Assessment Framework for Public Satisfaction of Urban Water Management Attributes in Central India

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Abstract: Urban areas of the present and future can be sustainably transformed by involving local community participation in decision-making because of their local knowledge. Most of the Indian cities have water management problems like water accessibility, availability, quality, adequate water infrastructure and user charges. Urban water management is one of the prime responsibilities of urban local bodies in India but there is no provision to assess public satisfaction. This study focuses on the assessment of the satisfaction level of the public on urban water management in central India to improve the efficiency of urban water. The methodology and proposed framework will help in improving the urban water management system by prioritizing their concern attribute for better public satisfaction.

Keywords: Urban Water Management, Public Participation, Public Satisfaction.

Introduction

The world's total population is expected to grow by 9.6 billion by 2050 while the urban population is expected to grow by 2.5 billion[1]. Rapid population growth combined with economic growth and climate change has created water shortage at the global level[2]. By 2051, it is expected that half the population of India would reside in urban settlements. India's rapid and extensive urbanization[3] is putting severe pressure on urban water management[4] and if the momentum of economic growth is to be maintained, both challenges and opportunities presented by large-scale urbanization will also have to be addressed on priority.

As the urban sector is governed by urban local bodies (ULBs), the role of state and central government is in taking up the projects for improving the delivery of urban infrastructure and amenities[5]. The planning process is lacking to create more convenient, equitable, healthy, efficient, sustainable places[6]. The present urban planning and development approach is far away from its goal. One of the reasons behind this is the failure of the equal supply of goods and services in place of equitable supply. Public satisfaction for urban services through analytical approach would be very useful in infrastructure planning. After Millennium Development Goals, the Ministry of Housing and Urban Affairs (MoHUA, GoI) took the initiative of launching Service Level Benchmarking System to provide good water and sanitation services to public. In this benchmarking system focus was shifted from the creation of infrastructure to the delivery of services and is used by ULBs to assess the quality of services. This benchmarking system resolves problem registered by the public but it does not consider their satisfaction from services. The perception and ideas from local consumers can be used to make infrastructure services and management more efficient.

One of the most effective methods to improve human health is to provide clean adequate water and sanitation services[7]. In the context of growing population and urbanization, the increasing scarcity of fresh and clean water management has been a challenging issue. Water availability and requirement disparities are a growing concern, but the ability to accurately assess both availability and demand for this valuable resource is limited[8]. Water stress is difficult to define because there are so many different aspects to water in an urban area like its availability and use, supply, storage system, quality (colour, odour) and user charges. Choosing the criteria for evaluating water can be as much a policy decision as it is a scientific one[9].

Climate change aggravates the global water scarcity situation[10]. Water scarcity has been linked to urbanization, agriculture, population growth, increases in household and industrial water usage[11,12]. To tackle this water scarcity problem many sustainability experts and scientists are advocating for radical movement in the urban water sector to promote better sustainable management practices[13,14,15,16]. The per capita average annual water availability is always shrinking as a result of population growth. Water scarcity is associated with a lack of readily and sufficient availability of water resources to meet the requirements of an urban area[4,17]. India's first Urban Water Mission was launched in 2015 under the AMRUT mission. Its central aim was focused on efficient water use and reduction in water scarcity. Sustainable Development Goal (SDG) 6 is about sustainable management of water resources. This will promote economic growth and productivity, as it is interlinked to the education and the well-being of people. To fulfil targets set under the SDG 6, Indian government has launched AMRUT 2.0 which empowers State and ULBs to increase the efficiency of water infrastructure using public participation. In AMRUT 2.0 Public participation is limited to few aspects like water quality testing. By promoting the

participation of local communities in urban water management attributes as discussed in the paper will further increase the efficiency of infrastructure and will help in mitigating water scarcity.

Role of Public Participation in Urban Planning

"SDG 11- Sustainable Cities and Communities" suggests to make cities and human settlements inclusive, safe, resilient and sustainable. Its "Target 11.3- Inclusive and Sustainable Urbanization" intents participatory, integrated and sustainable human settlement planning and management. It encourages inclusive development of the community and their participation in decision-making. In India, the involvement of the public in planning and decision-making was promoted in 1992 by the introduction of the 74th Constitutional Amendment Act. Urban centres play a pivotal role in the economic growth of a country and positive transformation of these urban areas can be helped with the local community participation, because of their knowledge of factual existing conditions at the grass-root level[18].

For a variety of reasons, numerous government administrators, authorities, and community leaders have acknowledged the need for public participation[20,21,22]. Public participation is an important aspect of sustainable development in urban planning. It provides an opportunity to embrace the social and cultural diversity that defines today's urban population[23]. It enables the local citizens to take part in and contribute to better planning solutions. In the future development and transformation of cities, public participation, as well as support for the population's commitment and guidance to urban planning measures, is critical[23].

No one has a complete understanding of how society is evolving. Experts can use knowledge based on facts and assessments offered by the local community. They have local experience and expertise which can help plan new features in planning[24,25]. Comprehensive knowledge is also critical for

communities having a diversified population because of their different needs. People's expectations regarding participation in planning processes are also influenced by their level of education and social mobility[24,25]. Local community challenges are too big for ULBs to solve on their own. Most decision-makers and planners consider open planning processes to be an adequate way of inspiring them to be more committed to their work. Involvement of different sections of diverse communities in local planning encourages a broader and better perspective of solutions, better coordination between communities, shared identity and a sense of belongingness[24,25].

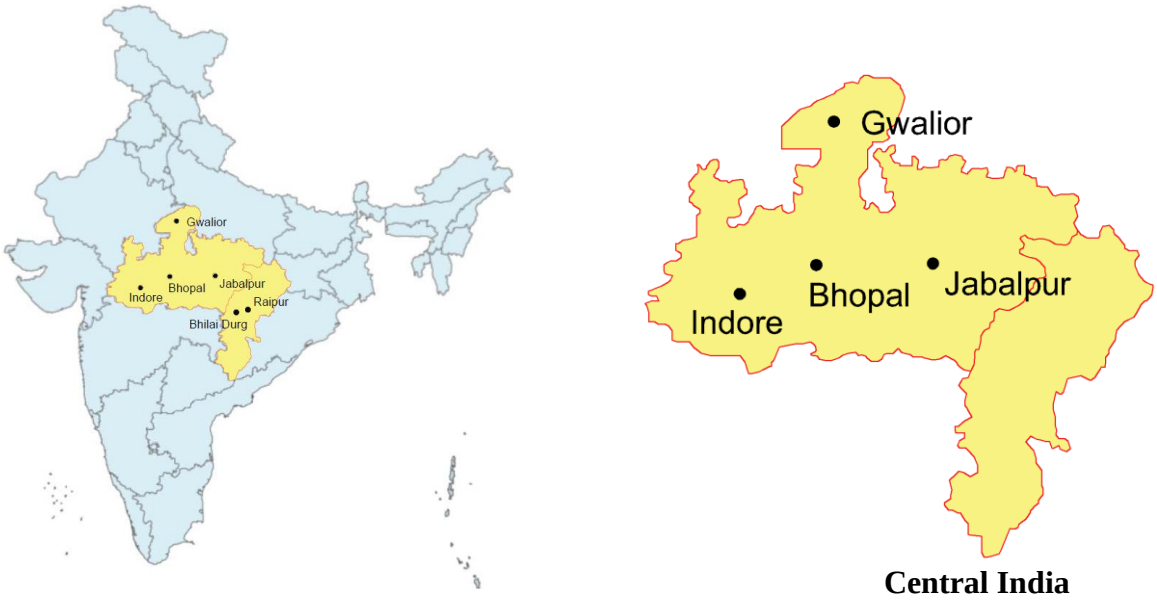

Figure 1. Study Area

Source: Ministry of External Affairs, GoI

Study Area

The research scope covers study of urban water management in the state of Madhya Pradesh and Chhattisgarh *(further referred as Central India,* Figure 1*)*. Central India has approximately 27% urban population and has 45 Class I cities (population more than 1,00,000) as per Census 2011. Out of this, it has six million-plus cities among which Indore is the most populous with a 2.1 million population followed by Bhopal, Jabalpur, Gwalior, Bhilai Durg and Raipur. These 6

million-plus cities carry around 32.4% of the urban population of Central India and 8.5 % of the total population of Central India. Around one-fourth of the urban population in Central India resides in 4 cities (million plus) i.e., Indore, Bhopal, Jabalpur and Gwalior. Therefore, these cities are selected to assess the overall public satisfaction of urban water management in Central India (Figure 1).

Indore city supply treated water to its residents from Narmada River (more than 100 km from city) and ground water source. Indore municipal corporation is focusing and expanding water infrastructure on Narmada River to meet water demand of the city and is ignoring locally available surface water resources. In case of Bhopal city most of the water demand is met by locally available water bodies and some amount of water is supplied from Narmada River. In Bhopal the water supplied is first stored in the small concrete tanks in the basement of the house/buildings and from these concrete tanks water is supplied to the tanks on roof of the building by water pumps. It helps in maintaining proper water pressure so that it can reach households far away from supplier. The city of Jabalpur meets its water demand from Narmada River (around 15km from city) and ground water. The city has various water bodies but they are not properly maintained and are not being fully utilized to use as water supply sources. In the early and mid 2000's Jabalpur city had rapid development in which new households, buildings and colonies dig tube wells which caused rapid fall in ground water level. All of the sample cities residents receive water for around 1-2 hours per day and several areas in these cities face acute water shortage during summer season.

Central India has almost 500 urban local bodies. Since, water is a state subject, it is regulated by their respective ULBs through their municipal act[26]. It has 6 major rivers and various tributaries. It has also an abundance of lakes and natural reservoirs which stores water from rainfall. Due to lack of water supply infrastructure, ULBs in Central India had promoted ground water for domestic

use but did not play any role in managing it. This caused overexploitation of ground water resources and is putting urban areas at water risk[27]. ULBs take limited consideration for the customer satisfaction of urban water management services. They do not have any provision to measure customer satisfaction for urban water services.

Research Methodology

Public participation is one of the urban planning tools to involve the community in decision-making process. The research method covers literature review findings and expert consultation, based on which final indicators were selected. These indicators were assessed to measure public satisfaction towards urban water management. Results obtained after analysis of the public satisfaction survey for different indicators would help ULBs in identifying water-related concerns which need to be examine to improve the efficiency of urban water management. This framework would help in the assessment of customer satisfaction for urban water management by ULBs and will promote efficient use of water resources. The methodology of this study can also be used to assess the public satisfaction of urban services for other basic infrastructure by changing attributes and indicators.

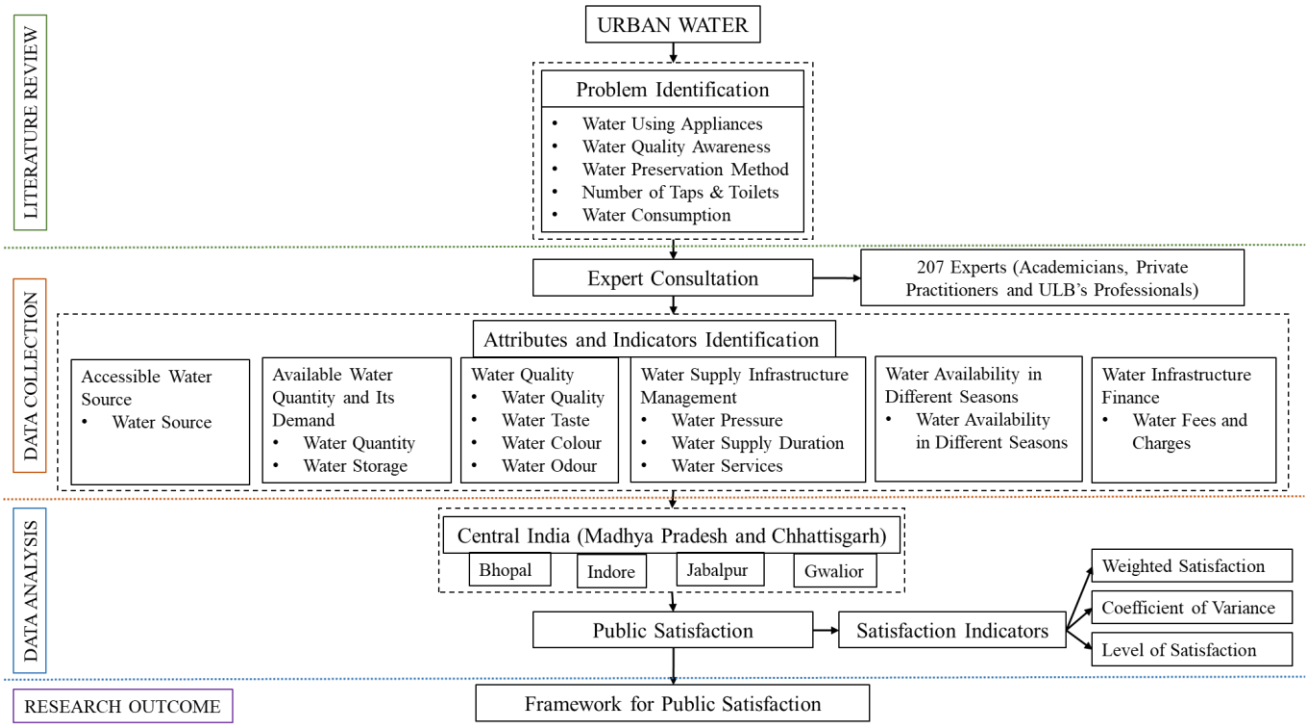

Figure 2. Research Methodology

Method for assessment of Public Satisfaction

In the analysis process of public satisfaction, initially public perception of the study area has been conducted for five aspects of water concern identified from the literature. These water concern areas include water-using appliances, water quality awareness, water preservation methods, number of taps & toilets and daily water consumption for different use in household activities.

From the result of this public perception, literature review and expert consultation, indicators related to public satisfaction for urban water management have been selected. 207 urban experts participated in survey process. The experts consulted were academicians, private practitioners and professionals from ULB's having experience of more than 5 years in urban water supply and management. The advocacy of urban experts helped in structuring the questionnaire for the primary survey. Total 1536 public responses have been recorded from 4 sample cities i.e., Indore, Bhopal, Jabalpur and Gwalior as shown in Table 1.

Table 1. Sample Collection for Different Density Regions

Density Zone	Density Size (person/hectare)	Bhopal	Indore	Jabalpur	Gwalior	Total
Low Density	less than 125	100	497	65	91	753
Medium Density	125 - 250	152	188	84	17	441
High Density	250 – 425	110	35	4	4	153
Very High Density	more than 425	70	101	18	0	189
Total		**432**	**821**	**171**	**112**	**1536**

The public responses have been recorded on a satisfaction scale of 1 to 5. Rank 1 is for poor, 2 for satisfactory, 3 for good, 4 for very good and 5 for excellent. Data from only completely filled questionnaires were extracted for the assessment. Based on this approach aggregate weighted satisfaction values are calculated for each attribute.

Data collected from density-based stratified samples have been assessed for five level of satisfaction. The satisfaction level presents the magnitude of the area of concern for different attributes. It also suggests which attributes needs to be focused by ULBs for better public satisfaction to manage the urban water system. The detailed methodology of this study has been presented in Figure 2.

Identification of water Attribute and Indicators

Over the last few decades, many indicators, particularly those associated with public water needs and water resource scarcity, have been developed[28]. Demographic and socio-economic variables are demand-driven water aspects. Similarly, there are supply-driven variables. From the literature review, six urban water management attributes were identified to assess public satisfaction. This includes accessible water source, available water quantity & its demand, water quality, water supply infrastructure management, water available in different seasons and water infrastructure finance. After expert advocacy, 12 indicators for these six urban water attributes (Table 2) were chosen.

Table 2. List of Attributes and Indicators for Customer Satisfaction

S.No.	Urban Water Attributes	References	Indicators
1	Accessible water source	Ishaku & Majid (2010)[29], Maryati & Humaira (2018)[31], McKenzie & Ray (2009)[33]	Water Source
2	Available Water Quantity and its demand	Das et al (2019)[30], Yang et al (2006)[32], McKenzie & Ray (2009)[33], Abrishamchi et al (2005)[34]	Water Quantity, Water Storage
3	Water Quality	Das et al (2019)[30], Yang et al (2006)[32], McKenzie & Ray (2009)[33], Abrishamchi et al (2005)[34]	Water Quality, Water Taste, Water Color, Water Odour
4	Water Supply infrastructure management	Ishaku & Majid (2010)[29], Yang et al (2006)[32], McKenzie & Ray (2009)[33]	Water Pressure, Water Supply Duration, Water Services
5	Water Availability in different seasons	Das et al (2019)[30], Yang et al (2006)[32]	Water availability in different seasons
6	Water infrastructure Finance	Das et al (2019)[30], Maryati & Humaira (2018)[31], Yang et al (2006)[32], McKenzie & Ray (2009)[33], Abrishamchi et al (2005)[34]	Water fees and charges

Water resources are limited and it makes it one of the most important attributes of urban water management. Water resources accessibility directly affects the cost of development and maintenance of infrastructure[35,36]. Rapid urbanization and excessive dependency on ground water resource for water supply is causing declination in ground water table. Improper waste management is degrading the quality and quantity of surface water. The water available and supplied is limited and it is important attribute to be considered for urban water management[37]. Supply of water of good quality helps in promoting good health of citizen and it needs regular test for microgeons and pathogens. There are around three million deaths per year in developing countries due to inadequate water supply, sanitation and hygiene[38]. Water fees is charged so that people properly use water.

Satisfaction Analysis

Data collected from the four sample cities have been assessed for its level of satisfaction. The satisfaction level presents the magnitude of public concern for indicators. Levels of satisfaction were examined for poor, satisfactory, good, very good and excellent. People marked any one of these five levels of satisfaction for each indicator. Based on their response's frequency table has been prepared (Table 3).

Table 3. Frequency Table for Level of Satisfaction

Indicators	**Water Source**	**Water Quantity**	**Water Quality**	**Water Pressure**	**Water Taste**	**Water Colour**	**Water Odour**	**Water Supply Duration**	**Water availability in Different Season**	**Water Fees / Charges**	**Water Services**	**Water Storage**
Level of Satisfaction	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Poor	55	349	78	29	60	40	33	40	151	57	38	61
Satisfactory	70	88	283	200	416	436	421	310	543	398	160	67
Good	628	803	963	918	916	933	952	871	749	810	919	735
Very Good	742	582	206	333	144	127	130	215	84	151	309	652
Excellent	41	14	6	3	0	0	0	0	0	0	0	21
Not Available	0	0	0	53	0	0	0	100	9	120	110	0
Total	**1536**	**1536**	**1536**	**1536**	**1536**	**1536**	**1536**	**1536**	**1536**	**1536**	**1536**	**1536**

The frequency table is further converted into a weighted value table. The weighted value of each indicator is the percentage of satisfaction value with respect to total number of samples (1536). For example, the weighted value of 'Water Source' for poor satisfaction is (55/1536) x100 i.e., 4 *(rounded off to the next integer).*

Table 4. Weighted Level of Satisfaction

Indicators	Water Source	Water Quantity	Water Quality	Water Pressure	Water Taste	Water Colour	Water Odour	Water Supply Duration	Water availability in Different Season	Water Fees / Charges	Water Services	Water Storage
Level of Satisfaction	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Poor	4	3	5	2	4	3	2	3	10	4	2	4
Satisfactory	5	6	18	13	27	28	27	20	35	26	10	4
Good	41	52	63	60	60	61	62	57	49	53	60	48
Very Good	48	38	13	22	9	8	8	14	5	10	20	42
Excellent	3	1	0	0	0	0	0	0	0	0	0	1
Not Available	0	0	0	3	0	0	0	7	1	8	7	0
Total	100	100	100	100	100	100	100	100	100	100	100	100
Average Weighted Satisfaction	**3.42**	**3.28**	**2.86**	**2.95**	**2.74**	**2.75**	**2.77**	**2.69**	**2.49**	**2.53**	**2.83**	**3.33**

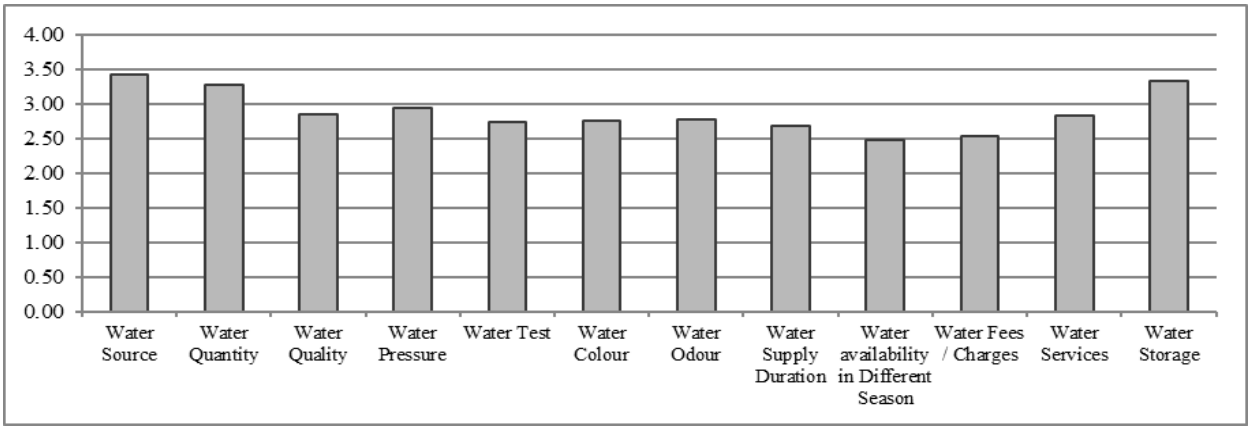

Figure 3. Satisfaction for Different Indicators

A weighted satisfaction bar chart has been prepared for urban water management indicators (Figure 3). The public is least satisfied with water availability in different seasons and water fees & charges while most satisfied with water source and storage. Water is being supplied in equal amounts throughout the year while demanded water quantity of different seasons is different. Besides the cities are not getting a 24x7 water supply. Water is supplied once for an hour a day. Failure in this schedule might also be the reason behind the least satisfaction towards water availability in different seasons. The sources of urban water in sample cities is mostly surface

water like rivers or lake having enough amount of water. Therefore, a maximum level of satisfaction is there for 'Water Source'. Water is being stored personally by each household in small tanks as per their requirement. Therefore, household is more satisfied with 'Water Quantity'. In totality, all water related-concern areas are satisfactory to good and good to very good for the 'Water Source', 'Water Quantity' and 'Water Storage' (Table 4, Figure 3).

The coefficient of variance (CV) has been evaluated to measure the consistency among samples (Table 5). Many researchers have adopted CV to measure consistency where 'CV<0.5' is highly acceptable and 'CV>1.0' is not acceptable. Based on the set standard of CV in literature, response for satisfaction level is examined and declared acceptable. Satisfaction responses had maximum consent for 'Water Quantity' while it is least for 'Water Fees'.

Table 5. Coefficient of Variance

Area of Concern	**Water Source**	**Water Quantity**	**Water Quality**	**Water Pressure**	**Water Taste**	**Water Colour**	**Water Odour**	**Water Supply Duration**	**Water availability in Different Season**	**Water Fees / Charges**	**Water Services**	**Water Storage**
Standard Deviation	**0.777**	**0.724**	**0.719**	**0.860**	**0.675**	**0.638**	**0.625**	**0.968**	**0.769**	**0.995**	**1.011**	**0.758**
Coefficient of Variance (CV)	0.227	0.221	0.252	0.291	0.246	0.232	0.226	0.360	0.309	0.393	0.357	0.228

All 1536 sample households are classified into four classes of density. Data has been categorized into these density classes for poor, satisfactory, good, very good and excellent level of satisfaction. Cumulative weighted satisfaction for each density zone of four sample cities has been calculated for each indicator.

Table 6. City-wise Level of Satisfaction for Density Classes

Density Class	Water Source	Water Quantity	Water Quality	Water Pressure	Water Taste	Water Colour	Water Odour	Water Supply Duration	Water availability in Different Season	Water Fees / Charges	Water Services	Water Storage
Low Bhopal	3.70	3.41	2.98	3.22	2.73	2.68	2.77	2.90	2.65	2.72	2.96	3.34
Medium Bhopal	3.59	3.24	2.66	2.99	2.63	2.66	2.66	2.83	2.68	2.91	2.97	3.32
High Bhopal	3.33	3.09	2.89	3.24	2.96	2.91	2.96	3.09	2.64	2.71	3.07	3.24
Very High Bhopal	3.80	3.43	2.93	3.04	2.99	2.84	2.77	2.79	2.71	2.61	2.99	3.49
Low Indore	3.50	3.34	2.89	3.03	2.66	2.71	2.72	2.79	2.48	2.70	3.05	3.36
Medium Indore	3.60	3.48	3.06	3.26	2.68	2.90	2.93	3.02	2.78	2.73	3.04	3.42
High Indore	3.66	3.51	3.17	2.31	3.09	3.09	3.17	2.14	2.54	2.23	2.40	3.49
Very High Indore	3.15	3.08	2.92	2.94	3.07	2.79	2.73	2.86	2.20	2.38	2.57	3.02
Low Jabalpur	3.31	3.68	3.14	2.26	3.00	2.78	2.74	2.22	2.49	1.74	2.40	3.60
Medium Jabalpur	3.12	3.19	2.85	2.90	2.86	2.90	2.73	3.02	2.58	2.64	2.96	3.29
High Jabalpur	2.50	2.50	1.75	2.25	2.25	1.75	2.75	2.75	2.00	2.25	2.50	3.00
Very High Jabalpur	3.17	3.17	2.78	2.72	2.83	2.61	2.83	2.72	2.44	2.78	3.00	3.56
Low Gwalior	2.56	2.60	2.09	2.03	2.42	2.35	2.65	0.93	1.54	1.11	1.48	3.14
Medium Gwalior	3.18	2.88	2.41	2.59	2.41	2.41	2.35	0.76	1.47	1.12	1.06	3.18
High Gwalior	2.75	2.75	2.75	2.25	2.50	2.75	2.25	0.25	1.25	1.00	1.50	2.75

The city-wise level of satisfaction has been presented in Table 6. Bhopal city has good public satisfaction for water sources in all density classes. Water availability, taste and user charges need to be more focused by ULB's to increase public satisfaction. The water source in Indore has good satisfaction for all density classes but needs more work on availability, taste and supply indicators. The city of Jabalpur public is more satisfied with water indicators like quantity & storage. Similarly, water indicators such as fees, availability and colour have the least public satisfaction level. Gwalior city needs more work on the water supply to increase public satisfaction levels.

Table 7. Density-Based Weighted Level of Satisfaction

Density Zone	Water Source	Water Quantity	Water Quality	Water Pressure	Water Taste	Water Colour	Water Odour	Water Supply Duration	Water availability in Different Season	Water Fees / Charges	Water Services	Water Storage
Low Density	3.40	3.29	2.83	2.87	2.67	2.67	2.72	2.53	2.39	2.43	2.79	3.35
Medium Density	3.49	3.32	2.86	3.07	2.68	2.80	2.78	2.87	2.66	2.71	2.92	3.35
High Density	3.37	3.16	2.92	2.97	2.96	2.92	2.99	2.79	2.56	2.54	2.86	3.27
Very High	3.39	3.22	2.91	2.96	3.02	2.79	2.76	2.82	2.41	2.50	2.77	3.24

To find the relation between density classes and water indicators multivariate correlation had been applied. It shows that satisfaction level decreases with increase in density for water source, water quantity, water availability in different seasons, water services and water storage. Water supply duration and water fees do not follow any pattern with changes in density. Thus, the impact of change in density might be observed by public satisfaction for urban water. Water quality and water quantity are inversely correlated. Strong-positive correlation was found between water source with water quantity and water fees/charges; water storage with water quantity; water quality with water taste and colour; water pressure with water supply duration, water availability in different seasons, water fees/charges, water services; water colour with water odour. Similarly, strong-negative correlation was found between water quantity with water quality and water taste; water storage with water quality and taste.

Discussion and Conclusion

India has about 17.7% of the world's population as compared to only 4 percent of its water resources. For a developing nation like India water is one of the important resources. Water is essential for human life, development and the environment, but it is a finite resource. Urban services like water-related infrastructure systems are made up of several attributes. The feasibility and the performance of an urban water system depend on their attributes. The success of the urban water system is the outcome of an integrated approach of its attributes functioning as its sub-system. Periodic accountability of urban water systems is important for their public satisfaction.

Public perception has the strength to measure user satisfaction. Water management attributes are considered in different perspectives at different levels due to demographic and socio-economic variables which can be accessed better at the local level. The demographic and socio-economic variation is responsible for variation in public perception. The local public is a key stakeholder for water management attributes and their local knowledge can be used to make the system more efficient and reliable. Integration of water-related concerns through spatial treatment would be helpful to improve the urban planning approach for better water management. Different sections of the community have different perceptions and attitudes toward the water which is reflected by the government organizations. Thus, stakeholder participation plays a significant role in urban water planning.

Every local area has its unique water-related problems. Local-level statistics give better information compared to the city level in terms of water-related issues. There are very few available models and approaches for an assessment tool to measure the performance of urban water management. There is a need for an integrated socio-economic and spatial method for the

assessment of water-related issues. The viability of the proposed satisfaction measure might be improved physically through enforcement into local area plans and development plans. The proposed approach to measure the level of satisfaction would be helpful for public participation before plan preparation and might also be used for scheduled review of the status of urban water management. The urban water management system can be upgraded through the inclusion of public satisfaction into a systematic assessment framework (Figure 4).

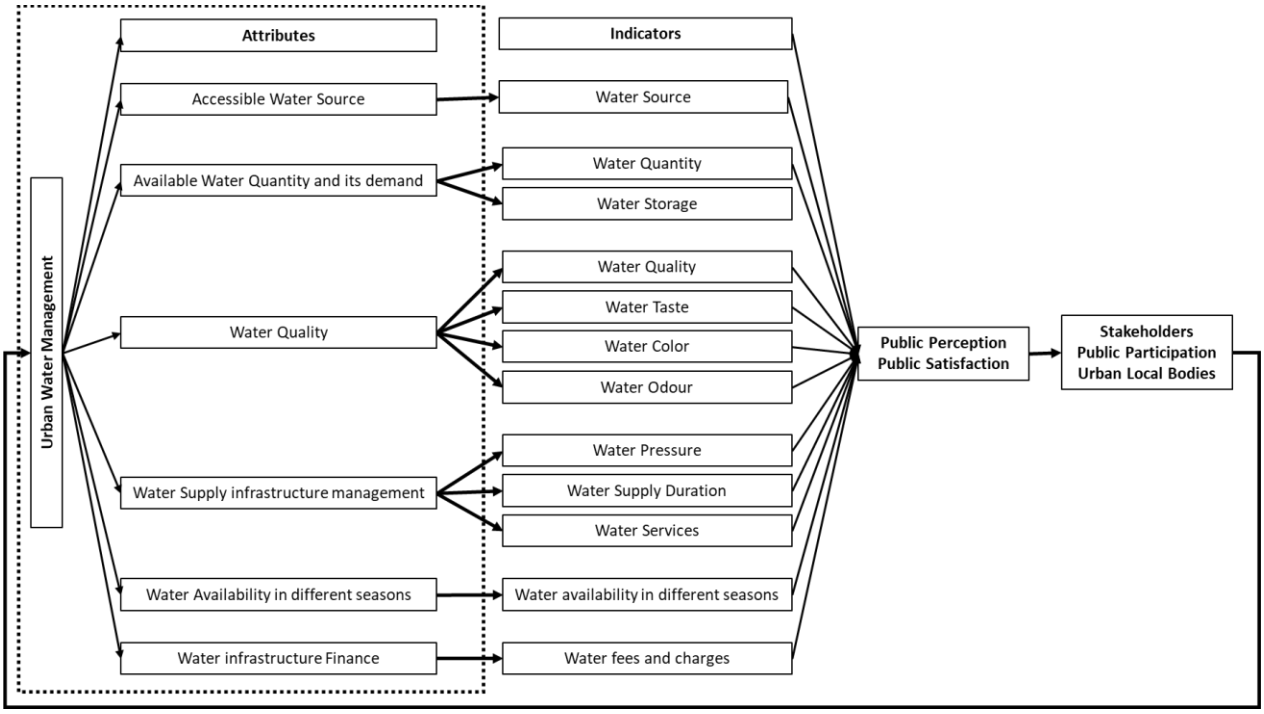

Figure 4. Assessment Framework for Public Satisfaction of Urban Water Management

Stakeholders, their participation in decision making and water services provided by ULBs are important aspects of urban water management. India is a rapidly urbanizing country and these urban areas either need new water infrastructure or renewal of the existing ones. Due to a lack of finance and low maintenance of the water infrastructure, there is water loss from source to destination. This is decreasing the overall capacity and efficiency of urban water infrastructure. To

maximize public satisfaction for the water services these losses should be minimized and the urban water aspects should be equitability focused.

The proposed assessment framework (Figure 4) for public satisfaction of urban water management can be adopted by city planners. It will guide them in distinguishing the poor functioning among water attributes that need to be strengthened to maximize the efficiency of the water management system. The framework will help to increase the public acceptability for urban water management and might also be replicated for other citizen services towards the functioning of ULBs. This framework can be used at the local, ward and city level efficiently with the same attributes and indicators listed in the study. The research might be extended by adding more number of generic indicators for different attributes. Statistical tests may also be adopted to assess changes in perceptions among different density groups and cities. It can also be used for different infrastructure services provided by ULBs with a different set of attributes and their indicators.

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