 3.0. Even in the construction stage, not enough attention is paid to human resources, which is less technical related and may have great potential to help the project to achieve the green objective.

3. RESEARCH WORK

3.1 Methodology



3.2 Water Efficiency in Green building rating systems

Various green building rating systems across the globe are enlisted below:

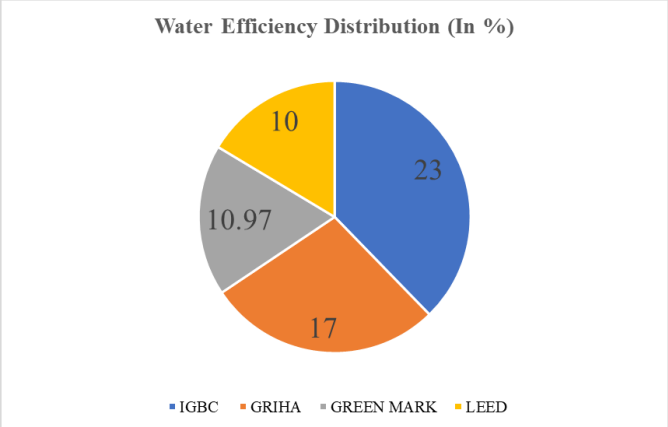
ARZ rating system	DGBC Woonmerk	Green Star SA
Assessment Standard for Green Building of China	EDGE	Green Star SA Kenya
BEAM Plus	GreenBuilding	GRESB
BERDE	GBC Brasil CASA	Home Performance Index
BREEAM-LV	Greenship	HQE
BREEAM-NOR	Green Building Index	ICP
BREEAM-NL	Green Key	IGBC
BREEAM-SE	GreenSL	INSIDE
BREEAM	Green Star	Korea Green Building Certification
Casa (Colombia)	Homestar	LOTUS
CASBEE	IGBC Home	LEED
Pakistan Green Building Guideline (PGBG) BD+C	Swiss DGNB System	VERDE
Zero Waste	The WELL Building Standard	GRIHA
Parksmart	SITES	TARSHEED
PEARL (Abu Dhabi)	PEER	Singapore Green Building Product/Services Certification
CEDBIK-Konut Green building certification system	GBC Historic Building	Miljöbyggnad
Citylab	GBC Quartieri	NABERSNZ
DGNB System	GBC Condomini	OMIR

The selected rating systems are : IGBC Green Homes Rating System – Version 3.0, BCA Green Mark for Residential Buildings – V 4.1, LEED V4 for Building Design And Construction and GRIHA V 2015. Each rating system has various verticals under which points are distributed. These are:

- Sustainable Sites
- Water Efficiency
- Energy Efficiency
- Materials & Resources
- Resident Health & well-being
- Innovation & Design

The IGBC Green Homes Rating System – Version 3.0, has a total of 100 points out of which 23 points are allotted to water efficiency. In a similar way BCA Green Mark for Residential Buildings – V 4.1 has 17 points allotted out of 155; LEED V4 for Building Design And Construction has 11 points allotted out of 110 and GRIHA V 2015 has 17 points allotted out of 100. The percentage wise distribution of all these rating systems is shown in Fig 1.

Fig -1: Water efficiency distribution (in %)



The pie chart clearly shows that IGBC has offered maximum distribution of its credit score to water efficiency out of all the other rating systems. Table 1 shows the further distribution of water efficiency in IGBC Green Homes Rating System – Version 3.0. Table 2 shows the similar distribution in BCA Green Mark for Residential Buildings – V 4.1. In both these rating systems maximum focus is given on providing Efficient Plumbing Fixtures and usage of Waste Water. Table 3 shows the distribution of water efficiency in LEED V4 for Building Design And Construction. Indoor water use reduction accounts for maximum credit score in this system where as water metering being the least. Table 4 shows the

distribution of water efficiency in GRIHA V 2015. On-site water reuse has the maximum weightage here followed by Use of low-flow fixtures and systems and Reducing landscape water demand. After obtaining the standard codes of practice and the thorough study of each and every rating system, all these are put together and compared in Table 5 where distribution for each category can be clearly seen.

Table -1: IGBC Green Homes Rating System – Version 3.0

Water Conservation	**Possible Points:**	**23**
WC Mandatory Requirement 1	Water Efficient Plumbing Fixtures	Required
WC Mandatory Requirement 2	Rainwater Harvesting	Required
WC Credit 1	Water Efficient Plumbing Fixtures	6
WC Credit 2	Landscape Design	3
WC Credit 3	Management Of Irrigation System	2
WC Credit 4	Recycle & Reuse Of Waste Water	4
WC Credit 5	Water Quality	1
WC Credit 6	Enhanced Rainwater Harvesting	1
WC Credit 7	Water Metering	3

Table -2: BCA Green Mark for Residential Buildings– V 4.1

(II) Other Green Requirements	
Part 2 : Water Efficiency	
RB 2-1 Water Efficient Fittings	10
RB 2-2 Water Usage Monitoring	1
RB 2-3 Irrigation System And Landscaping	3
Category Score For Part 2 - Water Efficiency	**14**
RB 3-6 Stormwater Management	3
TOTAL	**17**

Table -3: LEED V4 for Building Design and Construction

SR.NO.	**LEED CREDIT**	**POINTS**
1.	Outdoor water use reduction	2
2.	Indoor water use reduction	6
3.	Cooling tower water use	2
4.	Water metering	1
5.	**TOTAL**	**11**

Table -4: GRIHA V 2015

Section Wise Break up	**Max Points**
Use of low-flow fixtures and systems	4
Reducing landscape water demand	4
Water Quality	2
On-site water reuse	5
Rainwater Recharge	2
TOTAL	**17**

Table -5: Comparison in tabular form

Credits	**IGBC**	**GRIHA**	**GREENMARK**	**LEED**
Efficient plumbing fixtures	6	4	10	6
Landscape design and irrigation systems	5	4	3	2
Waste water recycle & reuse	4	5		
Water quality	1	2		2
Rain water harvesting, storm water management	4	2	3	
Water metering	3		1	1
Leak detection and prevention				
TOTAL	**23**	**17**	**17**	**11**

4. DATA COLLECTION AND ANALYSIS

Table 6 shows the details of the site location. Apart from this data from Hydrogeological Report, Water Balance Charts, Central Ground Water Authority (CGWA) NOC, Rain water harvesting plan, Site plan, Site layout, Development plan, RCC drawings, Floor plans, Underground services layout, Plumbing layout and details, Flow fixtures details and etcetera was gathered and studied in detail. This helps in studying the flow pattern of the site.

Table -6: Site Details

Sr. No.	**Particulars**	**Details**
1	Name of the site	Yashwin, Hinjawadi, Pune.
2	Total no. of buildings	4 (A, B, C & D)

3	No. of floors	21 storey (excluding 2 parking)
4	Buildings under possession	2 (A and D)
5	Flats in each building	168 (8 flats on each floor; 6nos - 2bhk, 2nos- 3bhk,)
6	Flats with people living	200
7	Source of water at site	Tankers and borewell
8	Capacity of each tanker	10,000 lit
9	No. of tankers per day	10 nos.
10	Capacity of Under Ground Water Tank (UGWT)	8.5 lakh lit.
11	Details of UGWT	5 compartments (per day provided capacity):
		a) fire - 2 (3,02,585 lit.)
		b) raw water and domestic - 1 (1,90,660 lit.)
		c) domestic (filtered) - 1 (1,89,850 lit.)
		d) drinking – 1 (76,035 lit.)
12	Over Head Water Tank (O.H.W.T.) in a building	a) Domestic water tank (63,000 lit.)
		b) Drinking water tank (13,000 lit.)
		c) Firefighting tank (25,000 lit.)
		d) Flushing water tank (38,000 lit.)
13	Rain water harvesting tank	6.5 lakh lit containing 14 recharge pits
14	Catchment area for RWH tank	1 lakh lit. sq. ft (10,000 sq. ft for one bldg. and 60,000 sq. ft podium)
15	Sewage Treatment Plant (S.T.P.) Capacity	430 KLD
16	Open well Submersible pump at STP	2 x 7.5 HP
17	STP tank height	5m (4m + 1m sump)
18	Backwash of STP	1 times in week and uses 1 tanker of 10,000 lit

4.1 Green measures for water conservation

The site has already applied for pre-certification of IGBC Green Homes rating systems. Hence, there are several water conservation measures and methods that are installed and practiced. These are mentioned as follows:

- Drip irrigation used as a method to irrigate the landscape area.
- Solenoid Valves used at the Overhead Water Tanks to automatically switch off the motor when tank gets filled so as to prevent the overflow.
- Water Efficient Plumbing Fixtures are used to keep flow in permissible green limits
- Use of aerators to reduce flow of water from faucets.
- Effective Rain water harvesting plant installed at the location to suffice the daily per capita limit.
- Waste water is treated with the help of STP keeping treatment standards in mind.
- The treated waste water is reused for flushing and irrigation in landscape areas.
- The water quality is checked precisely with the help of filtration system thus satisfying the standards.

4.2 Water Audit

The meters were installed at STP and borewells; hence, no monitoring of water consumption at individual dwelling units and other facilities was observed. The average per capita water consumption was determined by measuring the heads of Overhead water tanks over the buildings. The head readings were collected for 20 days straight. The consumed water could be determined by measuring the heads because the dimensions of the overhead water tanks were known and there were neither any open discharges available nor the water meters. Despite, the above mentioned practices there are water issues that are faced daily by the residents and the builder. These can be analyzed with the help of proper audit which is shown below:

- **INPUT**

INPUT			
Sr. No.	**Sources of water**	**Per day water consumption (in lit.)**	**Consumed volume of water in 20 days (in lit.)**
1	Borewells	Nil	Nil
2	Tankers (Domestic Use)	1,00,000	20,00,000
3	Tankers (Backwashing)	7 trucks in 20 days (1000 lit. each)	70,000
4	Sewage Treatment Plant (STP)	46,000	9,20,000
	TOTAL		**29,90,000**

Drinking Water supply is currently at the user's end via water cans, hence it is not considered into account.

- **OUTPUT**

The Table below shows the data calculated from head measurement of 20 days.

Sr. No.	Date	Domestic Water Consumption (LIT.)	Flushing Water Consumption (LIT.)
1	Feb-15	100268	47562
2	Feb-16	100127	46143
3	Feb-17	98094	45129
4	Feb-18	98631	43561
5	Feb-19	97732	45860
6	Feb-20	97541	46658
7	Feb-21	98275	46158
8	Feb-22	100582	47123

9	Feb-23	101120	47162
10	Feb-24	97007	44195
11	Feb-25	99820	46052
12	Feb-26	98069	46321
13	Feb-27	98354	42629
14	Feb-28	96516	45443
15	Feb-29	100148	46890
16	Mar-01	100504	46028
17	Mar-02	98653	45212
18	Mar-03	97986	44410
19	Mar-04	98780	44312
20	Mar-05	98993	45452
TOTAL		**1977200**	**912300**

OUTPUT		
Sr. No.	**Water consumption (in lit.)**	**Consumed volume of water in 20 days (in lit.)**
1	Domestic water use in OHWT	19,77,200
2	Irrigation	unmetered
3	Flushing	9,12,300
4	Backwashing	70,000
	TOTAL	**29,59,500**

TOTAL REVENUE WATER	**29,90,000**
TOTAL NON-REVENUE WATER	**30,500**

A total of 30,500 liters is accounted for loss. The similar pattern if followed for an year can be detrimental to the financial viability of water utilities, as well to the quality of water itself. Also, the water consumption gradually increases on weekends and drops in weekdays.

The theoretical Per Capita Demand as per the National Building Code 2016 is 135 lpcd. Out of which 45 liters per head is for flushing purpose, 10 liters per head for drinking purpose and remaining 80 liters per head is for domestic purpose. Hence considering 125 lpcd into account, in this case the per capita consumption turns out to be 144.475 (nearly 145) lpcd out of which 45.615 liters per head is for flushing purpose and 98.86 is for domestic purpose.

4.3 Potential Wastages

- No measurement of water quantity procured from tankers due to local political issues.
- Unmetered use in every flat (individual dwelling unit) without knowing per capita consumption as a result of which exceeding the limit sometime.
- Pipe failure / bursting due to pressure.
- Leakage below basin trap.
- Blocked and freed flush water, which results in huge wastages.
- Unmetered use of irrigation water.
- Unmetered borewell water use.
- Excessive usage of water in back washing of treatment plants.
- Excessive wastage of water for automobile cleaning.

5. CONCLUSION

The second significant consumer of water is residential sector after agriculture. Hence, the use has to be directed, managed and controlled in a proper way. Though the green building rating systems provide a set of guidelines which indeed helps in maintaining the overall water efficiency but there are certain loop holes that needs to be taken care of. After comparing LEED, GRIHA, IGBC and GREENMARK, it is clear that water metering plays a vital role in maintaining and improving the water efficiency. The conservation measures, no matter how big or small, has to be metered in order to minimize the unnecessary wastages.

The audit of the building clearly shows amount of non-revenue water that is generated on a daily basis. This water is certainly a loss to both the occupants and the builder in monetary terms. Around 30,500 liters of non-revenue water was generated in 20 days, this can be reused and utilized in far better manner. The potential areas of wastage were identified and feasible recommendations are provided.

6. SUGGESTIONS

a) Metering :

Meters are the mirrors to show the exact scenario water consumption at each facility. Also, metered customers use considerably less water than unmetered customers because they know they must pay for any misuse or negligence. The meters should be calibrated properly and should be checked in regular interval of time. Fig 2 shows the meter plan for the site. This covers the details of number and sizes of meters that are required to install on site.

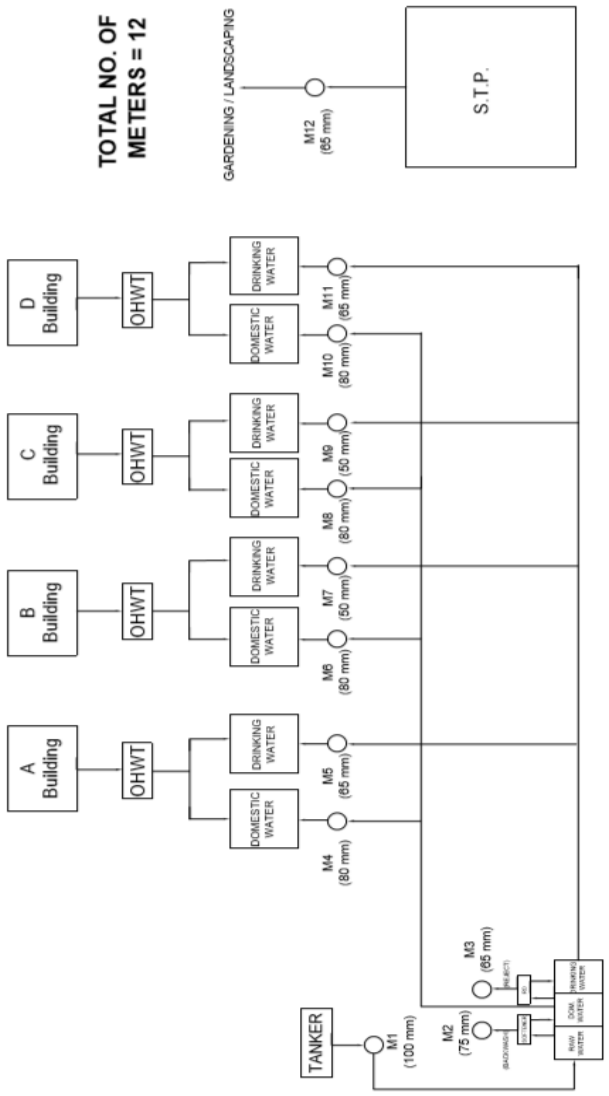


Fig -2: Meter Plan

b) Leak Detection:

Leak detection begins with regular inspection of pipe, its cleaning, lining and other maintenance efforts to improve the distribution system and prevent ruptures and leaks. This can also be done under leak detection surveys of entire distribution system via various equipment. Maintaining a water accountability report helps in identifying lost water.

c) Filter Wash Water Recycling:

Mixing backwash water with raw water recycles it. During times of drought, this filter backwash water can be very helpful. But, if the water system has no means of recycling the backwash water, the water treatment plant can retrofit portable pumps and piping from the backwash sediment basin to create its own system.

d) Educating and encouraging people towards water conservation.

The cost differences between obtaining water from tankers and municipal sources to that of borewells, treated water from rainwater harvesting plant and STP could be shown to people in educating them that conservation of water could lead to tangible benefits as well. They can be informed via articles, notices, hoardings, advertisements, people education programs. The more people know about water conservation the more they'll want to save and the community will be better off for it.

e) Maintenance Flushing and Public Water Use:

Restricting the use of water for individual dwelling unit helps in conserving water. This not only saves excessive water to get wasted but also realizes its importance to people. Many people do not realize that flushing the distribution system is necessary maintenance, especially when water use is restricted. Because there is less turnover in the water storage tank, flushing may need to be done more frequently. This flushed water can be dealt with local landscape contractors, local farmers or hauled back to water treatment plant and retreated.

f) Setting water rates:

Water rates plays a vital role when it comes to reducing the unwanted use of water. The rates should be devised including transporting, treating and delivering charges. Also, fines for exceeding the per capita demand could be workable.

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