Water Policy 20 (2018) 266–281

Understanding public perception, knowledge and behaviour for water quality management of the river Yamuna in India

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Abstract

The paper aims to understand how the public perceives river water quality and related risks and behaviour. Using the stratified semi-purposive sampling process, the study explores the perception of people residing along the river Yamuna in India. The method applied involved a structured questionnaire survey of 2706 respondents and four focused group discussions with people residing within two kilometres of the river bank. Non-parametric tests such as Kruskal Wallis, Mann Whitney U-test and One-Sample Wilcoxon Signed-Rank Test were used to analyse the data. The findings suggest that the majority of the respondents formulate their perceptions using non-scientific methods like sensorial and heuristics. Perception on sources of pollution is shaped by personal experiences and people do not perceive diffused sources of pollution that affect river water quality. Respondents attributed the pollution in the river to anthropogenic activities and their risk perception was found to be linked to their direct dependence on the river for their daily needs. The paper suggests behavioural change strategies to focus on social, governance, and technological drivers.

Keywords: Awareness; Behaviour; Policy; River; Water quality perception

1. Introduction

The need for public participation in water management has been emphasized on several occasions since the International Conference on Water and the Environment (ICWE) held in Dublin in 1992 (ICWE, 1992; Tippett *et al*., 2005; Pahl-wostl *et al*., 2008) and has been increasingly forming a part of government policies on water resources in the last two decades (Yufei *et al*., 2007; Ministry of Water Resources (MoWR), 2012). Despite widespread recognition, there are several challenges

doi: 10.2166/wp.2018.134

associated with securing public participation as it is linked to a wide variety of pre-conceived thoughts, beliefs and values associated with people (Mostert, 2003; Korff *et al.*, 2012). Thus, to identify the type, scope and scale of engagement and corresponding methods for positive behavioural response from people, it is important to gain insight into public perception (Tran, 2006; Clay *et al.*, 2007; Dobbie & Green, 2013). Perception is man's predominant form of cognitive contact with his or her environment, and is of seminal importance when understanding his or her behaviour (Efron, 1969). Therefore, a detailed understanding of how individuals perceive and behave, becomes imperative for policymakers and researchers, especially the ones seeking solutions that require behavioural change to manage natural resources (Anderson *et al.*, 2007; Larson *et al.*, 2009; Hu & Morton, 2011). Literature suggests that public perception of the quality of water varies with education (Anderson *et al.*, 2007), age, income level (Larson & Lach, 2008), gender (Larson *et al.*, 2010), social and psychological belief (Tran, 2006) and geographic proximity of a person to the water source (Hu & Morton, 2011). Research on analysis of public perception for public participation in water quality restoration programmes has been conducted in many successful river management projects, such as the river Thames in the United Kingdom (Tunstall, 2000), river Murray in Australia (Larson *et al.*, 2013) and river Rhine in Europe (Buijs, 2009) and in developed countries such as Spain, Australia, United States, Canada, United Kingdom, Japan, etc. (Tunstall, 2000; Yamashita, 2002; Turgeon *et al.*, 2004; Lepesteur *et al.*, 2008; Roca & Villares, 2008; Le Lay *et al.*, 2013). However, the same is not the case with respect to developing countries. Furthermore, it is interesting to note that most published studies reported in the body of literature have been prior to planning an intervention.

The study presented in this paper is different from the earlier studies, as it has been carried out at a river site where there have been multiple attempts during the past two decades to revive the river. Water quality restoration measures predominantly include infrastructure interventions to reduce pollution load into the river, an approach popular in all *river action plans* of India. The Yamuna Action Plan (YAP) was launched in 1993 with a soft loan of approximately 217 million dollars from Japan Bank for International Co-operation (JBIC) to take up pollution abatement works in the river Yamuna by building diversion sewer lines, sewage pumping stations and sewage treatment plants (STPs). The YAP I was extended to YAP II in 2004 with an additional budget of 142 million dollars and to YAP III in 2016 with allocation of 127 million dollars and with similar objectives (Tokyo Engineering Consultants (TEC), 2009; Ministry of Environment and Forests (MoEF), 2011; The Indian Express, 2016).

The study aims to bring out evidence regarding public perception of river water quality, factors influencing perception, perception about sources of pollution, significance of the river, risk perception due to change in water quality and reasons behind water-related behaviour of the people. Further, the study suggests interventions that would help in creating desirable behavioural changes among the people and provides policy relevant information to design effective public participation strategies for river quality restoration projects. A mixed method approach comprising of both quantitative and qualitative techniques was used to achieve the objectives of the study. The oral questionnaire survey was chosen to capture the response of a diverse set of respondents and to ensure that every question was answered. Focus Group Discussions (FGDs) helped in gaining deeper insights into the findings from the survey as well as validating the findings through triangulation of the data. The next section explains the materials and methods used for the study which include site description, data collection methodology, analysis tools and sampling. This section is followed by results and discussion, policy implications, and the conclusion.

2. Materials and methods

2.1. Site description

Three stretches of the river Yamuna have been considered in this study (Figure 1). These include a 22 km critically polluted stretch of the river along Delhi (Sharma *et al*., 2015), a 183 km relatively cleaner stretch upstream of Delhi and a 155 km stretch downstream of Delhi (Rani *et al*., 2013). The survey was conducted in the districts of Yamunanagar, Muzaffarnagar, Panipat, Baghpat and Sonipat upstream of Delhi, in Delhi, and at Faridabad and Mathura districts downstream of Delhi. The ranking for water quality used in the study is aligned with the designated best use classification of surface water quality by

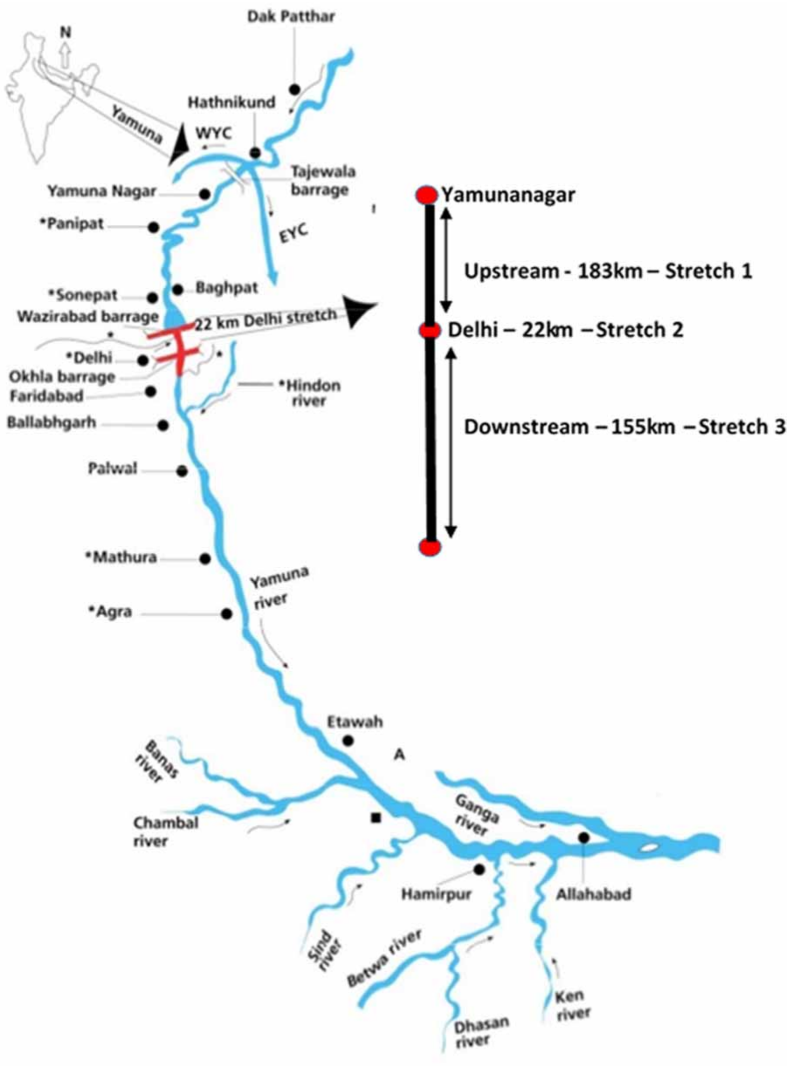

Fig. 1. Schematic diagram of the study area.

Table 1. Designated best use classification of surface water. *Source:* CPCB (2007).

Designated best use	Class of water	Water quality ranking (used in the study)
Drinking water source without conventional treatment but after disinfection	A	5
Outdoor bathing	B	4
Drinking water source after conventional treatment and disinfection	C	3
Propagation of wild life and fisheries	D	2
Irrigation, industrial cooling, controlled waste disposal	E	1

the Central Pollution Control Board (CPCB) as shown in Table 1. These categories for the purpose of the study have been ranked as '1' for very poor and '5' for very good.

Since 1993, Government of India (GoI) has been making efforts to clean the river through its mega project, Yamuna Action Plan (YAP) which mainly focuses on water treatment based infrastructure projects (TEC, 2009). According to the Ministry of Environment and Forests (MoEF), the Government invested over 350 million dollars on YAP I and II between 1993 and 2011; 40% of which was used within Stretch 2 for building infrastructure and creating public awareness to restore the water quality of the river Yamuna (MoEF, 2011). Despite these investments and interventions, the water quality of the Yamuna in Stretch 2 continues to be of Class E (Sharma *et al*., 2015). The water quality in Stretch 1 is reported to be of Class B and in Stretch 3 it is of Class C (Khan & Singh, 2013; Rani *et al*., 2013; CPCB, 2016).

2.2. Data collection and analysis

2.2.1. Questionnaire design. The first section of the questionnaire focused on the demographic status and location aspects of the respondent. The information was recorded by assigning codes for variables:

- gender – male, 1; female, 2
- income category – low income (LI), 1; medium income (MI), 2; high income (HI), 3
- level of education – illiterate, 1; semi-literate, 2; literate, 3
- location – Stretch 1, 1; Stretch 2, 2; Stretch 3, 3

The income status of an individual has been classified differently by various agencies such as National Council of Applied Economic Research (NCAER) and McKinsey Global Institute (MGI) (Beinhocker *et al*., 2007). Drawing from these reports, for the purpose of this study, we have considered 'low income' as those having monthly household earning of less than INR 15,000, 'medium income' for monthly household earning between INR 15,000–60,000 and 'high income' for monthly household earning of INR 60,000 and above (1 US Dollar ~ 64 INR). To ascertain that the income being mentioned by the person was reported correctly, questions on family size, nature of employment of the earning members and type of residence were asked in order to arrive at a judgemental income.

The Census of India has defined literacy as the ability to read and write with understanding of any language, and minimum educational qualification is not necessary to be considered literate (National Commission to Review the Working of the Constitution (NCRWC), 2001). The Census further classifies literates into 'below primary', 'primary', 'middle', 'matric/secondary', 'higher secondary', 'diploma' and 'graduates and above' levels (Census, 2001). The classification given by the Census was analysed according to the number of years of education under each category and for the purpose of this study, a person with 5 years or less schooling is considered as illiterate, 6 to 12 years is considered as semi-literate and greater than 12 years is considered as literate.

The second section assesses the perception of river water quality which was measured on a scale of 1–5. The following parameters were considered to ascertain the basis of perceiving water quality (de França Doria, 2010):

- **Sensorial**: decision based on taste, colour and smell
- **Contextual**: relating to the presence of refuse in the water, on the bank, sewer line and drain outlets entering the river and the presence of aquatic life
- **Scientific**: relating to knowledge of presence of harmful chemicals based on evidence
- **Heuristics**: opinion based on experience, intuitive judgement, educated guess, etc.
- **Culture and belief**

The perception about the various sources of pollution was determined based on the respondent's response to the choices presented; namely, '*industrial*', '*domestic*', '*agricultural activities*', and '*customs and rituals*'. Furthermore, they were also given the option to cite any source beyond the choices presented. The third section focused on understanding the perception of risk among the public with respect to the changes in water quality. Unlike risk assessment by scientists, risk perception is a personal understanding of risk built over time due to experience, knowledge and memory. It is highly subjective and relates to an individual's judgement about the risks they believe they are exposed to (Slovic, 1994; Rohrmann, 2008). These were first assessed by identifying the significance of the river among the people. To capture this, participants were asked to choose from the following categories: '*emotional/cultural*', '*occupational*', '*environmental*', '*daily needs*', '*recreational*', '*no relation*' and '*no idea*'. Risk perception was further measured with a single item scale by asking the respondents: 'Do you perceive any risk to quality of your life from the changing water quality of the river Yamuna?' The respondents could reply with either yes (1) or no (0). Those who answered in the affirmative were asked to select the nature of the risk. The respondents were given five choices, '*health*', '*economic*', '*environmental*', '*socio-cultural*' and '*any other*'. In all the multiple-choice questions, the respondents were given the flexibility of choosing multiple options as the response to each option was to be given as yes (1) or no (0).

The fourth section of the questionnaire was designed to understand the behaviour of people related to water. In 1975, Fishbein and Ajzen coined the 'theory of reasoned action (TRA)' for evaluating the factors responsible for a specific behaviour. TRA suggests that a person's behaviour is determined by his intention to perform the behaviour. The behavioural intent, in turn, is a function of his attitude and subjective norm. Whereas attitude is a personal trait, subjective norm is the influence of society on the perception of the person to perform a specific behaviour (Ajzen, 1991). The reasons behind water related behaviour were thus computed using eight questions and the respondents were asked to record their answers using a five-point Likert scale, with 1 representing strongly disagree, and 5 representing strongly agree. The questions sought responses on *public ownership of their action for degrading water quality*, the reasons for their action – *habit, convenience, societal influence, lack of option, ignorance, absence of penalty* and whether *awareness would bring the required change in behaviour*.

A pilot run of the questionnaire was performed on 25 volunteers selected from each stretch to pre-test and fine tune the questions. Furthermore, Cronbach's alpha reliability test was performed on Likert-scale questions for measuring internal consistency of scores. The alpha coefficient for the eight items was found to be 0.777 suggesting that the items had high internal consistency (Gliem & Gliem, 2003). To ensure consistency in the response, the data was collected in two phases around the same time period during the year May to June 2014 and April to May 2015. Survey forms were filled in by the researchers during face-to-face interactions with the respondents. This ensured that all questions were answered with no missing values. The interviews were conducted in Hindi which was the native language of the respondents.

2.2.2. Sampling. Keeping in mind the broad spectrum of respondents, semi-purposive sampling was used for the study (Crona *et al.*, 2009; Sovacool *et al.*, 2012). People residing within two kilometres of the river bank and having the opportunity to view the river more frequently than others, were surveyed for a perception analysis. This was based on the commonly known fact that dependency on the river for a livelihood reduces as one moves away from the river due to diversification in the availability of sources of water. However, to capture the diversity of views, each segment was further divided into sections comprising residential areas, educational institutions, market place and other public places like parks, religious places, etc. A sampling grid was designed to sample participants representing key independent variables such as gender, education and income. The questionnaire was administered to 2706 individuals in three stretches (see Figure 1); Stretch 1 ($n = 834$), Stretch 2 ($n = 1,168$), and Stretch 3 ($n = 704$). The demographic attributes of the surveyed population sample are shown in Table 2.

Four FGDs were conducted with homogeneous groups to gain detailed insights into the perception, extent of knowledge and behavioural patterns of the public towards water quality of the river. Of the four groups, one group had only female participants. The FGD began with a general question regarding the water quality of the river Yamuna. Participants were asked to express their views on the river and its changing water quality. This was followed by a few probing questions on the reasons behind their views on the water quality of the river. The participants were also asked to share their opinions on the significance of the river and its impact on their well-being due to the changing water quality. All FGDs were audio recorded.

2.2.3. Data analysis. Numerically coded data was used for carrying out statistical analysis. Descriptive statistics were calculated across all variables to summarize the data and to gain understanding of its distribution and spread. Since the data did not follow a normal distribution, non-parametric tests, Kruskal

Table 2. Demographic attributes of surveyed population ($\boldsymbol{n} = 2,706$).

		Illiterate			Semi-literate			Literate			
		LI	MI	HI	LI	MI	HI	LI	MI	HI	Total
Stretch 1	Male	117	49	10	20	75	40	10	3	233	557
	Female	50	49	10	10	14	24	5	10	105	277
Stretch 2	Male	123	55	10	84	92	49	25	44	89	571
	Female	95	50	15	89	95	20	40	30	163	597
Stretch 3	Male	40	14	9	15	74	25	39	64	40	320
	Female	70	54	4	55	39	3	96	44	19	384
	Total	495	271	58	273	389	161	215	195	649	**2,706**

Wallis and Mann Whitney U-tests (Larson & Lach, 2008; Steinwender *et al*., 2008) were used to assess the difference of means with respect to the above referred variables.

The One-Sample Wilcoxon Signed-Rank Test was conducted to gauge the public perception of water quality of the river Yamuna. This was done with the aim of determining whether the median of the sample was equal to the hypothesized value of 3 (neither good nor bad). The reporting of all statistically significant differences was based on the 0.05 level of significance (p-value). Pairwise comparison of the means was carried out through the Bonferroni post hoc test on variables that consisted of more than two independent samples. The means were later compared with scientifically available data on water quality of the river Yamuna to understand the similarities and differences in the perception and reality. The responses from the FGDs were also considered after content analysis to support the quantitative analysis.

The questionnaire data measuring water-related behaviour using the Likert scale was initially subjected to exploratory analysis. This included plotting of a scatter graph amongst all the independent variables and the computation of a correlation matrix, in order to explore possibilities of subjecting advanced multivariate methods to extract more insights from the data. It was noted that the correlation between most of the independent variables was statistically significant. This suggested exploring possibilities of using multivariate data analysis techniques like principal component analysis (PCA) and factor analysis (FA) to extract the grouping variables, if any, in the form of major factors which could help in bringing the required behavioural change in people.

3. Results and discussion

3.1. Public perception of water quality

A summary of the means of public perception of water quality has been provided in Table 3. It is evident from the values of the weighted mean scores in Stretches 1, 2 and 3 that the public perceives water quality as 'medium' in Stretch 1 but 'bad' in Stretches 2 and 3. The Wilcoxon Signed-Rank Test on one sample revealed that at a significance level of 5%, the median value of public perception of water quality was equal to the hypothesized value of 3 in Stretch 1 and lower in Stretches 2 and 3. The finding contradicts the

Table 3. Mean values of public perception of water quality on a scale of 1 to 5 (1 representing very bad and 5 representing very good).

		Illiterate			Semi-literate			Literate			
		LI	MI	HI	LI	MI	HI	LI	MI	HI	Mean
Stretch 1	Male	3.48	4.18	3.50	4.25	3.00	2.88	5.00	1.00	2.46	**3.04**
	Female	2.70	4.18	4.50	5.00	3.57	3.58	5.00	3.00	2.57	**3.24**
Pooled data		**3.63**			**3.34**			**2.59**		**3.11**	
Stretch 2	Male	1.41	1.36	2.00	1.77	1.44	1.61	1.20	1.34	1.54	**1.50**
	Female	1.52	2.10	2.00	1.79	1.79	1.50	1.75	2.50	1.69	**1.78**
Pooled data		**1.59**			**1.68**			**1.66**		**1.64**	
Stretch 3	Male	1.38	1.57	1.44	1.00	1.53	1.60	1.00	1.08	1.13	**1.28**
	Female	1.64	1.37	1.00	1.36	1.26	1.30	1.41	1.32	1.53	**1.42**
Pooled data		**1.48**			**1.41**			**1.24**		**1.36**	

scientific evidence which reveals that water quality is 'good' (Class B) in Stretch 1 and 'medium' (Class C) in Stretch 3 (Rani *et al.*, 2013). Underestimating the water quality in Stretch 1 indicates that people have higher expectations where few visible polluting sources exist. The FGDs revealed that people were unaware of YAP and their perception is being influenced by the multiple visible sources of pollution on Stretches 2 and 3. It is important to note here, that scientific information is rarely accessible to the common man who does not have the requisite skills to interpret the data if provided to them.

A Mann Whitney U-test for gender groups revealed that the perceptions of water quality among men and women were statistically different in all stretches. Women in general were found to be slightly more positive about the river water quality as compared to men. A possible rationale behind this finding that emerged in the FGD was that women were not as educated in comparison to men and had limited exposure to sources of information like the newspaper. A Kruskal Wallis test revealed a significant difference based on income only in Stretch 1, wherein the lower income group perceived water quality to be better than the higher income group. The reason that emerged for this was higher dependency of the lower income group on river water for their daily requirements in comparison to the higher income respondents, who had access to the piped water system and were not dependent on the river. Also, a substantial difference in the perception of water quality was seen based on education in Stretch 1 and Stretch 3. A pairwise comparison was conducted through a Bonferroni post-hoc test, to understand whether a difference existed between literate and illiterate, semi-literate and literate, or illiterate and semi-literate respondents. The result revealed a significant difference in the perception only among illiterate and literate respondents in Stretch 1 and 3. No difference in perception was observed between the illiterate and semi-literate, and the semi-literate and literate community. The literate people were more conservative in water quality perception compared to illiterate respondents.

3.2. Factors that influence public perception of water quality

The sensorial factor has emerged as the most important basis of public perception of water quality in all stretches and across all independent variables. Among the total sample surveyed, 93.8% considered parameters like taste, colour and odour as their basis of perception. On the contrary only a meagre 6.2% of the total respondents, mostly from the literate and semi-literate community from Stretch 2, based their perception on scientific parameters of water quality. The reasons for such findings can be attributed to the lack of access to scientific data and information and growing attention, investment and public debate on the revival of the river water quality in Stretch 2.

However, 46.9% of the respondents from Stretches 2 and 3, considered contextual indicators as another significant basis for developing water quality perception. The FGD revealed that the reason for this was visible drains carrying raw sewage into the river, the diminishing aquatic life, open defecation and the presence of trash on the banks.

Perception based on heuristic was notable only in Stretch 1 where water quality is good. The FGD findings indicate that this was primarily because people of this stretch have not experienced any negative consequence due to the river water quality in their knowledge and recall time. Significant difference was also observed between income groups and education groups in Stretch 1 while considering heuristic ($p < 0.001$) as the basis of perception. The illiterate lower income group primarily based their perception on sensorial factors and seldom considered heuristics as the basis of perception.

Culture and belief was not reported to be the prominent factor affecting perception except by a small percentage of male respondents in Stretch 3. The literature review also did not provide any succinct information on the cross linkage of culture, demographics and water quality perception. Several researchers have argued that traditions associated with culture and belief play a role in building perception about the environment (Larson *et al*., 2009; de França Doria, 2010). The findings of FGDs revealed that the respondents from an older age category were more critical about the deteriorating water quality as they had seen the river when it was cleaner. However, perception based on knowledge of scientific parameters did not resonate even in the FGDs. The participants said that unlike air pollution, which is broadcast both on television and on digital boards in the city, there were no mechanisms in place to share scientific information about the water quality. Refusal of animals to drink water from the river, stomach infection from consumption of vegetables grown on the river bank, and black coatings in the vessels in which river water was stored were other factors people cited as having influence on their perception.

3.3. Perception of sources of pollution

Domestic and industrial discharge was perceived to be the main cause of pollution irrespective of the socio-economic status and the place of residence of the respondents. Significant difference ($p < 0.001$) was observed in the perception about the sources of pollution among women of different education levels and income groups in Stretch 1. The reason for this, that emerged from the FGD, was that perception is highly dependent on personal experience. Since, interaction of the lower income women with the river water is for domestic use only; they are unable to perceive other sources of pollution. Furthermore, only 10% of the respondents of the literate group from Stretch 2 cited agriculture as a source of pollution; suggesting that the public is unable to perceive diffused sources of pollution, like agricultural activities, as the cause for deteriorating water quality of the river. Similarly, pollution due to customs and rituals was also perceived mainly by the literate respondents along all of the three stretches. The findings of the FGD reveal that education enables people to gain access to information and to visualize the problem from multiple perspectives. A small percentage (1.3%) of respondents could not identify specifically with the options provided in the questionnaire. They stated that the drains from Stretch 2 that bring untreated sewage directly to the river were responsible for polluting the river.

3.4. Significance of the river and risk perception

3.4.1. Significance of the river. The emotional and cultural significance of the river in the lives of the people was found to be the highest across all three stretches. Stretch 1 (88%) and Stretch 3 (79%) had a higher percentage of respondents who were emotionally and culturally connected with the river than Stretch 2 (52%). Significant differences in the responses towards cultural significance were observed between men and women in Stretch 2 ($p = 0.039$) and Stretch 3 ($p = 0.046$). Men were found to be more culturally connected than women. In addition, the environmental significance of the river was mentioned by 50% of the respondents in all of the three stretches. However, a significant difference was seen between literate, semi-literate and illiterate respondents in Stretches 2 ($p < 0.001$) and 3 ($p = 0.011$). Contrasting opinions were noted on the basis of income group in Stretch 2 ($p < 0.001$). Respondents from the higher income, literate category believed that the deteriorating water quality had an adverse impact on their quality of life, including health, and has had a great impact on the ecosystem of the river. Elevated levels of pollution in the middle stretch, in addition to the encroachment on flood plains and river catchment area, has led to depletion of the water resource, decrease in biodiversity, increase in air pollution and rise in extreme weather events like floods and drought.

Dependence on the river for their daily needs, like bathing and washing, was cited by 52% of the respondents. A contrast in responses was observed between income groups in Stretch 1 and among men and women in Stretch 2. The lower income group in Stretch 1 and illiterate and semi-literate women in Stretch 2 were more dependent on the river water for daily needs. However, only a meagre 13% of the overall respondents mentioned dependence on the river for their occupational needs. The findings of the FGD brought out that the deteriorating water quality has severely impacted the occupational significance of the river in the lives of people.

3.4.2. Risk perception. The percentage of the population perceiving risk due to changes in water quality of the river Yamuna was higher in Stretch 1 (93%) and Stretch 3 (88%), in comparison to Stretch 2 (73%), despite water quality being scientifically assessed as 'very bad' in Stretch 2 (Sharma *et al.*, 2015). Minimum direct exposure to the river in Stretch 2 was one of the reasons highlighted in the FGDs. Respondents further stressed the health associated risks with the river. The participants stated that the river was a breeding ground for mosquitoes, resulting in several vector-borne diseases. The foul smell emanating from the river triggered respiratory problems among the people living near the river. In addition, the poor surface water quality has led to the contamination of the ground water and the consumption of untreated water caused gastrointestinal and associated diseases. They also reported that the contaminants in the water caused skin infection when used for bathing. The respondents also elaborated upon the economic risk associated with the deteriorating water quality. The perception of impact due to the economic risk was higher in Stretch 2 (36%), followed by Stretch 3 (31%). The impact as mentioned by the respondents was primarily on the household budget, as they had to either purchase water for consumption or install expensive treatment systems to purify the water prior to use. Other impacts were loss of livelihood options, low return on vegetables grown on Yamuna plain, stagnation in prices of property close to the river and the effect on the metallic parts of household equipment. Environmental risks due to pollution in the river Yamuna were also stated by 46% of the total respondents. They indicated that it was not only polluting the surrounding air, but has also led to reduced rainfall and increase in temperatures over the last decade. An impact on the ecosystem by way of loss in aquatic life, reduced crops, and threat to migratory birds was perceived by several respondents. A significant difference in perception of economic and environmental risks was observed between income groups ($p = 0.031$) and education groups ($p < 0.001$). While the literate respondents were more concerned about the environmental risk due to pollution in the river, the lower income respondents felt it was more an economic risk. Social and cultural risk was mainly cited by 36% of the respondents from Stretch 1. Differences based on gender ($p < 0.001$) were observed; with a greater number of men than women citing social and cultural impact. Low self-esteem due to inferior quality of the river water was yet another impact mentioned by the respondents.

3.5. Water-related behaviour of public

The mean scores of eight Likert-scale questions that were used to ascertain water-related behaviour of the public are presented in Table 4. The findings of the survey support studies that attribute anthropogenic activities as a leading cause for river pollution (Brewer & Stern, 2005). With an average score of 4.2 the respondents agreed that degradation in water quality can be attributed to human behaviour. It was believed that the reasons for disposing of waste in water were not ignorance but habit or convenience. Although, the absence of penal action emerged as a primary reason behind pollution of the river, a lack

Table 4. Mean values of reasons behind water related behaviours and *p*-values between groups. Measured on a 5-point agreement scale with 1 representing strongly disagree and 5 representing strongly agree.

Independent variables	Mean score: Public action degrades water	Habit	Societal influence	Convenience	No alternate option	Ignorance	Absence of penalty	Need for awareness
Illiterate (I)	4.04	4.16	3.95	4.12	3.92	3.56	4.30	4.03
Semi-literate (SL)	4.17	4.02	3.81	3.98	3.89	3.29	4.34	4.30
Literate (L)	4.36	4.18	3.67	3.73	3.88	3.18	4.45	4.31
p-value ($\alpha = 0.05$)	**0.001**	0.161	**0.029**	**0.001**	0.942	**0.009**	0.300	**0.004**
Sig. L-I	**0.001**		**0.024**	**0.001**		**0.008**		**0.007**
L-SL	0.072		0.587	0.067		1.000		1.000
SL-I	0.461		0.596	0.618		0.134		**0.015**
Male	4.10	4.00	3.75	3.90	3.87	3.26	4.21	4.09
Female	4.33	4.27	3.85	3.94	3.93	3.41	4.06	4.37
p-value ($\alpha = 0.05$)	**0.001**	**0.001**	0.231	0.655	0.492	0.140	**0.001**	**0.001**
LI	4.13	4.07	3.85	3.92	3.91	3.47	4.42	4.18
MI	4.21	4.14	3.76	3.91	3.86	3.23	4.32	4.20
HI	4.45	4.29	3.80	4.00	4.05	3.35	4.45	4.45
p-value ($\alpha = 0.05$)	**0.030**	0.222	0.654	0.847	0.488	0.102	0.448	0.114
Sig. LI-MI	0.766							
LI- HI	**0.025**							
MI-HI	0.127							

of options to dispose of waste was also considered an important reason behind indiscriminate disposal. The respondents also agreed that behavioural patterns and the cultural landscape of society have an influence on their actions. They stated that if disposing of waste on the banks or in water has a societal sanction then individuals do not feel embarrassed in adopting that behaviour.

Further, three components with eigenvalues greater than 1 were extracted using PCA and FA to determine grouping of variables into important drivers which could help in bringing the required behavioural change in people. The factor loading of each variable is shown in Table 5. The first factor that has been extracted can be named as '*social drivers*', as items like habit, societal influence, and convenience load highly on it. The second factor can be called '*governance drivers*', as items like absence of penalty and awareness to bring in change in behaviour load heavily on it and the third factor can be named '*technology drivers*', as items like lack of disposal options and ignorance load highly on it. These components clearly outline the immediate reasons behind river water pollution; namely, lack of available infrastructure for proper disposal of waste, weak governance and the behavioural and cultural conundrums in the society.

4. Policy implications

The research brings out that public perceptions regarding water quality are primarily based on sensorial parameters and contextual indicators, underlining the primacy of aesthetic quality. The river water quality classification methods such as Water Quality Index (WQI) and *ambient water standards*, promulgated by regulatory agencies, are predominantly a measure of dissolved impurities in water, and

Table 5. Extraction of factors for grouping of variables.

	Component Matrix		
	Social	Governance	Technological
Public action degrades river water	0.437	0.343	−0.346
People dispose of waste in water and river bank due to personal habit	0.602	−0.201	−0.511
People dispose of waste in water and river bank due to societal influence	0.660	−0.409	−0.133
People dispose of waste in water and river bank due to convenience involved	0.673	−0.416	
People dispose of waste in water and river bank as no alternate option is available	0.479	−0.147	0.596
People dispose of waste in water and river bank due to ignorance	0.519	0.140	0.510
People dispose of waste in water and river bank due to absence of penalty	0.373	0.672	
Creating awareness can bring the required change in behaviour	0.496	0.540	

aesthetic parameters like floating solids, colour, odour, etc., though recognized as pollutants, are not a part of the water quality measurement standards. Further, the inability of people to perceive the water quality on the basis of scientific parameters often leads to misestimating of risks associated with water quality (Larson *et al*., 2009). Planners should ensure that the awareness programmes are designed in a way to help people develop a holistic understanding of the issues affecting water quality, and additional efforts should be undertaken to make actual water quality information available to them in comprehensible language. The study further suggests that the perception of sources of pollution is largely based on personal experience. People are unable to perceive non-point sources of pollution, like that from agricultural runoff, and they largely attribute pollution to the indiscriminate discharge from urban areas. The research also reveals that the perceptions of people and their preferences vary geographically, which highlights the necessity of undertaking surveys and FGDs, to acquire useful insights into public perception, knowledge, and preferences prior to planning interventions.

Research has shown that perceived benefits by the public from participation and a sense of ownership of the resource affects the willingness to participate (Jingling *et al*., 2010; Brandt & Svendsen, 2013; Marks *et al*., 2014). There is evidence from the study that while people attribute the cause for degradation of water quality to public action, they believe that the responsibility for cleaning the river lies with the government. The study also indicates that the adverse water-related behaviour by people is often due to habit and convenience rather than lack of infrastructure. While rivers provide social, cultural as well as economic benefits for the people, the study brings out that only a small percentage of the respondents are dependent on the river for occupational needs due to poor water quality. It is pertinent that policymakers should take these findings into consideration while designing river action plans and engage with influential actors such as community leaders, religious groups, and local elected representatives to catalyse apposite behavioural change among people. The respondents of FGDs were also of the opinion that water quality is not accorded the same level of importance as air quality. Success of use of mass media and digital display boards has been seen in the case of creating awareness about the air quality index in Indian cities (Times of India (ToI), 2015). Similar steps can be taken to inform communities about water quality levels. Furthermore, understanding local social norms and individual choices is also important for planning interventions and communication strategy. As brought out in the study, activities need to be undertaken at the community level in addition to the use of mass media platforms to mobilize public action. Finally, the findings reveal a more liberal assessment of water quality by women, and greater dependence of women, especially from rural areas, on the river for their daily needs, making them more vulnerable to infections associated with poor water quality. This finding demands adequate emphasis on gender mainstreaming in water management and integration of women in decision-making activities related to river management (United Nations Development Programme (UNDP), 2006).

5. Conclusion

This study is an attempt to report research that examines factors influencing public perception of water quality and public knowledge regarding sources of pollution, risk perception and water-related behaviour. The policymakers may subsequently use these findings to better address perceptions that underpin public behaviour, knowledge and associated action towards river water quality. The study brings out that technical interventions by way of building STPs and sewer diversion lines, as part of the YAP, do not seem to have had a positive influence on the perception of the public regarding water quality of the river, thereby signifying the need for a paradigm shift in strategy from a techno-centric approach to a people-centric approach, which takes into consideration the diverse viewpoints and cultural beliefs of all stakeholders. The authorities also need to simultaneously provide adequate infrastructure for waste disposal and put in place a robust mechanism for punitive measures against defaulters. In India, where people consider the river alive and sacred, a socio-emotional connection can also be leveraged to re-establish the community's sense of belongingness to the rivers and build grass-root government-public collaborations for enhanced effectiveness of intervention measures.

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Received 23 August 2016; accepted in revised form 3 January 2017. Available online 29 January 2018