Research Paper

Rural communities' perception of and willingness to pay for wastewater and stormwater management infrastructure in Bihar, India

Mohammad Rashid and Debapratim Pandit

ABSTRACT

Management of wastewater and stormwater is required for achieving total sanitation and conservation of fresh water resources. The wastewater and stormwater management (WSM) infrastructure suitable to rural areas is usually determined based on technical, environmental, and economic considerations and local communities' perception of infrastructure is ignored. This study analyses the rural communities' choice and perception of WSM infrastructure and their willingness to pay (WTP) for their improvement and maintenance. The households' choice and perception of different aspects of rural WSM infrastructure are determined using the RIDIT (relative to an identified distribution and transformation) analysis, service quality gap analysis, through establishing the relationship between households' satisfaction with individual aspects and overall quality of WSM, and WTP for the service improvement and maintenance. The study finds that rural people like to dispose of wastewater offsite as a good network of drains is found in the villages. However, several aspects of WSM are perceived as poor and require the attention of the policymakers. The rural households want improvement in several attributes and are willing to pay for the maintenance of improved service. The service quality of individual attributes of WSM infrastructure and socioeconomic characteristics of the households are essential determinants of their WTP.

Key words | India, rural, sanitation, user preferences, wastewater management, willingness to pay

Mohammad Rashid (corresponding author)
Debapratim Pandit
Department of Architecture and Regional Planning,
Indian Institute of Technology,
Kharagpur,
India
E-mail: *rashidgeog@gmail.com*

INTRODUCTION

Management of wastewater and stormwater in rural areas of India and other developing countries is essential for the improvement of sanitation services and conservation of fresh water resources and, subsequently, the environmental quality. Rural areas in India include settlements with less than 5,000 inhabitants, having a population density of less than 400 people per square kilometre, and where about 75% of the male working population are engaged in the primary sector (Census of India 2011). In most rural habitations, wastewater is directly discharged into the surrounding areas, mostly without treatment, which affects human health and the environment (Massoud *et al.* 2010; Lam *et al.* 2015; Teklehaimanot *et al.* 2015; Kurian *et al.* 2016). While several experts and government programmes in India recommend the use of on-site systems such as leach pit, root zone system, and others for wastewater and stormwater management (WSM) in rural areas (MoDWS 2013), all wastewater cannot be managed on-site due to lack of space, the problem of social acceptance and other factors (Massoud *et al.* 2010; Haase *et al.* 2011). Thus, offsite WSM systems are a necessity in most rural habitations. This requires considerable infrastructure and investment since it includes the collection, conveyance, treatment and disposal of wastewater generated from households, community spaces, effluents from poorly

doi: 10.2166/washdev.2020.033

designed household septic tanks and stormwater (MoDWS 2013). The provision of this infrastructure within the limited financial resources available with the service providers or rural administrative bodies is another challenge and requires active involvement of local communities in construction and maintenance in terms of both financial and physical (time/labour) contributions. The local communities' participation in such projects is influenced by their perception and preferences of various aspects of WSM (Hensher *et al.* 2005; Black & McBean 2017; Rashid & Pandit 2019a). The studies conducted in the field of rural sanitation have also found that perceived quality of provided sanitation services determines their functionality and maintenance (Rashid & Pandit 2017a, 2017b, 2018, 2019b). However, most of these studies have focused on users' perception of toilet attributes, and there is a need to analyse rural households' perception of various aspects of WSM infrastructure for overall improvement of sanitary environment in rural areas. In the case of management of wastewater, most of the studies have focused on the identification of wastewater treatment and disposal techniques most suitable to rural areas, and other aspects of WSM have remained neglected (Massoud *et al.* 2010; Haase *et al.* 2011; Kurian *et al.* 2016; MoDWS 2013; Lam *et al.* 2015). Therefore, the present study aims to analyse households' perceptions and preferences for various aspects of WSM infrastructure in rural areas and their willingness to pay (WTP) for improvement and maintenance of the services. This will help policymakers to design appropriate policies and programmes for providing adequate, acceptable and sustainable WSM infrastructure in rural habitations.

THEORETICAL BACKGROUND OF STUDY

The adequacy of WSM infrastructure to be provided in rural habitations of developing countries is often determined by experts based on economic, technical and environmental aspects and the factors determining their social acceptance is usually ignored (Starkl *et al.* 2013; Padilla-Rivera *et al.* 2016). Consideration of social concerns/acceptance is one of the significant pillars of sustainable service provision (Catlin *et al.* 2017) which is influenced by communities' perception and preferences of the service quality attributes of the service (Starkl *et al.* 2013; Mekala & Davidson 2016; Padilla-Rivera *et al.* 2016). Perceived service quality represents an important concept in understanding the ways how users appraise the service or infrastructure provision (Hou 2016; Rashid & Pandit 2017a), which in turn, affects their attitude and behaviour towards the use and maintenance of the service (Tumwebaze *et al.* 2013). Maintenance of the service is an important issue in developing countries because there have been several instances of failure of the WSM infrastructure and facilities due to lack of proper maintenance (Massoud *et al.* 2010). Incorporating the communities' perception and preferences of service quality attributes while providing WSM infrastructure in rural areas also provides a sense of ownership among the local communities, which influences the communities' WTP for its operation and maintenance (Al-Jayyousi 2003; Massoud *et al.* 2009). The analysis of households' WTP also helps in analysing the value rural households give to the improvement of various aspects of WSM infrastructure (Eboli & Mazzulla 2008).

In the literature, two approaches, namely, the stated importance method and the method of derived importance have been widely applied to analyse the perceived service quality. The derived importance method is considered more accurate than the stated importance method (de Oña & de Oña 2015). However, stated importance is required to establish the importance of service quality attributes perceived important by users before service delivery, particularly in cases where users have no experience of the service (Das & Pandit 2013; Rashid & Pandit 2017a). In this method, perceived service quality is established through the degree of importance directly stated by the users, whereas in the derived importance method, perceived service quality is determined through service quality gap analysis models and weighted perception models.

In the gap models, the perceived service quality is analysed by calculating the service quality gap in the service provision. The SERVQUAL and ZOT are some of the popular techniques of gap estimation which determine the perceived service quality through calculating the gap between users' perception and expectation and between desired and minimum acceptable service quality, respectively (Parasuraman *et al.* 1988; Shahin & Janatyan 2011; Kankam-Kwarteng *et al.* 2016; Rashid & Pandit 2019b). In

the weighted perception models, the perceived service quality is analysed by establishing the relationship between service quality gap or users' satisfaction with individual service quality attributes and overall service quality and/or WTP using regression, logistic regression, structural equation modelling and others (Eboli & Mazzulla 2008; Shahin & Janatyan 2011; Rashid & Pandit 2017b).

In recent times, several WTP methods have been applied by researchers for analysing users' WTP for the provision and improvement of drinking water and sanitation services in rural areas of developing countries (Whittington *et al.* 1990; Venkatachalam 2006; Gunatilake & Tachiiri 2012; Lema *et al.* 2012; Lienhoop *et al.* 2014; Rashid & Pandit 2018). Most of these studies have applied the contingent valuation method (CVM) for estimating WTP. While CVM has been often criticized for overstatement or understatement of WTP by the respondents, empirical studies have demonstrated that WTP can be accurately estimated with carefully designed and pre-tested CVM surveys (Memon & Matsuoka 2002; Venkatachalam 2004; Miller *et al.* 2011). The CVM studies estimate WTP using several elicitation formats such as dichotomous choice, open-ended, bidding game and payment card (Venkatachalam 2004). These elicitation formats have their own merits and limitations, and while none of the techniques have been proved to be perfect in eliciting true WTP (Venkatachalam 2004; Miller *et al.* 2011), most of the WTP studies conducted in developing countries have applied and recommended the use of bidding game format for eliciting WTP (Gunatilake & Tachiiri 2012).

Thus, all approaches adopted for analysing users' perception of service quality have some advantages and limitations. Hence, the present study determines rural households' perception of service quality attributes of WSM facilities using both the stated and derived importance methods.

METHODOLOGY

Selection of attributes of WSM

The attributes of rural WSM were identified from the available literature on wastewater management in rural and urban areas. The identified attributes were selected based on the researcher's analytical judgement of probable application of attributes in the rural Indian context. Next, the selected list was validated and revalidated through focus group discussions (FGDs) and experts' opinion survey, respectively. The attributes finally selected for the study are given in Table 1.

Study area and data collection

The data were collected in different stages, first from FGDs and then from experts' opinion and household surveys. Four FGDs, that lasted for an average of 2 hours, were conducted in four different villages with ten participants in each discussion in the year 2013. In the FGDs, rural households' perception and expectation of each service quality attribute of wastewater management were discussed in detail. The households' WTP for the provision and maintenance of WWM infrastructure was also discussed. Next, different CVM techniques were also tested in the FGDs and after observing the responses and the comfort level of the participants, the bidding game elicitation technique of CVM was found as appropriate. Although the bidding game format of WTP elicitation has some limitations, several precautions were taken in designing and conducting the bidding survey as specified by different researchers (Whittington *et al.* 1990; Mcfadden 1994; Gunatilake *et al.* 2007).

The questionnaire applied for the household survey was also tested in FGDs. The questionnaire includes questions on (a) the socioeconomic characteristics of the households and respondent, (b) degree of importance of attributes, (c) perceived service level for each of these attributes, (d) level of satisfaction for each attribute and overall service quality, (e) expected service levels for each attribute and (f) WTP for the provision and maintenance of the service in an open-ended format. The attributes' importance and level of satisfaction is rated on a five-point Likert scale (5 = very important; 4 = important; 3 = neutral; 2 = less important; 1 = not important) (5 = very satisfied; 4 = satisfied; 3 = neutral; 2 = dissatisfied; 1 = very dissatisfied), respectively. The validity of attributes identified after the literature review and FGDs were tested through experts' opinion surveys. A total of 20 experts from different fields, such as representatives of GPs, academicians, NGOs and government officials were surveyed. The experts were asked to rate the attributes on a five-point Likert scale (5 = very important; 4 = important; 3 = neutral; 2 = less important; 1 = not important).

Table 1 | Service quality attributes of WSM selected for the study

Attributes	Definition and units
Dissipation time of stormwater	Time is taken in the clearing of stormwater from streets and drains after heavy rain (minute/s)
Distance to community drains	The distance of community drains from the household (feet)
Availability of closed drains	Street length with closed/covered drains (percentage)
Availability of concrete drains	Street length with concrete drains (percentage)
Distance of wastewater treatment and disposal site	Distance of wastewater disposal site from individual household (metre)
Maintenance of drains	Repairing and replacement of damaged parts of community drains (instantly, routine, after some time, not fixed, never)
Overflow from drains	Frequency of flooding of streets during the rainy season (never, occasionally, frequently, always)
Frequency of drain cleaning	Frequency of drain channel cleaning (number of times/year)
System for wastewater disposal	The techniques of wastewater treatment and disposal at the community level (leach pit, septic tank, stabilization pond, duckweed pond, others)
Maintenance of wastewater disposal system	Replacement, repairing and cleaning of wastewater treatment systems (instantly, routine, after some time, not fixed, never)
Maintenance agency	Type of agency for maintenance of wastewater treatment and disposal systems (GP, NGO, SHG, PA, households, others)
Availability of drains	Street length with drains (percentage)

Finally, the data on the perceived service quality and WTP for WSM infrastructure were collected through conducting a household survey in six Gram Panchayats (local administrative units) of Gaya District in Bihar, India. All Gram Panchayats of the district were classified into six groups based on the quality of sanitation infrastructure, including access to toilets and availability of drains (Census of India 2011), to ensure inclusion of respondents with different levels of experience and awareness of the importance of improved sanitation services. Total sample size was determined to be 1,404 (including 10% of samples for incomplete and/or no responses) considering the total number of households in rural areas of the district. The total number of samples was first allocated to different Gram Panchayats (first stratum) and next to each village (second stratum) of the Gram Panchayats in proportion to the total number of households. The technique adopted for the sample size calculation is described in detail in the Appendix. Households within each village were randomly selected for conducting a questionnaire-based interview with an adult household member available at the time of survey.

The household surveys were conducted using the same questionnaire used during FGDs, with some modifications. The analysis of FGDs data revealed that a three-point Likert scale (3 = very important; 2 = important; 1 = little importance) would be more appropriate to measure the stated importance of attributes in the households' survey. Regarding the WTP, most of the participants of the FGDs have opined that rural households would pay for the maintenance and not for the construction or provision of WSM infrastructure. The participants also agreed to pay an average amount of INR 250 per year for the maintenance of provided WSM infrastructure. Therefore, in the WTP section of the final household survey, the bidding game format of CVM was used and respondents were asked if they were willing to pay INR 250 per year. Those who responded yes to this question were asked to state whether they would pay more and when the answer was yes, they were asked the amount in the open-ended format. When the response was no, the respondents were asked if they were willing to pay a lower value. In the case the response was yes, respondents were asked for the maximum amount they were willing to pay and when the response was no, the respondents were asked if they were willing to contribute in the form of time involving physical labour related to maintenance. The respondents who neither wanted to

pay money nor wanted to contribute in the form of time were asked to state the reasons for their choice.

Data analysis

The present research determines the rural communities' perception of attributes of WSM using different techniques. These techniques include the RIDIT analysis, which is applied to the stated importance data collected from the experts and households. This technique assigns a continuous quantitative value (varies between 0 and 1) to different categories of ordinal scale and the attributes rated on the scale through empirical cumulative probability transformation of scale (Jansen 1984; Rashid & Pandit 2017a). Next, a relationship between the households' satisfaction with individual attributes and overall quality of WSM was established using ordered logistic regression (OLR). The five categories of satisfaction scale for individual service attributes (independent variables) is dummy coded into 1 and 0 where 'very satisfied', 'satisfied' and 'moderately satisfied' categories are clubbed together as 1, and the 'dissatisfied' and 'very dissatisfied' categories are coded as 0. The overall service quality (dependent variable) was retained in its initial ordinal categories. This was done because first, the frequency of responses in the very satisfied and satisfied groups were few for some of the attributes and next, to ascertain the impact of individual attributes on overall quality in a form that would help to prioritize them. Several models of OLR were tested, and insignificant attributes with p values of more than 0.1 were removed from the final model. The regression coefficients estimated for the attributes are used to rank the attributes.

Service quality gap analysis is another technique applied to identify the rural communities' perception of WSM infrastructure. The gap in the service provision is determined by calculating the gap between perceived and expected service quality of individual attributes. While the zero differences in service quality are coded as 0, the difference of one and more is coded as 1 for each service attribute and each respondent. The proportion of households that found a gap in the service provision is used to determine the households' perception of different aspects of WSM infrastructure.

Finally, a relationship between the service quality gap for each attribute and WTP for maintenance is established using an OLR. The model also includes socioeconomic characteristics of the respondents as control factors. The respondents with zero WTP are initially eliminated from the data used to build the model. The attributes of WSM and socioeconomic factors with insignificant p values (>0.1) are also removed from the final model. The rankings of the attributes are determined using the regression coefficients calculated for the attributes.

RESULTS AND DISCUSSION

Socioeconomic description of respondents

The socioeconomic details of the respondents are presented in Table 2. The majority of respondents are males belonging

Table 2 | Share of survey respondents in different socioeconomic groups

Socioeconomic groups	% of total respondents
Total number of respondents	1,250
Age (years)	
<30	15
30–39	36
40–49	30
≥50	19
Level of education	
Illiterate	20
Primary school	17
Middle school	22
Secondary school	15
Senior secondary school	17
Graduation and above	9
Economic status	
Below poverty line (BPL)	35
Low income	24
Middle income	23
High income	18
Type of drains	
Concrete	51
Earthen	31
Mixed	18
Connectivity to community drains	
Yes	80
No	20

to the age group of '30–49 years'. Only 15% respondents are females, which is due to traditional family hierarchy and values that restrict females from freely interacting with outsiders in rural India, particularly with stranger males. Eighty per cent of the respondents reported the availability of some type of household drain and its connectivity with community drains. While household drains dispose of wastewater of a single household, community drains collect wastewater from a number of households and different segments of the habitation. Out of the total respondents with household drains, 51% have concrete drains, 31% earthen drains and 18% mixed drains (Table 1).

The existing condition of WSM infrastructure in villages

In surveyed villages, surface drains are found to be the preferable means for stormwater disposal and for disposing of the wastewater generated from the households and community facilities. Surface drains in the villages can be classified as household drains, and community drains. Household drains dispose of the wastewater of a single household whereas community drains collect wastewater from a number of households and different parts of the village. Community drains can further be classified into primary and secondary drains. Primary community drains run through the length and breadth of the village, and a majority of the households connect their wastewater outlets into these drains, which finally discharge the wastewater at the end of the habitation. Secondary community drains collect wastewater from two or more households and dispose of it into primary community drains, as shown in Figure 1. During the survey, most of the community drains were found to be open with concrete or earthen lining and inappropriately designed in terms of their profile with the width and depth remaining the same from the beginning to the end in many cases. Consequently, wastewater overflows from these drains frequently in the lower sections where a number of drains merge, and the number of households connected to a particular drain increases. Community drains are also not properly maintained and cleaned. The

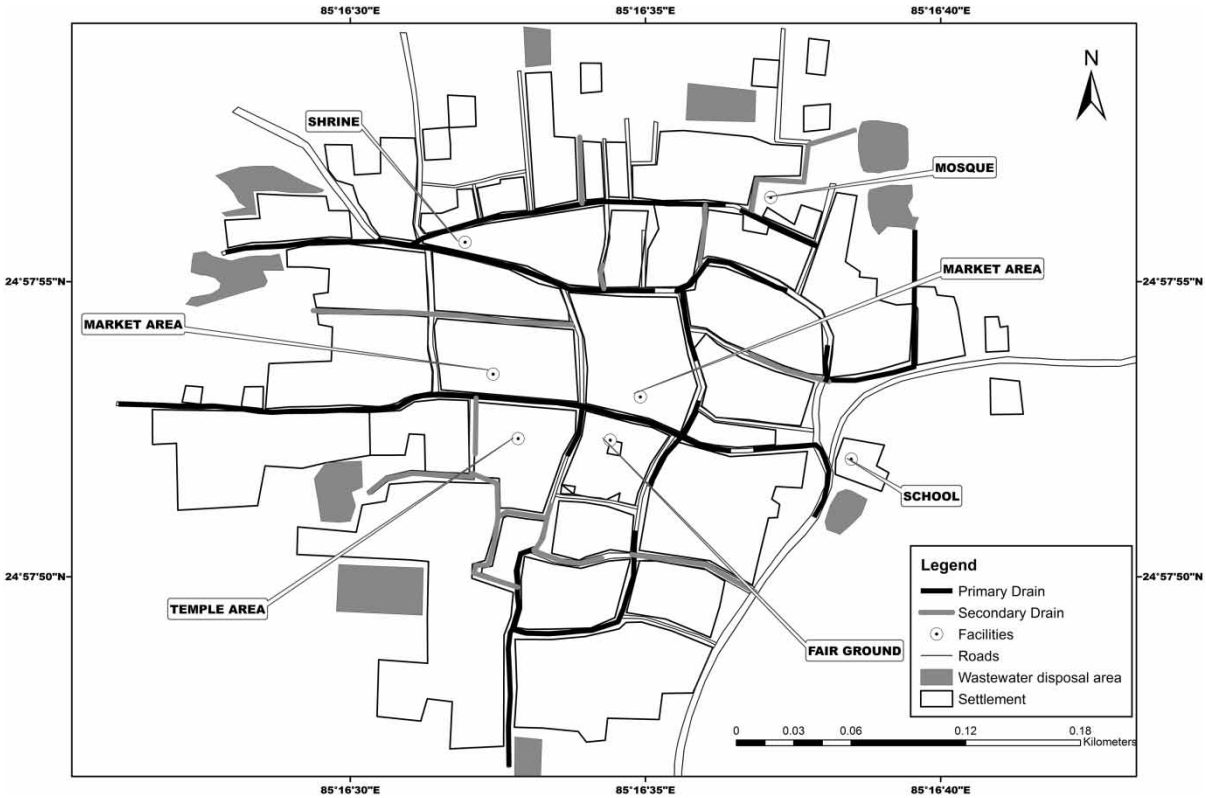

Figure 1 | WSM facilities and system in a surveyed village (Natesar).

drains were full of sediment and garbage, and in several places the lining of the concrete drains was broken. The villagers also stated that no one maintains and cleans the community drains except for a few households that clean the community drains located in front of their house, although not regularly. Proper wastewater treatment systems have also not been found in any of the surveyed villages, with only a few households stating that they use pits for wastewater treatment and disposal which is further reused for gardening. Some of the households also reported reusing the wastewater for gardening and irrigation of crops without treatment. The untreated wastewater from the primary drains is directly discharged onto agricultural land, waste land and different water bodies like tanks, ponds, canals and rivers. The households have reported several problems, such as foul odour, mosquitoes, rodents and others, resulting from improper wastewater disposal. The disposal of wastewater together with stormwater contaminates surface water bodies and underground water causing diseases, as reported by the villagers. Disposal of wastewater on agricultural land also leads to frequent fights and quarrels among the inhabitants of the villages due to loss of fertility of agricultural lands resulting from continuous discharge of wastewater on the same land. In some villages, ponds are used to collect wastewater, as shown in Figure 1. These ponds are used for fish rearing and crop irrigation as well as other purposes. They are small in size and usually overflow during the rainy seasons.

Determinants of rural communities' perception

Results of stated importance

Table 3 shows the attributes influencing the rural households' perception of WSM facilities derived from the importance stated by the respondents and the experts. The most important determinant of households' perception is 'dissipation time of stormwater from drains' followed by 'distance to community drains', and 'availability of drains' is stated as the least important determinant. While 'availability of closed drains' and 'availability of concrete drains' are considered as important, 'availability of drains' (availability of any drain in the street) is stated as less important. This is because drains were available in almost all streets of the surveyed villages, but closed and concrete drains were missing. Another reason for the lower importance given to 'availability of drains' is because villagers dislike the presence of open drains in every street. The experts consider 'maintenance of drains' as the most important attribute followed by 'distance to and type of wastewater treatment and disposal system', and they perceive the 'availability of concrete drains' as the least important. Some of the attributes like 'availability of closed drains' and 'maintenance of wastewater treatment and disposal system' are not rated by the experts because these attributes were included in the study after their suggestions.

Table 3 | Importance of attributes from households' and experts' perspective

	Users*		Experts**	
Attributes	**RIDIT value**	**Rank**	**RIDIT value**	**Rank**
Dissipation time of stormwater	0.37	1	0.51	8
Distance to community drains	0.38	2	0.62	9
Availability of closed drains	0.39	3	–	–
Availability of concrete drains	0.40	4	0.69	10
Distance of wastewater treatment and disposal site	0.47	5	0.39	2
Maintenance of drains	0.48	6	0.31	1
Overflow from drains	0.49	7	0.49	7
Frequency of drain cleaning	0.50	8	0.46	5
System for wastewater disposal	0.55	9	0.42	3
Maintenance of wastewater disposal system	0.62	10	–	–
Maintenance agency	0.63	11	0.43	4
Availability of drains	0.70	12	0.47	6

*Kruskal–Wallis statistics (W) = 1,900.94; critical Chi-square = 19.68; degree of freedom df (12 − 1) = 11; level of significance = 0.05.
**Kruskal–Wallis statistics (W) = 28.24; critical Chi-square = 16.92; degree of freedom df (10 − 1) = 9; level of significance = 0.05.

Analysis of satisfaction

The estimation of perception through establishing a relation between households' satisfaction for individual attributes and overall quality reflect the influence of individual attributes on the perception of overall quality and help in identifying attributes that need improvement to increase the users' satisfaction of overall quality. The results of the OLR presented in Table 4 show that the attributes included

Table 4 | Determinants of households' perception of the overall quality of WSM

Attributes	Estimate	95% Confidence interval		Ranks
		Lower bound	Upper bound	
Distance to community drain	2.012*	1.508	2.516	6
Dissipation time of stormwater	2.251*	1.776	2.726	5
Overflow of drain water	2.863*	2.434	3.291	1
Frequency of drain cleaning	1.210**	−0.317	2.738	11
Distance to wastewater disposal site	2.409*	2.012	2.807	3
Availability of drains	1.649*	0.478	2.821	10
Availability of concrete drains	1.799*	1.297	2.302	8
Availability of closed drains	1.914*	1.037	2.791	7
System for wastewater disposal	1.771*	0.398	3.143	9
Maintenance of drains	2.598*	2.012	3.184	2
Maintenance agency	2.298*	1.795	2.802	4
Model fit				
−2LL (intercept)	1,205.882			
−2LL (final)	244.779			
Chi-square (df = 11)	961.105*			
Nagelkerke R^2	0.707			

**p value ≤ 0.10; *p value ≤ 0.05.

in the model can explain about 71% of variations in rural households' satisfaction of overall service quality of WSM facilities. The findings indicate that while 'overflow of drain water', 'maintenance of drains' and 'distance to wastewater disposal site' are major determinants, 'frequency of drain cleaning' is the least important determinant of households' satisfaction of overall service quality of WSM infrastructure. The lower importance of 'frequency of drain cleaning', 'type of wastewater treatment system' and 'availability of covered drains' in determining overall satisfaction is due to users' lack of experience of these attributes as these service aspects were absent in most of the villages and users were asked to state their satisfaction level against the available service quality.

While the relative importance of 'availability of drains' and 'wastewater disposal system' is low, which is similar to earlier findings on stated importance of attributes, the derived and stated importance of other attributes vary significantly. The low level of derived and stated importance of the above-mentioned attributes may be due to rural people's experience of the service. In the case of 'availability of drains', drains are available in almost all streets of the villages and several people have stated that they do not like the presence of drains in all streets. Wastewater disposal systems were not found in several villages, and people are thus not aware of their advantages and disadvantages, which may be a reason for the low importance of attributes. The derived weights of some attributes are more close to the weights given by the experts, except for a few attributes where experts' ranking and users' ranking of attributes differ from each other.

Gap analysis

The results of the gap model are presented in Table 5, and shows that improvement of 'distance to community drains' and 'availability of closed drains' would improve the rural households' perception of WSM infrastructure. Maintenance of provided facilities is another important concern of the households as a considerable proportion of households want improvement in 'maintenance agency' and 'maintenance of drains'. The gap for 'frequency of drain cleaning' is not estimated because the attribute is not applicable in any of the villages. While comparing the results of a gap analysis with the results of earlier techniques shows that although more than 90% of households want

Table 5 | Proportion of households that expect improvement in attributes of WSM facilities

Attributes	Percentage of households	Rank
Dissipation time of stormwater	53	9
Distance to community drains	98	1
Availability of closed drains	97	2
Availability of concrete drains	63	7
Distance of wastewater disposal site	49	10
Maintenance of drains	85	5
Overflow from drains	69	6
Frequency of drain cleaning	–	–
System for wastewater disposal	97	2
Maintenance agency	91	4
Availability of drains	55	8

improvement in 'distance to community drains', availability of closed drains, and wastewater disposal systems, their influence on households' satisfaction of overall quality is less. On the other hand, some attributes such as 'distance to wastewater disposal site', 'overflow from drains' and others have higher impact on overall quality, but their relative weights in the gap model are low. These findings suggest that users' experience and awareness of service influences their degree of satisfaction of service quality. The relative importance of attributes determined through the gap model is closer to the weights given by the experts, with some exceptions.

Willingness to pay

A considerable proportion (80%) of the sampled households is found to be willing to pay for the maintenance of improved WSM infrastructure and facilities, as shown in Figure 2. A majority of the households (53%) was comfortable in paying INR 250. The households (31%) who did not want to pay money have stated to contribute their time involving physical labour for maintenance works. The respondents that neither want to pay in cash nor are interested to contribute their time have stated different reasons for their unwillingness. The majority of the households have stated 'government should pay' (32%) and expected 'failure of the program' (32%) as the reasons for their unwillingness to contribute cash or time, as shown in Figure 2.

Figure 3 presents the households' demand and the maintenance cost they want to pay for the WSM infrastructure. The average amount they want to pay is about INR 246 and the confidence interval of WTP at 90% is INR 243–249. The findings indicate that about 97% of respondents would pay a maintenance cost of about INR 250. The change in the proportion of respondents' WTP for maintenance cost is relatively lower, from INR 250 to INR 350, but WTP sharply declines above INR 350, as shown in Figure 3.

This section discusses the influence of perceived service quality of attributes of WSM infrastructure and impact of socioeconomic factors on rural households' WTP. The Nagelkerke pseudo R^2 of the model (0.590) suggests that about 59% variation in households' WTP can be explained through the rural households' perception of various service quality attributes and their socioeconomic characteristics, as shown in Table 6. However, the influence of socioeconomic

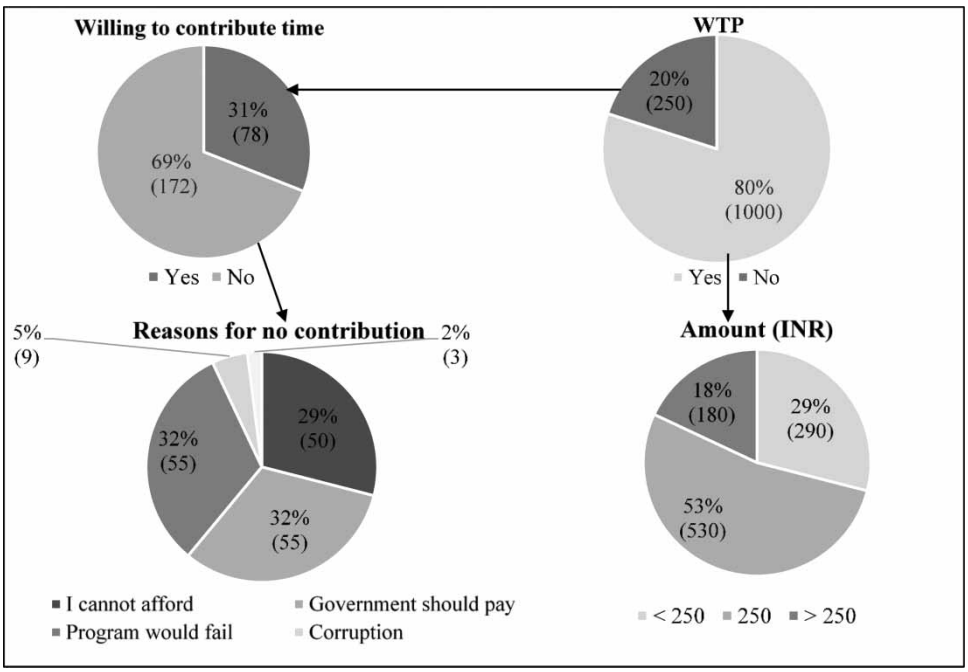

Figure 2 | Different aspects of WTP for the maintenance of WSM infrastructure.

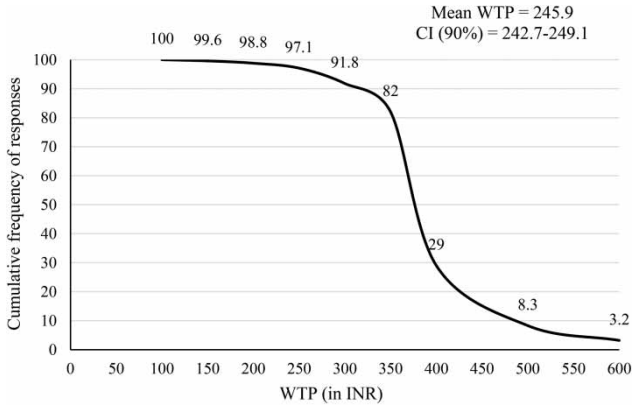

Figure 3 | Households WTP for the maintenance of improved WSM facilities.

Table 6 | Ordered logistic regression analyses of determinants of WTP for maintenance

Variables	Estimate	95% Confidence interval		Rank
		Lower bound	Upper bound	
Maintenance of drains	1.064**	0.438	1.690	1
System for wastewater disposal	0.574**	0.192	0.957	2
Availability of closed drains	0.543**	0.232	0.855	3
Availability of concrete drains	0.340**	0.035	0.646	4
Frequency of overflow	0.331**	0.040	0.622	5
Distance to wastewater disposal site	0.306*	−0.038	0.650	6
Dissipation time of stormwater	0.272*	−0.056	0.599	7
Level of education				
Illiterate	Reference			
Lower primary school	0.679**	0.214	1.143	
Upper primary school	1.153**	0.704	1.602	
Secondary school	1.868**	1.352	2.385	
Senior secondary school	1.975**	1.444	2.505	
Higher education	2.239**	1.578	2.899	
Economic status				
Below poverty line	Reference			
Low income group	1.103**	0.735	1.472	
Middle income group	3.423**	2.968	3.879	
High income group	3.546**	3.031	4.062	
Model fit				
−2LL (intercept)	1,815.32			
−2LL (final)	1,095.01			
Chi-square (df = 18)	720.32**			
Nagelkerke R^2	0.590			

*p value ≤ 0.10; **p value ≤ 0.05.

factors on WTP is more than the perceived service quality of the attributes. The improvement of perceived service quality of various attributes such as 'maintenance or cleaning of drains', 'wastewater disposal system', 'availability of closed drains' and a few others would influence the households' attitude towards WTP for the operation and maintenance of WSM facilities. In the case of socioeconomic factors, economic status of the respondents has a greater influence on WTP than level of education. The respondents with a higher level of education and income would be likely to contribute more money than the illiterate and less educated respondents and poor people. While WTP values estimated in the study are not accurate and do not match with actual maintenance cost in real life, it gives an idea about rural people's WTP for improvement and maintenance of different aspects of WSM infrastructure and helps in analysing the impact of perceived quality on WTP and vice versa.

CONCLUSION

The current research finds that rural people prefer to dispose of wastewater offsite because every village has a good network of drains used to dispose of household wastewater and stormwater. Therefore, policymakers should not only focus on the provision of on-site wastewater treatment and disposal systems, but offsite treatment and disposal systems should also be provided in rural areas. Further, most of these villages lack proper infrastructure for wastewater treatment and disposal, which remains stagnant in nearby ditches for several days, creating another set of problems. Hence, it is required to provide proper infrastructure in villages for WSM.

The study finds that rural communities' perception of WSM infrastructure depends on the quality of different aspects and it also influences their WTP. The findings of the study suggest that the attributes of WSM influencing rural households' perception vary across approaches applied in the study for analysing perception and preferences. Therefore, it is necessary to apply different approaches for analysing rural households' perceptions while formulating policies on rural WSM in future. The importance of attributes estimated using derived methods is more close to the weights of attributes assigned by the

experts. However, the relative weights of some attributes vary between households and the experts. Therefore, local communities' perception should also be considered while planning and designing WSM facilities for rural areas.

In the study, WTP is included to see its effect on villagers' desire for improvement in service quality of the WSM infrastructure. The results suggest that a majority of rural households are willing to contribute either money or time for the maintenance of WSM facilities, but they do not want to contribute to the provision of infrastructure. Therefore, it is necessary to make them aware of the importance and benefits of WSM because WTP increases with an increase in level of education as found in the current research. The dominance of male respondents in the study may have an influence on the results and this should be addressed in future works.

The findings of the present research can be used by local government agencies and organizations concerned with the improvement of rural sanitation for providing WSM infrastructure as per the perception and choice of the local population. However, there is a need to study the perspectives of households belonging to different socioeconomic groups and regions as perception varies from person to person over space and time and this aspect should be dealt with in future research.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this paper is available online at https://dx.doi.org/10.2166/washdev.2020.033.

REFERENCES

Al-Jayyousi, O. R. 2003 Greywater reuse: towards sustainable water management. *Desalination* **156**, 181–192. http://doi.org/10.1016/S0011-9164(03)00340-0.

Black, K. & McBean, E. 2017 Analysis of challenges and opportunities to meaningful indigenous engagement in sustainable water and wastewater management. *Water Policy* **19** (4), 709–723. http://doi.org/10.2166/wp.2017.078.

Catlin, J. R., Luchs, M. G. & Phipps, M. 2017 Consumer perceptions of the social vs. environmental dimensions of sustainability. *Sustainability Science* **40**, 245–277. doi:10.1007/s10603-017-9356-x.

Census of India 2011 *Percentage of Households to Total Households by Amenities and Assets*. Available from: http://www.censusindia.gov.in/2011census/HLO/HL_PCA/Houselisting-housing-BR.html

Das, S. & Pandit, D. 2013 Importance of user perception in evaluating level of service for bus transit for a developing country like India: a review. *Transport Reviews* **33** (4), 402–420. http://doi.org/10.1080/01441647.2013.789571.

de Oña, J. & de Oña, R. 2015 Quality of service in public transport based on customer satisfaction surveys: a review and assessment of methodological approaches. *Transportation Science* **49** (3), 605–622. http://doi.org/10.1287/trsc.2014.0544.

Eboli, L. & Mazzulla, G. 2008 Willingness-to-pay of public transport users for improvement in service quality. *European Transport* **38**, 107–118.

Gunatilake, H. & Tachiiri, M. 2012 *Willingness to pay and inclusive tariff designs for improved water* supply services in Khulna, Bangladesh. South Asia Working Paper Series, Asian Development Bank, Manila, Philippines. http://doi.org/10.5539/jsd.v7n5p212.

Gunatilake, H., Jui-Chen, Y., Subhrendu, P. & Kyeong, A. C. 2007 *Good Practices for Estimating Reliable Willingness-To-Pay Values in the Water Supply and Sanitation Sector*. ERD Technical Note 23. Asian Development Bank, Manila, Philippines. Available from: https://www.adb.org/sites/default/files/publication/29866/tn-23-good-practices-willingness-pay-values.pdf

Haase, P. H., Wang, S., Zhao, J. & Chandra, G. 2011 *Guide for Wastewater Management in Rural Villages in China, Water Partnership Program*. World Bank, Washington, DC, USA.

Hensher, D., Shore, N. & Train, K. 2005 Households' willingness to pay for water service attributes. *Environmental and Resource Economics* **32** (4), 509–531. https://doi.org/10.1007/s10640-005-7686-7.

Hou, D. 2016 Divergence in stakeholder perception of sustainable remediation. *Sustainability Science* **11**, 215–230. doi:10.1007/s11625-015-0346-0.

Jansen, M. E. 1984 Ridit analysis, a review. *Statistica Neeralandica* **38** (3), 141–158.

Kankam-Kwarteng, C., Acheampong, S. & Amoateng, F. 2016 Service quality and customers' willingness to pay for vehicle repairs and maintenance services. *Journal of Scientific Research and Reports* **10** (5), 1–11. http://doi.org/10.9734/JSRR/2016/24918.

Kurian, M., Reddy, V. R., Dietz, T. & Brdjanovic, D. 2016 Wastewater re-use for peri-urban agriculture: a viable option for adaptive water management? *Sustainability Science* **8**, 47–59. doi:10.1007/s11625-012-0178-0.

Lam, L., Kurisu, K. & Hanaki, K. 2015 Comparative environmental impacts of source-separation systems for domestic wastewater management in rural China. *Journal of Cleaner Production* **104**, 185–198. http://doi.org/10.1016/j.jclepro.2015.04.126.

Lema, Z., Beyene, F. & Ababa, A. 2012 Willingness to pay for improved rural water supply in Goro-Gutu District of Eastern Ethiopia: an application of contingent valuation. *Journal of Economic and Sustainable Development* **3** (14), 145–160.

Lienhoop, N., Al-Karablieh, E. K., Salman, A. Z. & Cardona, J. A. 2014 Environmental cost-benefit analysis of decentralised wastewater treatment and re-use: a case study of rural Jordan. *Water Policy* **16** (2), 323–339. http://doi.org/10.2166/wp.2013.026.

Massoud, M. A., Tarhini, A. & Nasr, J. A. 2009 Decentralized approaches to wastewater treatment and management: applicability in developing countries. *Journal of Environmental Management* **90**, 652–659. http://doi.org/10.1016/j.jenvman.2008.07.001.

Massoud, M. A., Tareen, J., Tarhini, A., Nasr, J. & Jurdi, M. 2010 Effectiveness of wastewater management in rural areas of developing countries: a case of Al-Chouf Caza in Lebanon. *Environmental Monitoring and Assessment* **161**, 61–69. http://doi.org/10.1007/s10661-008-0727-2.

Mcfadden, D. 1994 Contingent valuation and social choice. *American Journal of Agricultural Economics* **76** (4), 689–708. Available from: www.jstor.org

Mekala, G. D. & Davidson, B. 2016 A review of literature on the factors affecting wastewater treatment and recycling across a broad spectrum of economic stages of development. *Water Policy* **18** (1), 217–234. http://doi.org/10.2166/wp.2015.191.

Memon, A. M. & Matsuoka, M. 2002 Validity of contingent valuation estimates from developing countries: scope sensitivity analysis. *Environmental Economics and Policy Studies* **5**, 39–61.

Miller, K. M., Hofstetter, R., Krohmer, H. & Zhang, Z. J. 2011 How should consumers' willingness to pay be measured? an empirical comparison of state-of-the-art approaches. *Journal of Marketing Research* **48** (1), 172–184. http://doi.org/10.1509/jmkr.48.1.172.

MoDWS 2013 *Technical Options for Solid and Liquid Waste Management in Rural Areas*. Government of India, New Delhi, India.

Padilla-Rivera, A., Morgan-Sagastume, J. M., Noyola, A. & Güereca, L. P. 2016 Addressing social aspects associated with wastewater treatment facilities. *Environmental Impact Assessment Review* **57**, 101–113.

Parasuraman, A., Zeithmal, V. A. & Berry, L. L. 1988 SERVQUAL – a multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing* **64** (1), 12–40.

Rashid, M. & Pandit, D. 2017a Determination of appropriate service quality attributes for household toilets in rural settlements of India based on user perception. *Environment, Development and Sustainability* **19** (4), 1381–1406. http://doi.org/10.1007/s10668-016-9807-6.

Rashid, M. & Pandit, D. 2017b Service quality of household toilets in rural settlements of India: an assessment from users' perspective. *Journal of Water Sanitation and Hygiene for Development* **7**, 589–600. http://doi.org/10.2166/washdev.2017.054.

Rashid, M. & Pandit, D. 2018 Determination of appropriate service delivery level for quantitative attributes of household toilets in rural settlements of India from users' perspective. *Environmental Management* **61**, 637–649. http://doi.org/10.1007/s00267-017-0987-0.

Rashid, M. & Pandit, D. 2019a Determining the provision of wastewater management infrastructure in rural India from the local communities' perspective. *Water Science and Technology* **79** (3), 489–500. https://doi.org/10.2166/wst.2019.074.

Rashid, M. & Pandit, D. 2019b Analysis of service quality of household toilets expected by households practicing open defecation: a study in rural settlements of Bihar, India. *Environment, Development and Sustainability* **21**, 2487–2506. http://doi.org/10.1007/s10668-018-0145-8.

Shahin, A. & Janatyan, N. 2011 Estimation of customer dissatisfaction based on service quality gaps by correlation and regression analysis in a travel agency. *International Journal of Business and Management* **6** (3), 99–108. http://doi.org/10.5539/ijbm.v6n3p99.

Starkl, M., Stenström, T. A., Roma, E., Phansalkar, M. & Srinivasan, R. K. 2013 Evaluation of sanitation and wastewater treatment technologies: case studies from India. *Journal of Water, Sanitation and Hygiene for Development* **3** (1), 11. http://doi.org/10.2166/washdev.2013.099.

Teklehaimanot, G. Z., Kamika, I., Coetzee, M. A. A. & Momba, M. N. B. 2015 Population growth and its impact on the design capacity and performance of the wastewater treatment plants in Sedibeng and Soshanguve, South Africa. *Journal of Environmental Management* **56**, 984–997. doi:10.1007/s00267-015-0564-3.

Tumwebaze, I. K., Orach, C. G., Niwagaba, C., Luthi, C. & Mosler, H.-J. 2013 Sanitation facilities in Kampala slums, Uganda: users' satisfaction and determinant factors. *International Journal of Environmental Health Research* **23** (3), 191–204. http://doi.org/10.1080/09603123.2012.713095.

Venkatachalam, L. 2004 The contingent valuation method: a review. *Environmental Impact Assessment Review* **24** (1), 89–124. http://doi.org/10.1016/S0195-9255(03)00138-0.

Venkatachalam, L. 2006 Factors influencing household willingness to pay (WTP) for drinking water in peri-urban areas: a case study in the Indian context. *Water Policy* **8** (5), 461–473. http://doi.org/10.2166/wp.2006.055.

Whittington, D., Briscoe, J., Mu, X. & Barron, W. 1990 Estimating the willingness to pay for water services in developing countries: a case study of the use of contingent valuation surveys in Southern Haiti. *Economic Development and Cultural Change* **38** (2), 293. https://doi.org/10.1086/451794.

First received 1 November 2018; accepted in revised form 13 December 2019. Available online 17 January 2020