Water Performance Index - An Efficient Water Management Tool

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Abstract: India has been raising the ladder of global scale, these developments have led to severe water use causing it to deplete drastically in prime years. India's growing population and advancement have immensely affected the water resources, demand & supplies which is leading to the demand for sustainable water use. In an attempt to reduce the water stress, the concept of water performance index (WPI) is introduced, it defines the total potable water consumed by an individual in a day. WPI is a tool applicable for various typologies including residential, institutional, commercial, transits, hotels & healthcare that set benchmark water usage for a person thereby reducing the excess demands. To arrive at the final values, an open-ended survey is conducted to acquire data for assessing current usage patterns. Using WPI alone shows a 25% reduction in total potable water demand of an individual, thus making it an effective and efficient sustainable approach towards reducing water scarcity in India.

Keywords: *Depletion, Benchmark, Portable water, Urbanization, Typologies, Performance Index*

1. INTRODUCTION

India's growing population is facing water scarcity due to an an increase in water demand & reduction in supplies hence making it important to focus on the need for sustainable water use. India hosts approximately 17 percent of the world's population, it holds only about four percent of its required annual water resources (Rivière, 2015). With a constant an increase in population demand and various subdivide the need of saving water becomes a priority to the nation (Institute for Defence Studies and Analyses, 2010). India does not have any tool to calculate the freshwater demand of a person. Rating systems focus mainly on rainwater harvesting, efficient plumbing, landscape, management of irrigation systems, is the water treatment & reuse and water metersing. They don't discuss setting a benchmark for water consumption in daily activities by the users. For a transparent calculation of water use (potable water footprint) in any building typology a tool to standardize water consumption is needed. The rural population of India contributes to 68% of lives while urban is 32%. It is expected that nearly 61% of the population will be living in urban areas by the year 2050. Hence WPI has been calculated for urban cities to help manage water supply and demand in urban regions of India. This will allow people to meet the basic water requirements in the future.

2. METHODOLOGY

A literature study is done to collect background data related to water resources in India, existing issues, government initiatives along with related valid statistical data. Further, analysis of the current scenario is conducted with available statistics and data to conclude on a possible causal relationship between these issues. To define & formulate a water performance index it is important to study the water uses in various typologies. The 6 main typologies were, Residential, Commercial, Airports, Institutional, Hotel and Healthcare. These typologies were further subdivided upon their requirements. The standard consumption of potable and non-potable water for each typology is calculated using the National Building Code. The water uses in each of these typologies and sub divisions were described based on these standards. To understand the current water usage pattern, a survey is conducted. The residential building typology is selected to study water consumption broadly on an individual level and Random sampling is the method used to collect data via google form survey. The sample size of 50 households is considered for this purpose. Finally, segregation of potable & non-potable is made, which is further divided into Fresh, Grey & Blackwater to understand the dependency on Freshwater.

3. DATA PRESENTATION AND ANALYSIS

With a constant an increase in population demand and various developments the need of saving water becomes a priority to the nation (Institute for Defence Studies and Analyses, 2010). Water shortages both in the form of stress and scarcity are emerging very fast and India is experiencing shortages especially when the demand for potable water is exceeding the supply. In the coming years, India will face subsequent problems, such as food shortages, intrastate, and international conflicts (Mehta, 2012).

Year	Agriculture	Industry	Domestic	Per Capita
India	Billion Lit/Day			Lit/Day
2000	1658	115	93	88.9
2050	1745	441	227	167.0

Figure 1 India's future water use (Hegde, 2012)

The requirement of water for livestock will rise from 2.3 billion m3 in 2000 to 2.8 billion m3 in 2025 and 3.2 billion m3 in 2050. Hence it becomes mandatory to reduce the use of potable water and encourage saving water & use of treated water (Hegde, 2012). The main sources of freshwater are surface & groundwater of which 690BCM is surface water while 433BCM is groundwater. From the total freshwater available 78% is used in agriculture while domestic and industrial use 6% & 5% respectively (Asian Development Reseach Institute). Rainfall contributes 68% to the total groundwater available. Overall, the national per capita availability of water reduced from 1,816 cubic meters in 2001 to 1,544 cubic meters in 2014 summing up to a total reduction of 15% (Suhag, 2016). The rural population of India contributes to 68% lives while urban is 32%. The minimum water requirement considered in rural areas is 40 litres per capita per day (lpcd), while that in urban areas is considered as 135 lpcd

(Purohit, 2015). Of the total freshwater, around 7km^3 surface water and 18km^3 groundwater are used to supply water to the urban and rural areas (Rakesh Kumar, 2005). It is reported that over 70% of the water is consumed by the rural while urban constitutes 30% but due to rapid growth in population, urbanisation & industrialisation the water requirements in urban is going to rise leading to high water demands (Bhat, 2014). Water usage standards are set by various organisations that state the urban cities require 135 lpcd whereas they only receive 69.2 lpcd on an average (Urban Water Supply and Sanitation In India, 2014).

Table 3.2: SLB Indicators for Water Supply

No.	Indicator	Unit	Benchmark	Median	Average
1	Coverage of Connections	%	100	53	50.2
2	Per Capita Supply	Lpcd	135	69	69.2
3	Metering of Connections	%	100	0	13.3
4	Non-Revenue Water	%	20	29	32.9
5	Continuity of Supply	Hours	24	2	3.1
6	Quality and Treatment	%	100	94	81.7

Figure 2 (Urban Water Supply and Sanitation In India, 2014)

These emerging water problems are due to various factors, for example, an increase in the population causing an increase in water demand wherein the supply is less, effluents from industrial, agricultural & domestic sectors polluting the water further limiting its use (Training, 2015).

3.1. CURRENT WATER USAGE PATTERN

To understand the water usage pattern, an internet survey via google forms with sample size of 50 households is conducted. Building typology selected is residential as it is allowing to understand water consumption broadly on an individual level. The questions asked in the survey was formulated to study and analyse the types of residential houses, number of residence living, type of water resource, type & number of fixtures used, type of plumbing systems used, areas of water consumption and water tariff.

Figure 3 Analysis of Building Types

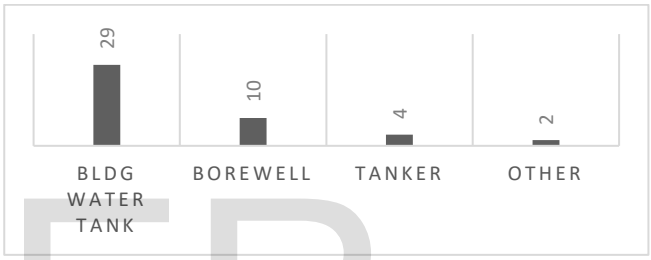

Figure 4 Water Sources

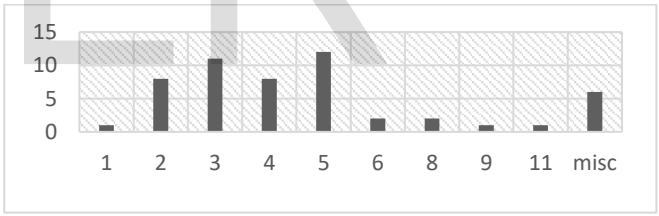

Figure 5 No of Houses on Floor Level

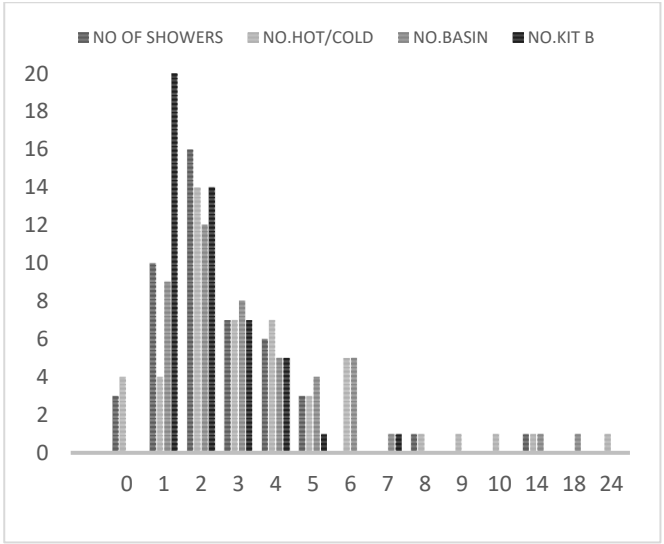

Figure 6 No. of Houses with No. of Fixtures

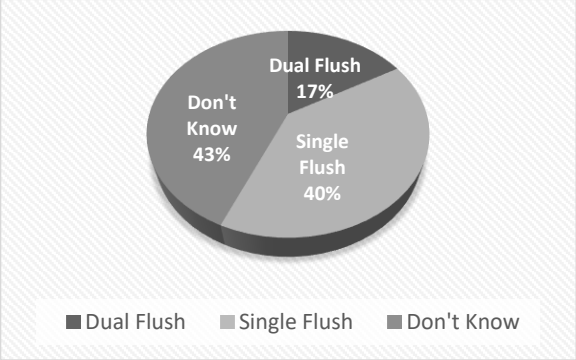

Figure 7 Type of Plumbing system

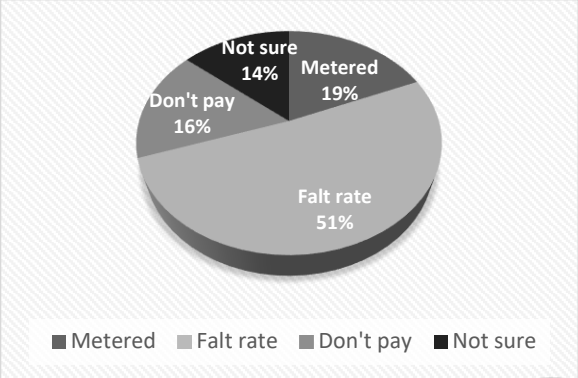

Figure 8 Billing System

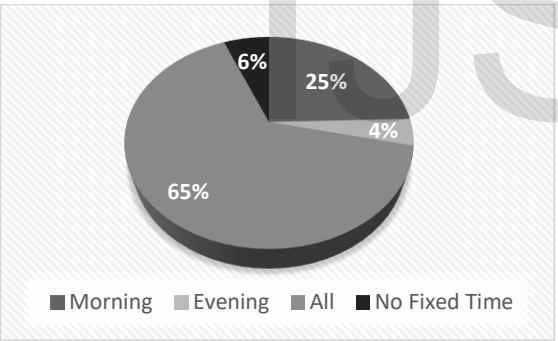

Figure 9 Supply Timings

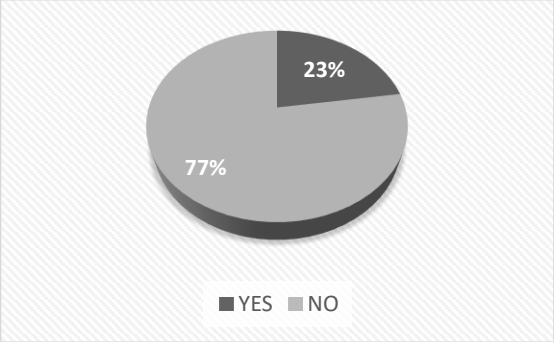

Figure 10 Recycle Practices

SURVEY RESULTS

1. 28 houses are apartments out of 50 while rests are bungalows & row houses.
2. 29 houses have their water supplies from building tanks, whereas 10 have it from borewells.
3. 12 houses are situated on the 5th floor, while 11 are on the 3rd floor.
4. The majority of the houses have 2 showers, basins, kitchen sinks.
5. 43% of the people don't know the type of plumbing system they are using, 40% use single flush systems.
6. More than 51% of people pay tariffs at flat rates. Only 19% have metered billing.
7. 65% of the people have supply all the time.
8. The recycling practices are as low as 23%.

It is concluded that, the majority of the people are unknown of the type of fixtures, plumbing systems, tariff rates they are paying & using. Most of the water supplied is through borewells. There are no water saving practices adopted by people

3.2. WATER PERFORMANCE INDEX (WPI)

This index serves as a useful tool to measures water consumption at building & site scale. Benchmarking standard water usage values allow portable water saving. WPI uses water described according to the National Building Code standards. This tool is applicable for various typologies including residential, institutional, commercial, transits, hotels & healthcare facilities. The water usage is divided into potable and non-potable category to understand quantity of water used in fresh form and treated form in the quantity which is described under codes.

For Example, residential zones have 135 litres used per capita per day, therefore 135 litres are divided into potable and non-potable usage. All the mentioned categories are therefore split under four major demand area which are Domestic uses, Irrigation Use, Hot water, Medical and Mechanical demands. These are further subdivided into Potable categories of water required per capita for bathing, washing clothes, drinking, cooking, washing utensils, cleaning, car wash, medical use and Non-Potable categories which include flushing, gardening, mechanical systems. This study allowed us to analyse the litres per person usage of potable water & non-potable water.

Building type		Domestic					
		Potable					
		bathing	wash. cloth	drinking	cooking	wash.utensil	cleaning
Residential		55 lpcd	20 lpcd	5 lpcd	5 lpcd	10 lpcd	10 lpcd
Insitutional	hostels	55 lpcd	20 lpcd	5 lpcd	5 lpcd	10 lpcd	10 lpcd
	school/colleges	12 - 18 lpcd	8 - 12 lpcd	5 lpcd	5 lpcd	3 - 5 lpcd	2 - 5 lpcd
Hospital		not exceeding 100 beds = 230lpcd					
		exceeding 100 beds = 300 lpcd					
		out patient = 10lpcd					
Airport	terminal	(assumption) 40 lpcd					
	station (exl mails)	(assumption) 40 lpcd					
	station (incl mails)	(assumption) 60 lpcd					
Hotel		3star (bathing + drinking + cleaning) = 120lpcd					
		(4 star & abv)bathing + drinking + cleaning = 260lpcd					
Commercial	office			12 - 15 lpcd			2 - 4 lpcd
	mall			25lpcd			
	restaurant			55 lpcd			
	cinemal hall			5 lpcd			

		Irrigation			Hot water demand			
N.Potable	P	Potable	N.Potable					
flushing	car wash	id plants	gardens	g.wall	cooking	washing	shower	laundry
30 lpcd	100 lit/car wash	1/4th of pot volume	15 lpcd	2 - 5 l/sqm	5lpcd	5 l/meal	25lpbath	10lpcd
30 lpcd					5lpcd	5 l/meal	25lpbath	10lpcd
5 - 10 lpcd								
110 lpcd					5lpcd	5 l/meal	25lpbath	10lpcd
150 lpcd								
5 lpcd								
5 lpcd					9.7l/meal			
5 lpcd								
10 lpcd								
60 lpcd					13.5 l/meal		25lpbath	55lpcd
60 lpcd								
20 - 28 lpcd					1lpcd			
10 lpcd					9.7l/meal	3.4 lpcd		
15 lpcd					8.2l/meal	3.3 lpcd		
10 lpcd					1lpcd			

Medical procedures				Mechanical systems	
Potable				N.Potable	
sterilize	rinsing	procedures	labs	c. tower	chillers
out patient 5 lit/ consultation				Use no more potable water than 2.3 gallons per ton hour (2.5 liters per kilowatt hour) for cooling tower or evaporative condenser make-up. source : usgbc Cooling tower water management | U.S. Green Building Council	
in patient 40-60 lit/patient					
opreation / maternity 100 lit/ intervention					
dry or supplementary feeding centre 0.5-5 lit					
wet supplemetary 15 lit/cons					
in patient therapeutic feeding 30 lit/patient					
cleaning the room 30l/day					
sterilization 45 lit/ autoclave					

The formulated data under each typology is further segregated into freshwater and grey water under both potable and non-potable category to understand the total water in litres that a person consumes as freshwater example drinking & cooking which cannot be compromised in Indian scenario and grey water which is the outcome of uses. Thus, grey water gives a total quantity of water that if treated under good measures can be used in other services like bathing, laundry, cleaning etc. The calculated quantity of fresh potable water in domestic sector thus becomes 5 litres per capita whereas that of grey water becomes 60 litres per capita from domestic category and an additional of 10 litres per capita from hot water demand, making it a total of 70 litres per capita.

Building Typology		Domestic			
		Potable		N.potable	
		Fresh water	Grey water	Grey water	Black water
		Drink & Cook	Other	Car wash	Flushing
Residential		5 lpcd	60 lpcd	100 lit/car wash	30 lpcd
Institutional	hostels	5 lpcd	60 lpcd		30 lpcd
	school/colleges	5lpcd	35 lpcd		10 lpcd
Hospital	nt ex 100	5lpcd	200 lpcd		110 lpcd
	ex 100	5lpcd	270 lpcd		150 lpcd
	out patient	5lpcd	5 lpcd		5 lpcd
Airports	terminal	5lpcd	25 lpcd		5 lpcd
	station (exl mails)	5lpcd	25 lpcd		5 lpcd
	station (incl mails)	5lpcd	50 lpcd		10 lpcd
Hotel	3 star	5lpcd	95 lpcd		60 lpcd
	4 star	5lpcd	235 lpcd		60 lpcd
Commercial	office	5lpcd	13 lpcd		28 lpcd
	mall	5lpcd	7.6 lpcd		10 lpcd
	restaurant	5lpcd	37 lpcd		15 lpcd
	cinemal hall	5lpcd	3 lpcd		10 lpcd

Irrigation				Boiler water			
Potable		N.potable		Potable		N.potable	
Fresh water		Grey water		Fresh water		Grey water	
Pots		Gardens	G.wall	Catering		services	
1/4th of pot volume				5lpcd	5l	25lpbath	10lpcd
				5lpcd	5l	25lpbath	10lpcd
9cm (1l)	0.25 l			5lpcd	5l		
13cm (2l)	0.5l			5 l	15l	25lpbath	10 lpcd
19cm (3l)	0.75l			5 l	15 l	25lpbath	10 lpcd
20cm (4l)	1l						
22cm (5l)	1.25l			10 lpcd			
25cm (7l)	1.75l	15 lpcd	5 l/sqm	10 lpcd			
28cm (10l)	2.5l			10 lpcd			
33cm (15l)	3.75l			40 lpcd		25 lpcd	55 lpcd
35cm (20l)	5l			40 lpcd		25 lpcd	55 lpcd
38cm (25l)	6.25l			1 lpcd			
41 cm (30l)	7.5l			9 lpcd			3.4 lpcd
50cm (40l)	10l			9 lpcd			3.4 lpcd
				1 lpcd			

Medical procedure	Mechanical systems		
Potable	N.potable		
Fresh water	Grey water		
Procedures	C.T	DG	Backwash
215l (no of patients/operations) + 30l/day cleaning + 45 l/autoclave (no. of autoclave) = total 290l	ooling tower make up water : 12 liter per ton per hour	1.4 liter per KVA	56 gal/min/sqf of filter area

Thus, when the fresh and grey water demand is clubbed & calculated, the final value in litres is considered as the total potable water consumption per capita. This quantity is considered as the base case for water consumption. When the total freshwater consumption is separated from the total usage per capita, it becomes the savings in water usage which is the ultimate sustainable aim. The values listed under every category thus becomes the benchmark in the use of water.

Building Typology		Total	Fresh Water
Residential		110	15
Institutional	hostels	110	15
	school/colleges	60	15
Hospital	nt ex 100	550	240
	ex 100	660	240
	out patient	15	
Airports	terminal	45	15
	station (exl mails)	45	15
	station (incl mails)	70	15
Hotel	3 star	280	45
	4 star	420	45
Commercial	office	47	6
	mall	35	14
	restaurant	69.4	14
	cinemal hall	19	6

4. INFERENCE

Through this study it is therefore concluded, that the freshwater demand which is required for drinking and cooking accounts for approximately 9% of the total daily per capita demand. If this requirement is excluded in each building typology, then the grey and black water which account for the rest 91% can be recycled and reused thereby reducing the daily per capita water consumption. The final quantity of per capita water that can be recycled in each typology is as follows, 110 litres in residential and hostel facilities, 60 litres in schools and colleges, 550 to 660 litres in hospitals, 45 to 70 litres in Airports, 280 to 420 litres in Hotels, 47 litres in offices, 35 litres in malls, 70 litres in restaurants and 19 litres in cinema halls. This will thus reduce the daily per capita demand in all typologies

5. CONCLUSION

Therefore, final results show the benchmark water consumption values which are defined based on all the water uses in all buildings which were achieved by adding all standard water consumption values & subtracting all the extra uses done by people. The values achieved approximately show a reduction of 25% in the water consumption, the total amount of water a person can save to reduce the freshwater demand, thereby, contributing in the reduction of portable water consumption on site and building scale. Thus, the Water performance index can be defined as the potable water used for any purpose excluding flushing. This water can be further distinguished into water that is sourced as freshwater or grey water. The total potable

freshwater demand can be considered as the benchmark base case for sustainable use of water which can be further reduced if grey water can be treated and used for all the other purposes except drinking & cooking which will be compromised in worst case scenario. Not only this, but the research also allowed us to further give detailed methods and possible techniques to the users in treating & reusing the grey water further adding to the reduction in water demands. Adopting the WPI concept will eventually help reduce water demand is accepted and put in use correctly by users and consultants. This approach will certainly not make a forceful difference but will definitely bring down the current high-water usages in buildings of various typologies as the benchmarks are set using the standard water demands published by various organisations who are working on national the level.

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