Assessment framework for public satisfaction on the urban water management attributes in Central India

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Urban areas of the present and future can be sustainably transformed by involving community participation in decision-making because of their local knowledge. Most of the Indian cities have water management problems like accessibility, availability, quality, adequate 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 distinguishing the poor functioning among water attributes that need to be strengthened to maximize the efficiency of the water management system.

Keywords: Assessment framework, city-planners, community participation, public satisfaction, urban water management.

THE total population of the world 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 resulted in water shortage at the global level[2]. By 2051, it is expected that half the population of India will reside in urban settlements. The rapid and extensive urbanization in India is putting severe pressure on urban water management[3,4]. 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), State Governments and Central Government must take up projects for improving the delivery of urban infrastructure and amenities[5]. More planning processes must be needed to develop more convenient, equitable, healthy, efficient and sustainable places[6]. The present urban planning and development approach is far away from its goal. One of the reasons for this is the failure of an equal supply of goods and services in place of equitable supply. Public satisfaction for urban services through an analytical approach would be useful in infrastructure planning. After the Millennium Development Goals, the Ministry of Housing and Urban Affairs (MoHUA), Government of India (GoI) launched a service-level benchmarking system to provide good water and sanitation services to the public. In this system, the focus was shifted from the creation of infrastructure to the delivery of services and is used by the ULBs to assess the quality of services. The benchmarking system resolves the problems registered by the public, but it does not consider their satisfaction from the services. The perception and ideas of 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 and adequate water and sanitation services[7]. In the context of the growing population and urbanization, the increasing scarcity of fresh and clean water has been challenging to manage. 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 many 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 and an increase in household and industrial water usage[11,12]. To tackle the water scarcity problem, many sustainability experts and scientists are advocating for radical movement in the urban water sector to promote better sustainable management practices[13–16]. The per capita average annual water availability is always shrinking due to population growth. Water scarcity is associated with a lack of ready 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 focused on efficient water use and reduced water scarcity. Sustainable Development Goal (SDG) 6 is about the sustainable management of water resources. This will promote economic growth and productivity, as it is interlinked with the education and well-being of the people. To fulfil targets set under SDG 6, GoI has launched AMRUT 2.0, which empowers the states and ULBs to increase the efficiency of water infrastructure using

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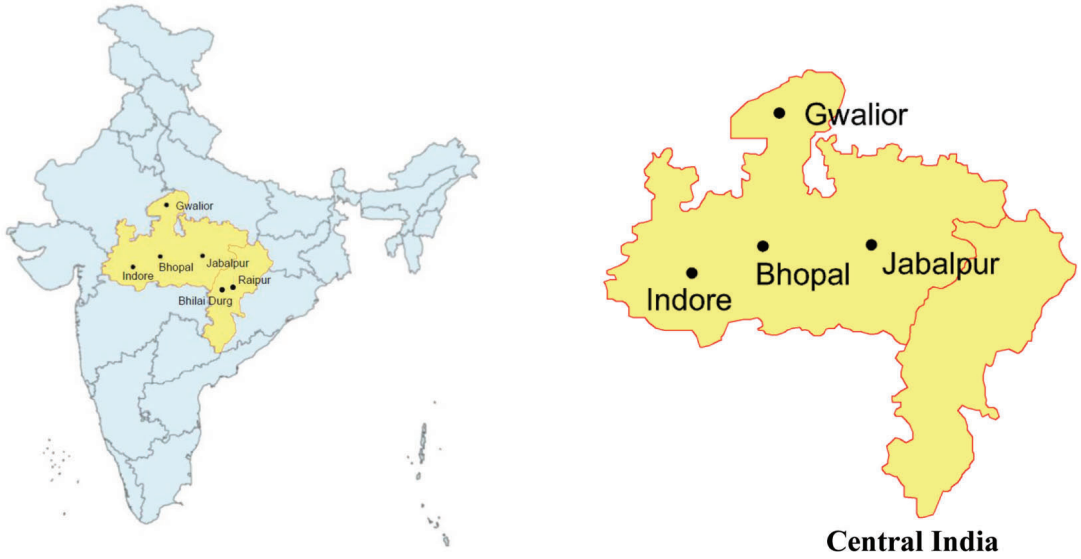

Figure 1. Study area. (Source: Ministry of External Affairs, Government of India.)

public participation. In AMRUT 2.0, public participation is limited to a few aspects, like water quality testing. By promoting the participation of local communities in urban water management, the attributes discussed in the present study will further improve the infrastructure and help mitigate 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 its participation in decision-making. In India, 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 achieved with the local community participation, because of their knowledge of factual existing conditions at the grassroots level[18,19].

For a variety of reasons, numerous government administrators, authorities and community leaders have acknowledged the need for public participation[20–22]. This 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 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 are 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 with 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].

Study area

The study area included Madhya Pradesh and Chhattisgarh (Central India, Figure 1). Central India has approximately 27% urban population and 45 class-I cities (population of more than 100,000), according to the 2011 census. It has six million-plus cities, of which Indore is the most populous with 2.1 million people, followed by Bhopal, Jabalpur, Gwalior, Bhilai Durg and Raipur. These six million-plus cities have around 32.4% of the urban population and 8.5% of the total population of Central India. Around one-fourth of the urban population in Central India resides in four cities (million-plus), i.e. Indore, Bhopal, Jabalpur and Gwalior. Therefore, these cities were selected to assess the overall public satisfaction with urban water management in Central India (Figure 1).

Table 1. Sample collection for different density regions

Density zone	Density size (persons/ha)	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

Indore city supplies treated water to its residents from the Narmada River (more than 100 km from the city) and groundwater sources. Indore Municipal Corporation is focusing and expanding water infrastructure on the Narmada to meet its water demand, while ignoring locally available surface-water resources. In the case of Bhopal city, most of the water demand is met by locally available water bodies and some water is supplied from the Narmada. In Bhopal, the water supplied is first stored in small concrete tanks in the basement of houses/buildings, from which it is supplied to the overhead tanks on the roof of the buildings using water pumps. This helps in maintaining proper pressure so that water can reach households far away from the supplier. The city of Jabalpur meets its water demand from the Narmada (around 15 km from the city) and groundwater. The city has several water bodies, but they are not properly maintained and are not being fully utilized as water-supply sources. In the early and mid-2000s, Jabalpur city witnessed rapid development with new households, buildings and colonies digging tube wells, which caused a rapid fall in the groundwater level. In all of the above cities, residents receive water for around 1–2 h per day and several areas in these cities face acute water shortages during the summer.

Central India has almost 500 ULBs. Since water is a state subject, it is regulated by the respective ULBs through their Municipality Act[26]. The region has six major rivers and various tributaries. It also has an abundance of lakes and natural reservoirs which store rainwater. Due to a lack of water supply infrastructure, ULBs in Central India promoted groundwater for domestic use, but they did not play any role in managing it. This has caused overexploitation of groundwater resources and puts urban areas at water risk[27]. ULBs take limited consideration regarding customer satisfaction with urban water management services. They do not have any provision for measuring customer satisfaction with urban water services.

Research methodology

Public participation is one of the urban planning tools to involve the community in the decision-making process. Our research methodology covers the 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 identify water-related concerns that need to be examined 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 promote efficient use of water resources. By changing attributes and indicators this methodology can also assess the public satisfaction regarding urban services for other basic infrastructure.

Method for assessment of public satisfaction

In the analysis of public satisfaction in the study area, initially public perception for five aspects concerning water was identified from the literature. These included water-using appliances, water quality awareness, water preservation methods, number of taps and toilets, and daily water consumption for different household activities.

From this public perception, the literature review and expert consultation, indicators related to public satisfaction for urban water management were selected. Two hundred and seven urban experts participated in the survey process. The experts consulted were academicians, private practitioners and professionals from ULBs 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. Totally 1536 public responses were recorded from four sample cities, i.e. Indore, Bhopal, Jabalpur and Gwalior (Table 1).

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

Data collected from density-based stratified samples were assessed for the five levels of satisfaction. The satisfaction level presents the magnitude of the area of concern for different attributes. It also suggests which attributes need to be focused on by the ULBs for better public satisfaction in managing the urban water system. Figure 2 presents details of the research methodology.

Identification of water attribute and indicators

Over the last few decades, many indicators, particularly those associated with public water needs and water resources

Table 2. List of attributes and indicators for customer satisfaction

Urban water attributes	Reference	Indicators
Accessible water source	29, 30, 31	Water source
Available water quantity and its demand	31–34	Water quantity, water storage
Water quality	31–34	Water quality, water taste, water colour, water odour
Water supply infrastructure management	29, 31, 32	Water pressure, water supply duration, water services
Water availability in different seasons	32, 33	Water availability in different seasons
Water infrastructure finance	30–34	Water fees and charges

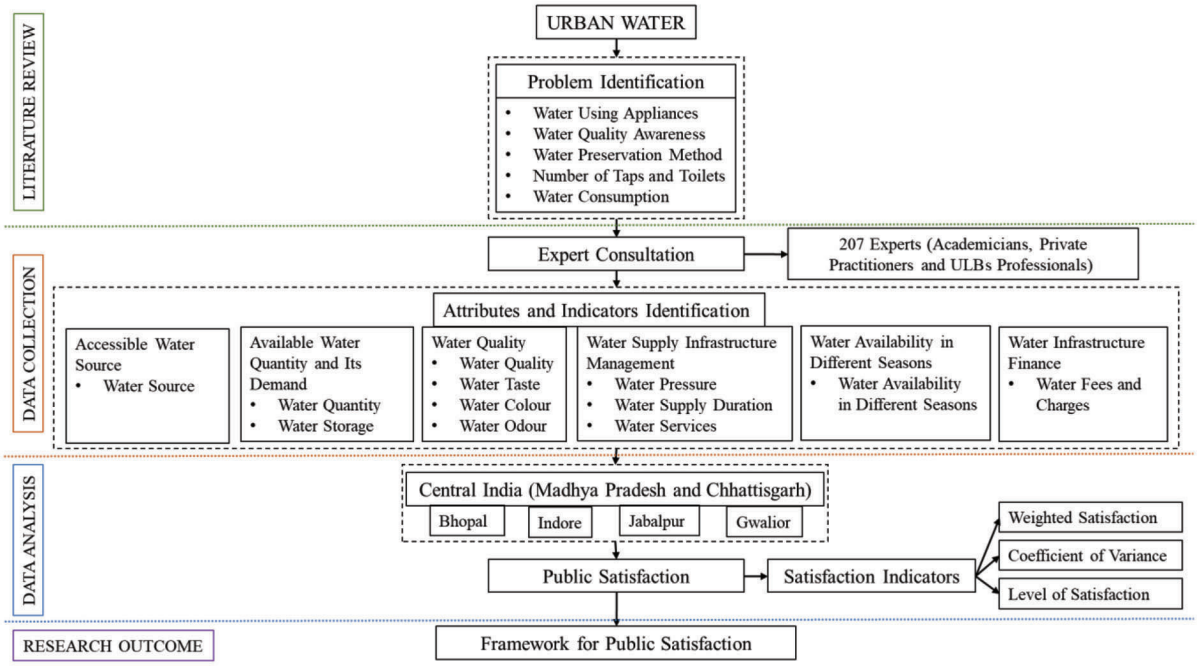

Figure 2. Research methodology.

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. These were accessible water sources, available water quantity and 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 were chosen (Table 2)[29–34].

Water resources are limited, making them one of the most important attributes of urban water management. Water resource accessibility directly affects the cost of development and maintenance of infrastructure[35,36]. Rapid urbanization and excessive dependency on groundwater resources for water supply are causing a decline in the groundwater table. Improper waste management is degrading the quality and quantity of surface water. The water available and supplied is limited, and it is an important attribute to be considered for urban water management[37]. The supply of good-quality water helps in promoting the health of the citizens. Water needs to be regularly tested for microgens and pathogens. Around three million deaths per year have been reported in developing countries due to inadequate water supply, sanitation and hygiene[38]. Water fees are charged so that people use it properly.

Satisfaction analysis

Data collected from the four sample cities were assessed for satisfaction. The satisfaction level presents the magnitude of public concern for indicators. The level of satisfaction were examined for five levels, i.e. poor, satisfactory, good, very good and excellent. Respondents marked any one of these five levels of satisfaction for each indicator. Based on the responses, a frequency table was prepared (Table 3).

The frequency table was further converted into a weighted value table (Table 4). The weighted value of each indicator is the percentage of satisfaction value with respect to the total number of samples (1536). For example, the weighted value of 'water source' for poor satisfaction is (55/1536) × 100, i.e. 4 (rounded-off to the next integer).

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 seasons	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

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 seasons	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

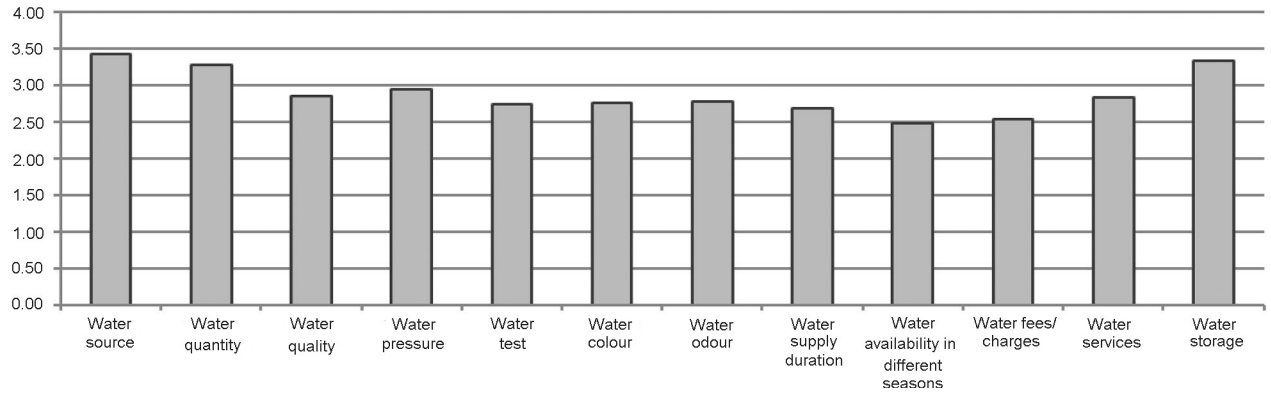

Figure 3. Satisfaction for different indicators.

A weighted satisfaction bar chart was prepared for urban water management indicators (Figure 3). The public was least satisfied with water availability in different seasons, and water charges, while it was most satisfied with water source and water storage. Water is supplied in equal amounts throughout the year, while water demand is changing in different seasons. Besides, these cities do not get a 24 × 7 water supply. Water is supplied for one hour per day. Failure in this schedule might also be the reason for the least satisfaction with water availability in different seasons. The sources of urban water in the sample cities are mostly surface water like rivers or lakes with enough water. Thus, the maximum level of satisfaction was water source. Water is stored personally by each household in small tanks according to their requirements. Therefore, households are more satisfied with water quantity. Therefore, all water-related concern areas are satisfactory to good and good to very good for water source, water quantity and water storage (Table 4 and Figure 3).

The coefficient of variance (CV) was evaluated to measure the consistency among samples (Table 5). Many researchers

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 seasons	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	0.227	0.221	0.252	0.291	0.246	0.232	0.226	0.360	0.309	0.393	0.357	0.228

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 cdour	Water supply duration	Water availability in different seasons	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

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 density	3.39	3.22	2.91	2.96	3.02	2.79	2.76	2.82	2.41	2.50	2.77	3.24

have adopted CV to measure consistency, where CV < 0.5 is highly acceptable and CV > 1.0 is not acceptable. Based on the standard of CV in the literature, the response for satisfaction level was examined and declared acceptable. Satisfaction responses had maximum consent for water quantity, while it was least for water fees.

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

Table 6 presents the city-wise level of satisfaction. Bhopal city had good public satisfaction for water sources in all the density classes. Water availability, taste and user charges need more focus from the ULBs to increase public satisfaction. The water source in Indore showed good satisfaction for all the density classes but needed more work on availability, taste and supply indicators. In Jabalpur, the public was more satisfied with water indicators like quantity and storage. Similarly, water indicators such as fees, availability and colour showed the least public satisfaction level. Gwalior city needs more work on the water supply to increase public satisfaction levels.

To find the relation between density classes and water indicators, multivariate correlation had been applied on the cumulative results of different density zones of sample cities (Table 7). It showed that satisfaction levels decreased 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 did not follow any pattern with the change in density. Thus, the impact of change in density might be observed by public satisfaction with urban water. Water quality and water quantity were inversely correlated. Strong positive correlation was found between water source and water quantity and water fees/charges; water storage and water quantity; water quality and water taste and colour; water pressure and

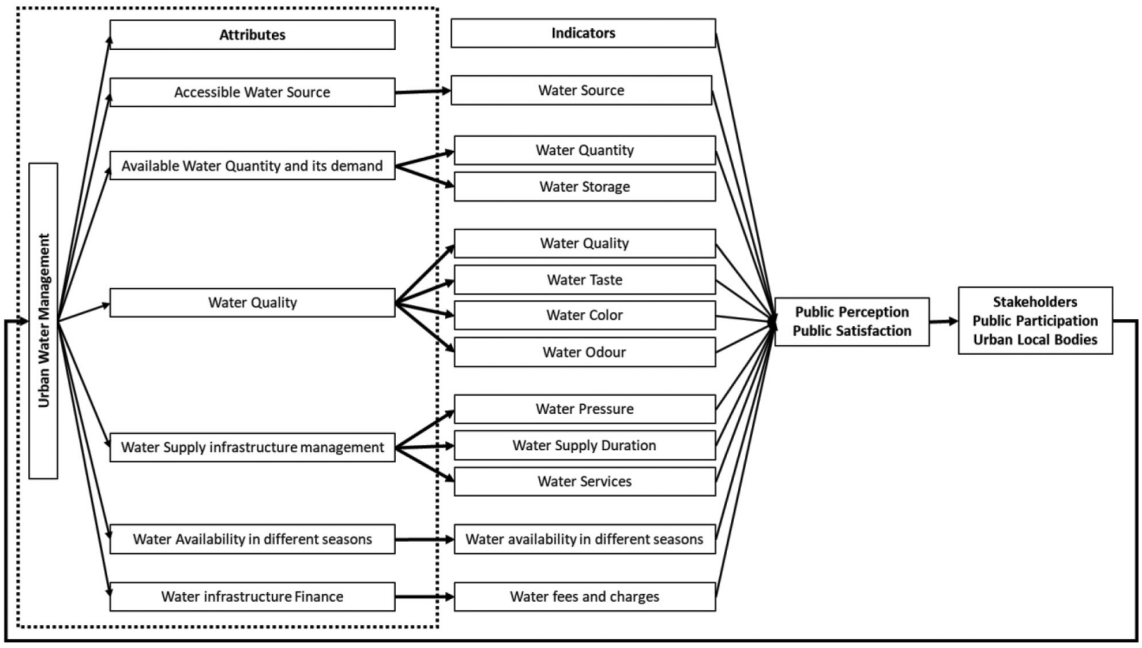

Figure 4. Assessment framework for public satisfaction on urban water management.

water supply duration, water availability in different seasons, water fees/charges, water services, as well as water colour and water odour. Similarly, a strong negative correlation was found between water quantity and water quality and water taste, as well as water storage and water quality and taste.

Discussion and conclusion

India has about 17.7% of the world's population compared to only 4% of its water resources. For a developing nation like India, water is one of the important resources. It 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 performance of an urban water system depend on its 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 public satisfaction.

Public perception has the strength to measure user satisfaction. Water management attributes are considered from 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 the variation in public perception. The local community is a key stakeholder in 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 gives better information compared to city-level information in terms of water-related issues. There are only a few available models/approaches 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 the enforcement of 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 a scheduled review of the status of urban water management. The urban water management system can be upgraded by indulging public satisfaction in a systematic assessment framework (Figure 4).

Stakeholders and their participation in the decision-making and water services provided by ULBs are important aspects of urban water management. India is a rapidly developing country and the urban areas need either 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 the urban water infrastructure. To maximize public satisfaction for the water services, these losses should be minimized, with an equitable focus on the urban water aspects.

The proposed assessment framework for public satisfaction of urban water management can be adopted by city-planners.

It will guide them in identifying the water attributes that need to be strengthened to maximize the efficiency of the water management system. This framework will help 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 also be used at the local, ward and city level efficiently with the same attributes and indicators listed in the present study. The research might be extended by adding more generic indicators for different attributes. Statistical tests may also be adapted to assess changes in perceptions among different density groups and cities. The framework can also be used for different infrastructure services provided by the ULBs with different sets of attributes and their indicators.

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