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ORIGINAL ARTICLE

Knowledge, behavior, and drivers of residents' willingness to pay for a sustainable solid waste collection and management system in Mymensingh City, Bangladesh

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Abstract
Excessive waste generation and ineffective waste management systems in developing cities have become a major challenge in achieving urban sustainability. As a developing city, Mymensingh City Corporation (MCC) is no exception. The demand for sustainable waste collection and management is increasing gradually. This study aimed to (i) document the existing solid waste collection and management system (SWCMS) of MCC and to (ii) explore the drivers and calculate the residents' willingness to pay for a sustainable SWCMS in MCC. The study conducted several field surveys with a structured questionnaire for primary data collection. We have employed the payment card approach of the contingent valuation method to calculate the willingness to pay (WTP). We used the Pearson's correlation model and the logistic regression model (considering WTP as a dependent variable) to evaluate the influences of different driving factors on WTP. Results show that the insufficient manpower, technological, and financial paucity of MCC authorities is responsible for poor SWCMS in Mymensingh. About 68.49% of people are not satisfied with the existing SWCMS. Approximately 85.42% of total respondents agreed to pay 283.38 Tk/month (USD 3.38 per month) for a sustainable SWCMS in MCC. Findings suggest that people's income, education, and employment have a strong positive influence, and that age, household size, and satisfaction level have a negative influence on residents' WTP. The study can help responsible authorities and policymakers develop and adopt efficient and optimal solid waste collection and management policies for immediate execution, focusing on future requirements.

Keywords Sustainable waste collection and management system · Contingent valuation method · Willingness to pay · Mymensingh city corporation

Introduction

Waste management activities shape environmental protection in sustainable development. Rapid population growth and economic growth have profoundly accelerated urbanization and industrialization and changed the living standards of the public, which has resulted in an increase in municipal solid waste (MSW) generation in the cities of Bangladesh. The amount of per-capita waste generation is 0.56 kg/day at present and is estimated to rise to 0.75 kg/day by 2025 [1]. The increase in solid waste generation and improper management of waste have been contributing largely to greenhouse gas emissions and all types of environmental pollution and are affecting the long term. Unmanageable waste accumulation harms the urban environment, destroys the landscape, spreads diseases, and affects human health [2, 3]. This problem is more severe in most developing cities. Besides affecting human health, it also affects the Gross Domestic Product (GDP) growth of a country [4]. The cities of Bangladesh have the highest exposure to environmental degradation due to poor solid waste collection and management systems (SWCMS) [5]. The government of Bangladesh has been growing concerned about environmental protection and sustainable development. In this regard, several policies have been adopted, but most of these policies emphasize the regulation and laws for environmental protection and pay less attention to the importance of public participation.

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Improper collection and management of MSW causes serious environmental pollution. Improper waste collection and management systems lead to clogged waste drains, stagnant water where insects breed, and also cause waterlogging during the rainy season [6]. This pollution pollutes soil, water, and groundwater. Waste is a major source of greenhouse gases, and the burning of waste pollutes the air. Organic waste decomposition in landfills produces greenhouse gases, and untreated leachate pollutes nearby soil and water. Improper SWCMS also affects human health and safety. The solid waste management system in the developing cities, especially in the cities of Bangladesh, is comparatively more acute than in many other developing countries. The urban population in the cities of Bangladesh has been increasing rapidly, as have urban activities [7]. Concerned found that it is mostly responsible for the production of a large volume of solid waste in Bangladesh. The waste generation rate ranges between 0.2 and 0.56 kg/cap/day in different cities in Bangladesh [8]. From 1971 to 2015, the waste generation increased from 11,00,000 tons to 52,00,000 tons with a rate of 1,34,300 tons/year [5]. Households account for 78% of solid waste generation in Bangladesh, followed by the commercial sector (20%), the institutional sector (1%), and other sectors [8]. The per-capita waste generation rate is projected to increase to 0.75 kg/cap/day, and the total waste generation volume will be 57,718 tons/day by 2025 [1].

Urban waste management is crucial as generated waste is often transported to areas outside urban areas for processing and treatment. The repercussions of waste disposal operations may be passed on to other jurisdictions or even future generations [9]. Sustainable SWCMs refer to the collection, transport, valuation, and disposal of waste in a way that does not cause any negative impact on the environment, human health, or future generations. Sustainable SWCM promotes minimal waste generation, proper collection, transportation, and disposal of waste without harming the environment. It encompasses any activity that is engaged in the organization of waste management, from the point of production to the point of final disposal. The circular economy's fundamental principle is sustainable waste management, which provides several opportunities and advantages to the economy, society, and environment [10]. Sustainable waste management includes collecting, sorting, treating, recycling, and, when correctly enabled, providing a source of energy and resources. As a result, it creates jobs, improves waste management systems, and reduces the environmental impact of human activities, consequently improving air and water quality. It also minimizes food waste, environmental costs, and prevents some human health problems, all of which contribute to a better quality of life. These contrasting the significance of sustainable SWCMS in any urban areas. Therefore, it is crucial to assess the existing scenario of SWCMS of any urban unit, appraising the daily waste generation at the household level, collection system, transportation, and disposal of wastes as well as the costs of collecting, transporting, and sorting the generated wastes to overcome the existing limitations.

Solid waste management is an essential and ancient phenomenon as it has profound effects on the environment as well as living beings. Since 1971, Bangladesh has been practicing the traditional management system. In Bangladesh, waste management allowed the disposal of waste into water bodies, indiscriminate open dumping, landfilling, burning, and direct disposal in rural areas. In urban areas, night soil collection was handled by Bullock Cart for solid waste collection, as well as nighttime waste collection and house-to-house collection by the city corporation. With the passage of time, the country's waste management system evolved from a traditional one to a modern one. Bangladesh has switched from waste management to resource management as waste is now considered a resource. Recently, the recycling and composting of organic wastes have been started in some cities. For improving the SWCMS, many initiatives were taken by the government of Bangladesh [1], but due to low awareness, technological and financial paucity, lack of motivation, and insufficient workforce, about 40% to 60% of waste remains uncollected and not disposed of [8]. The waste collection system faces numerous problems in the cities of Bangladesh, such as, an increasing population, unconsciousness of people, an insufficient workforce, variations in household conditions, poor urban planning, and lack of awareness of the environmental pollution of solid waste. Besides these, being a developing economy, the poor economic condition of Bangladesh is largely responsible for this [1, 5]. In this regard, the compensation fund is important for the city residents to ensure sustainable SWCMS to protect the environment and human health as well as maintain sustainable urban neighborhoods.

Considering SWCMS as a hot topic, various studies have documented the SWCMS of different cities around the world and also documented the health and environmental impacts of poor SWCMS in prior studies [11–15]. However, few studies have examined the environmental and health impacts of solid waste on nearby residents [16–18]. Most of the prior studies explored waste collection systems and their health and environmental impacts. An insufficient number of studies documented the residents' attitudes towards paying for a sustainable SWCMS. Some researchers have explored residents' willingness to pay (WTP) for improved waste collection systems in several cities around the world [19, 20]. In this regard, one of the most widely used tools is the Contingent Valuation Method (CVM). CVM is a review-based monetary appraisal method for the assessment of non-market assets [21]. Contingent valuation strategy follows the most extreme measure of cash that individuals are eager to spend on improving the nature of any assistance, to keep up the presence of an ecological component are deciding through this strategy. This strategy assists with assessing the worth that an individual spots on a good [22]. The approach asks individuals to reveal their WTP to get any offices, or willingness to acknowledge (WTA) to

surrender a decent, instead of inducing it from watched practices in customary commercial centers. Another method, the hedonic pricing method (HPM), is also used for the evaluation of environmental economics. The HPM focuses on market values of goods and services, that's why it is more difficult and expensive to apply than the CVM [3, 19, 21]. CVM is widely used in developed, developing and under developing countries for assessing different environmental goods and services [23–27]. The CVM of solid waste management studies also conducted in developing countries, Pakistan [28], Ethiopia [29], Malaysia [30], Nepal [31], China [32], India [33]. The WTP has been employed in several studies in Bangladesh, including Gunatilake and Tachiri [34] for an improved water supply system, Sehreen et al. [35] for water pollution control, Ahmed et al. [36] for health insurance, Ahsan et al. [37] and Islam et al. [38] for safe drinking water. Prior studies showed the impacts of a few factors on the residents' WTP for improved waste collection and management systems. In Bangladesh, very few studies focused on the residents' WTP for the sustainable SWCMS using CVM. For example, Afroz et al. [7] adopted the CVM with WTP of the household for an improved waste management system in Dhaka City in 2009. However, no prior study calculated the WTP for sustainable SWCMS where they introduced the residents to waste recycling in the cities of Bangladesh. Besides, the evaluation of the knowledge, attitudes, and willingness of the residents towards sustainable SWCMS has not been conducted in Bangladesh till now, particularly by projecting the future waste generation on a large scale, which in itself is the novelty of this research.

To fill the aforementioned knowledge gaps, this study, the first of its kind, investigated the existing waste collection and management scenario of one of the major cities in Bangladesh and also assessed the knowledge, behavior, and drivers of residents' WTP for a sustainable SWCMS using the CVM. Also calculated the daily waste generation at the household level, as well as the costs of collecting, transporting, and sorting these wastes, and forecasted future waste generation in Mymensingh. The findings of the study will help policymakers about the financial contribution of city residents to the sustainable SWCMS, and will have policy implications for the sustainable waste management sector in developing countries.

Methods and materials

Study area

Bangladesh is a developing country. Bangladesh is the world's 33rd nominal and 31st largest purchasing power parity economy. In 2021, the GDP of the country was $23.00 trillion, with a per-capita income of $2.91 and a 5.3% unemployment rate (5.6% of the employed population earns less than $1.90 a day). Since 2004, the average GDP growth was 4.5%, which was mainly driven by domestic agricultural sectors, readymade garment exports, and remittances. The key export sectors are textiles, seafood, fish, shipbuilding, leather, and jute goods. About 20.5% of the population lives below the national poverty line. Mymensingh is one of the major financial centers of Bangladesh, located between 24°15' and 25°12' north latitudes and between 90°04' and 90°49' east longitudes. The Mymensingh division is located in the Haor & Char region, mainly characterized by remote areas flooded every year during the monsoon season. Mymensingh City Corporation (MCC) in Fig. 1 is the fourth largest city in Bangladesh with a population of 4,78,889 males and 2,39,469 females (density of 9,017 per square km) in 90.173 sq. km. The city is located about 120 km north of the capital city, Dhaka [39]. Mymensingh was known as "Golden Fiber" because of its jute production and the revenue it added as a cash crop. The jute sector has suffered a significant downturn as a result of strong demand for polythene bags and other economic factors. The city has a considerable population of unskilled and semi-skilled workers who work as taxi drivers, hawkers, rickshaw pullers, mechanics, and others [39].

The Mymensingh City Corporation area is divided into 33 wards. According to MCC officials, urban dwellers are the main sources of waste generation in Mymensingh, with 400 tons of waste produced daily in 2020. The MCC authorities are trying to follow the national level procedure in waste collection. But still, due to the lack of manpower and technological support, the MCC authority cannot maintain the waste collection and disposal process properly. There is only one dumping site for the whole Mymensingh District, which is located in Samvugonj, and the capacity of this dumping site has been crossed, but still waste is dumped here. For this reason, waste has become a big issue in making the city more livable and polished.

Data collection

This study was conducted across the MCC. We have collected both primary and secondary data. For primary data collection, we have used quantitative approaches through a structured questionnaire. Before designing the questionnaire, several prior related literatures were reviewed, and a small scale (20 locals) reconnaissance survey was conducted, which helped improve the questionnaire's quality. The questionnaire was prepared in both English and Bangla, the native language of Bangladesh, and was interviewed randomly in all of the wards. The sample size was determined 384 (for a total of 82,687 households, where the confidence interval was 1.96 at the 95% confidence level).

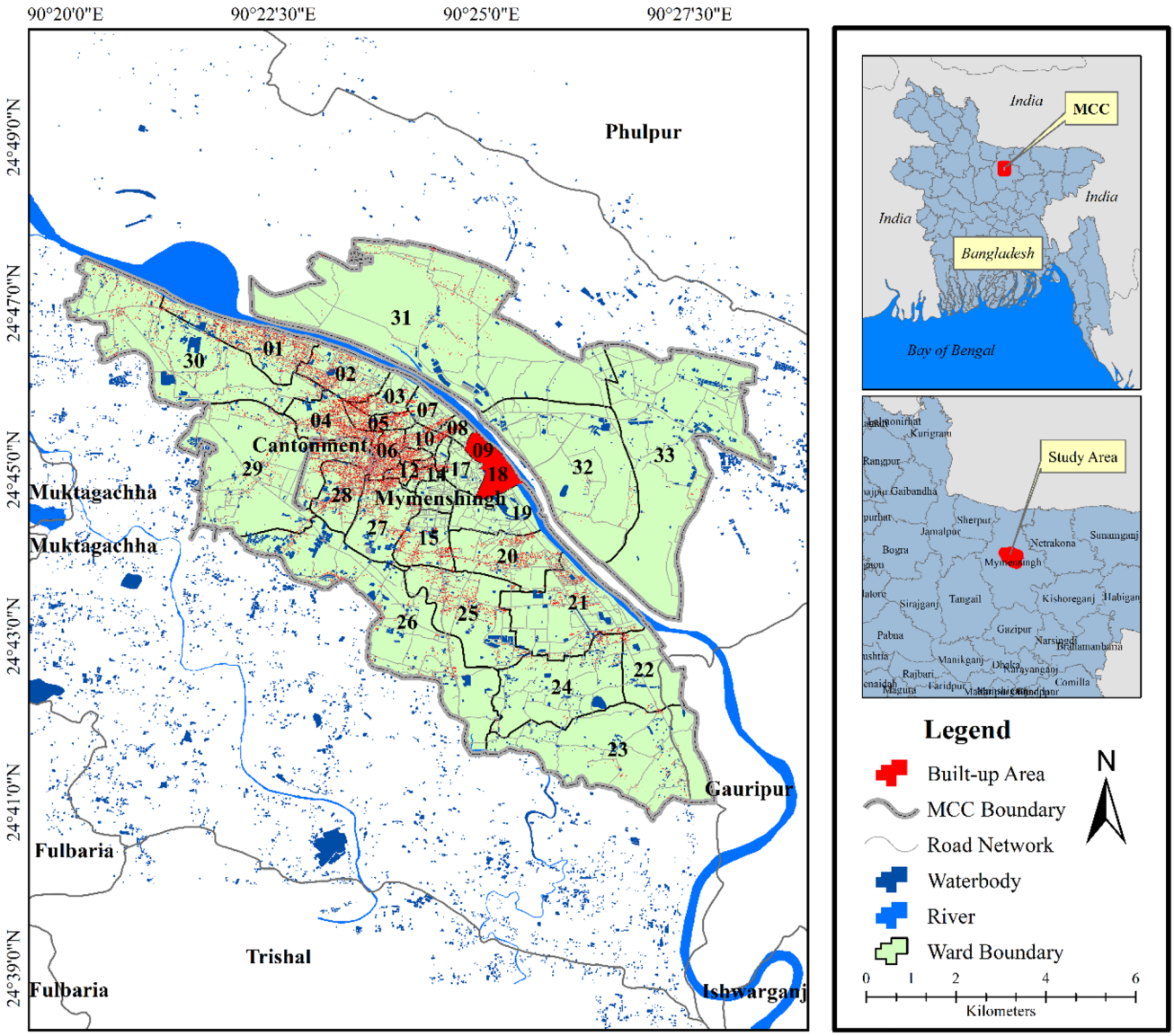

Fig. 1 The MCC map shows the wards with settlements

Future projection

Waste generation is directly proportional to the rate of change in the population. To project the future possible waste generation in MCC, we have followed the growth rate model, by which we have calculated the population growth rate in MCC and forecasted the population for the years 2025, 2030, 2035, and 2040. A growth rate model is a process that begins with the estimation of the future population based on the average increase in population. Based on the per-capita waste generation and projected population, we have calculated the prospective amount of municipal solid waste generation using Eqs. 1 and 2.

$$\text{Future population } P(f) = Po\left(1 + \frac{R}{100}\right)^{y} \quad (1)$$

Here, Po = Initial Population (2020), R = Population growth rate, y = years.

Future amount of municipal solid waste generation per day:

$$\text{Quantity } Wq = P(f) \times \frac{Wr}{1000} \quad (2)$$

Here, $P(f)$ = Predicted population, Wr = Waste generation rate (kg/capita/day).

Costs estimation

To calculate the collection costs, transport costs, sorting costs, and recycling costs of solid waste, this study used data from the Ministry of the Environment and also asked the Mymensingh City Corporation officials for the costs. Table 1 represents the costs for different operational activities for solid waste [39, 40].

Contingent valuation method

The contingent valuation method was first used to assess the benefits of outdoor recreation in the United States' backwoods of Maine [41]. It is a simple, mostly used, and flexible non-market approach that is widely used for assessing the environmental impact of non-market resources and cost–benefit analysis [42]. Although the approach has been criticized for the reliability and validity of the outcome, this problem has been evaded due to the enormous efforts of numerous experts. The CVM has been applied in many research fields, such as renewable energy [43], wetlands [44], recreation [45], watersheds [46], buses [47], waste management [7], water quality improvement [35] and other non-market resources [48, 49]. The use of CVM in the field of environmental protection studies has been increasing.

The CVM is a survey-based strategy that contains a hypothetical scenario, creating a speculative market for a service or good. Respondents are asked how much they would be ready to pay for a change in the quantity or quality of the services or goods [50]. A CVM is characterized by different parameters based on the type and needs of the research, such as period of payment (e.g., month, year), payment vehicle (e.g., donation, tax), and format of the response (e.g., dichotomous choice, open question) [51]. We have employed the CVM method to calculate the residents' willingness to pay (WTP) for a sustainable solid waste collection and management system (SSWCMS) in MCC.

There are several layouts of CVM study such as "Dichotomous choice, Open-ended, Iterative bidding, Multiple bounded dichotomous choices, and Payment cards" [35, 52]. Due to some complexities and prejudices of other approaches, such as the possibility of hypothetical bias, we have employed the Payment Card Method (PCM) of CVM in this study. During the field survey, the respondents were explained the details of the sustainable waste collection and management system and decision rules by a payment card which was adopted from the literature by Rowe et al. [53]. A list of payment amounts (per month) is displayed on the payment card, from which respondents selected the amount that best represents their maximum WTP for the services.

Table 1 Costs for different operational activities in SWCMS (Unit: BDT, 1USD = BDT 85 Tk)

Types of wastes	Collection	Sorting	Recycling
Organic	8400	5,880	4200
Paper	7140	3,360	
Plastic	13,860	25,200	
Metal	11,508	1260	
Glass	9492	420	

To identify the influences of different factors on households' WTP for the SSWCMS program in MCC, a regression model was developed using SPSS 23 software. The respondents were asked whether they are WTP (defined by 1) or not WTP (defined by 0) for SSWCMS. We considered WTP as the dependent variable and other sociodemographic characteristics as independent variables, as the dependent variable is in 0 and 1 format, the researcher can choose between probit regression and logistic regression [48]. We have used logistic regression to evaluate the influences of different factors in Table 1. The WTP probability model was expressed in the following way:

For the agreed probability i.e., when respondents were positive to WTP:

$$\Pr\left(\overline{Y}_{\mathrm{i}}=1\right)=\log_{\mathrm{e}}\left[\frac{\{\Pr(Y=1)(X_1,\ldots\ldots..X_n)\}}{\left\{1-\Pr(Y=1)\left(X_1,\ldots\ldots..X_n\right)\right\}}\right]=\log_{\mathrm{e}}\left[\frac{P'}{1-P'}\right] \tag{3}$$

$$=\alpha+\beta_1X_1+\ldots\ldots\ldots..+\beta_nX_n=\alpha+\sum_{j=1}^{n}\beta_jX_j \tag{4}$$

Here, P' is the conditional probability of $\Pr(Y=1)(X_1,\ldots\ldots..X_n)$.

The logistic function is:

$$\Pr(Y=1)(X_1,\ldots\ldots..X_n)=\frac{e^{\propto+\sum_{j=1}^{n}\beta_jX_j}}{1+e^{\propto+\sum_{j=1}^{n}\beta_jX_j}} \tag{5}$$

For the non-response probability, when the respondents respond a negative WTP:

$$\Pr(Y=0)(X_1,\ldots\ldots..X_n)=\frac{e^{\propto+\sum_{j=1}^{n}\beta_jX_j}}{1+e^{\propto+\sum_{j=1}^{n}\beta_jX_j}} \tag{6}$$

The logistic regression equation for the log-odds to estimate WTP can be calculated using the set of predictors [54].

$$\log\left[\frac{Pr_1}{1-Pr_1}\right]=b_o+b_1X_1 \tag{7}$$

Here, b_o indicates the coefficient gauges on the offer sum, b_1 indicates the assessed consistent.

Data analysis

We used SPSS version 23 for conducting the chi-squared test, logistic regression, and Pearson's correlation analysis. To assess the influence of different sociodemographic factors (age, education, income, household size, employed family member) and respondents' satisfaction level, daily waste generation, and distance of home from the waste bin on residents' WTP for a sustainable SWCMS in MCC, the regression model considered these factors as independent variables and WTP as dependent variables.

Results and discussion

Respondents' sociodemographic profile

There are 82,687 households in MCC, from which we surveyed 384 households and asked about solid waste collection and management systems (SWCMS) and WTP for the improvement of SWCMS in MCC. Table 2 represents the sociodemographic profile of the respondents. Out of 384 respondents, 92.70% are educated, 90.10% have a monthly income of more than 15,000 Tk and most of the households have four to seven members in the family. Among the respondents, the majority of them are aged between 25 and 55 years old. The demographic characteristics of the respondents' can be regarded as a good composition of the population.

Table 2 Sociodemographic profile of the respondents

Categories	Groups	Frequency	%	Level indicator
Gender	Man	280	72.92	1
	Women	104	27.08	2
Age group	≤25	56	14.58	1
	25–40	132	34.38	2
	40–55	119	30.99	3
	≥55	77	20.05	4
Education	No education	27	7.03	1
	Primary	46	11.98	2
	Secondary	63	16.41	3
	College	59	15.36	4
	Diploma	35	9.11	5
	Undergraduate	84	21.88	6
	Postgraduate	70	18.23	7
Income	≤15,000	38	9.90	1
	15,000–30,000	50	13.02	2
	30,000–45,000	66	17.19	3
	45,000–60,000	85	22.14	4
	≥60,000	145	37.76	5
Household size	≤3	79	20.57	1
	4–5	156	40.63	2
	6–7	122	31.77	3
	≥7	27	7.03	4

Knowledge and awareness of respondents about SWCMS

Table 3 provides the summary of the respondents' knowledge of the SWCMS and their source of knowledge. Most of the respondents reported knowledge of SWCMS. Out of 384 respondents, 69.79% have knowledge of SWCMS, where 47.39% of them obtained this knowledge by reading newspapers and 33.21% by watching TV. Recently, the government of Bangladesh has been more conscious about environmental protection and promoting a clean environment, thus increasing public awareness. Table 3 shows that about 59.11% of respondents were concerned about recycling, while 40.89% were not concerned at all. This indicates that a large portion of the population is not concerned about the sustainable waste management system.

Table 3 Respondents' knowledge and source of knowledge about SWCMS

	About management		About recycling	
	Frequency	%	Frequency	%
Knowledge				
Yes	268	69.79	227	59.11
No	116	30.21	137	40.89
Source				
Newspaper	127	47.39	118	51.98
Radio	17	6.34	13	5.73
TV	89	33.21	57	25.11
Social media	23	8.58	23	10.13
Others	12	4.48	16	7.05

Existing condition of SWCMs in MCC

Technological and administrative condition

The Bangladesh government and German Technical Cooperation (GTZ) introduced a solid waste collection and management project in MCC. The respondents said the involvement of both public and private authorities in waste collection

systems. According to MCC officials, the MCC generates approximately 400 tons of waste per day, of which 320 tons are disposed of at the riverside dumping site in Shambhuganj Bridge. The area of this dumping site is 6.5 acres and has been used since 1990. The officials said that 95% of the dumpsite area has already been filled up, and they are thinking about expanding the dumping site.

Table 4 represents the logistic support of the MCC authority for waste collection. Due to insufficient bins, manpower, and vehicles in the MCC authority, several private authorities also collect waste from households. For which they collect 100–300 Tk/month ($1.2–$3.6 per month) from each household (Table 5). Each van serves 996 households, each garbage truck serves 3,937 households, and each hand trolly serves 2,667 households. Variations in payment have been observed in different wards due to the differences in service quality and the distance of homes from disposal sites. Table 6 represents the yearly wages of the employees of waste collection systems and their operation costs.

Respondents' perspective

Field survey analysis shows that 61.98% of respondents rely on public authorities, and 38.02% rely on private management. As illustrated in Fig. 2a, the majority of the household's (48.44%) waste is collected through the van, while 28.13% said the same about the door-to-door waste collection system. About 17.97% of the respondents said they put waste in the nearby waste containers and placed the waste at roadside waste collection points as they did not receive any services. However, 5.47% of the respondents said they throw waste in nearby open spaces or drains. In this case, they blamed poor waste collection systems, and some of them said that the waste collection points are far from their houses. The majority of the respondents claimed that the waste collection services were not trustworthy. About 21.09% of respondents said that the waste was collected every day, while 45.05% said it was collected thrice a week, 28.13% said once a week, and the rest of the respondents responded seldom or never. Figure 2b shows that 40.63% of respondents said that it took less than 5 min to go to waste collection points, while 6.51% claimed it took more than 10 min, which forces them to throw waste into the nearby open space or roadside drains. We have observed that illiterate respondents are not aware of this. In some cases, we found that waste collectors do not collect waste from some areas.

Though both public and private authorities together collect waste from the households of MCC, the satisfactory analysis shows that 68.49% of respondents were not satisfied with the existing SWCMS of MCC. Only 6.25% were found fully satisfied with the existing services. 13.02% of the respondents said that they were exhausted with the existing conditions.

Table 4 Logistic supports of MCC for waste collection

Types of vehicles	Number of vehicles	Each serves no of HH
Garbage Truck	21	3,937
Vacutag for faucal sludge management	01	82,687
Mini pay loader	02	41,344
Excavator	01	82,687
Power trolly	19	4,352
Van	83	996
Hand trolly	31	2,667

Table 5 Privates sectors' waste collection fees

Ward No	Fees (Tk/month)
1, 3, 4, 16, 18, 20	100
2, 6, 7, 8, 9, 10, 14, 25	130
11, 12, 13	150
29, 30, 31, 32, 33	200
17, 19, 21, 22, 23	250
24, 26, 27, 28	300

Household waste generation and prediction

Daily waste generation

We asked the respondents about their waste generation and generated types, which are summarized in Fig. 3. About 40% of the respondents replied that about 1–2 kg of waste is produced every day, and 20.83% of households produced 3–4 kg (Fig. 3a). We have found a variation in waste production among different income groups (Table 7). The higher income group (with an income of more than 45,000 Tk) produces about double the waste of the lower-income groups. This study found that, on average, 3.21 kg of waste is produced every day by a household, where 80.07% of it is organic/

Table 6 Operation and maintenance costs for the operation of waste collection

Operational costs	Cost (Tk/year)
Salary of backhoe driver	2,88,000
Salary of landfill & compost plant supervisor	2,88,000
Fuel cost	5,93,125
Protection gear	7,200
Repair and maintenance costs of backhoe	40,000
Chemicals for leachate treatment and electricity bill	48,000
Total	12,64,325

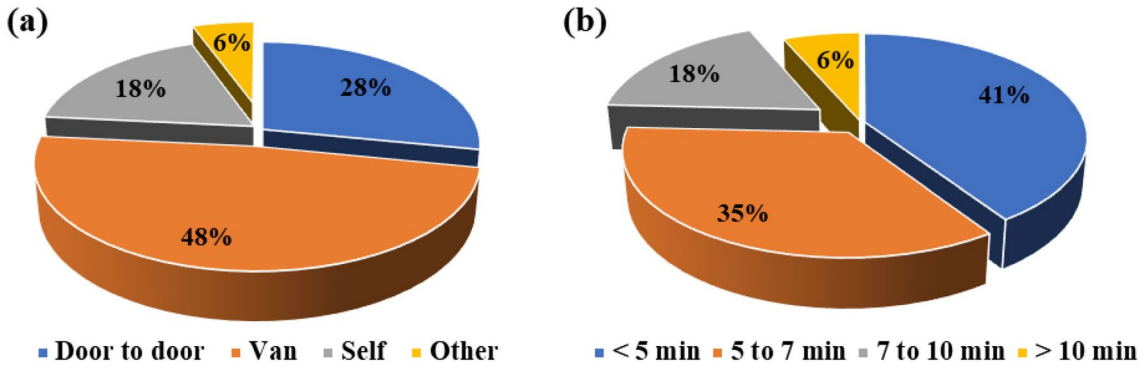

Fig. 2 **a** Household waste collection system; **b** Household distance from waste collection points

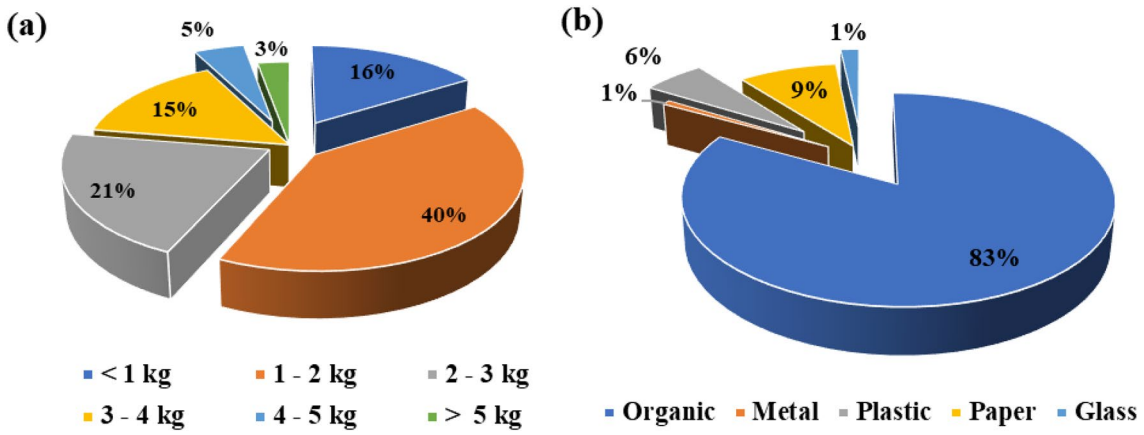

Fig. 3 **a** Household waste generation; **b** Composition of generated waste types

Table 7 Generated waste and management costs

Types of waste	Daily generated waste (kg/HH)				Monthly		Costs (million Tk/month)				Value of compost
	LC	MC	HC	Avg	kg/HH	Total*	Collection	Sorting	Recycling	Total	
Organic	1.80	2.50	3.70	2.67	80.00	7,291.7	61.25	42.88	30.63	134.75	437.50
Paper	0.20	0.30	0.35	0.28	8.50	774.8	5.53	2.60		8.13	
Plastic	0.15	0.20	0.20	0.18	5.50	501.3	6.95	12.63		19.58	
Metal	0.02	0.02	0.03	0.02	0.70	63.8	0.73	0.08		0.81	
Glass	0.03	0.03	0.10	0.05	1.60	145.8	1.38	0.06		1.45	
Total	2.20	3.05	4.38	3.21	96.30	8,777.4	75.85	58.25	30.63	164.73	437.50

LC Lower class, *MC* Middle class, *HC* Higher class

*Total = Total generated waste of entire MCC (Tons/month)

kitchen waste (Fig. 3b). This study estimated 8777.40 tons of waste produced in MCC every month, whereas MCC officials reported that a total of 400 tons of waste (including household and others) was produced in MCC every day.

Table 8 summarizes the person(s) in the family who are in charge of waste management in their home. The study found that females (32.29%), children (23.96%), and maids (39.06%) are mostly responsible for the management of waste. Higher-income people rely on maids to place waste for waste collectors.

Table 8 Who does the placing of wastes?

Relation	Respondents (%)
Father/husband	4.69
Mother/wife	32.29
Child	23.96
Maid	39.06
Total	100

Monetary values of generated wastes

This study calculated the probable waste collection, sorting, and recycling costs (Table 7). The total collection cost was estimated 75.85 million Tk/month, with 58.25 million Tk/month for sorting and 30.63 million Tk/month for recycling (only organic wastes, as only organic wastes are recycled and used as organic compost in Bangladesh). The value of recycled waste (organic compost) was calculated 437.50 million Tk/month, which signifies the importance of waste recycling for economic needs. Moreover, the sustainable management of waste will assist in ensuring a clean and sound community environment.

Future projection

Waste generation is directly proportional to the rate of change of population. According to the MCC officials, about 400 tons of waste is produced each day at MCC. Waste generation has been increasing with the increase of population. This study projected future waste generation based on the projected population growth in the MCC (Fig. 4). By 2040, about 472 tons of waste will be produced in MCC, and per-capita waste generation will increase to 0.45 kg/person/day. But 95% of the landfill area has already been filled up. This signifies the sustainable management of waste with advanced technology. Otherwise, MCC will face a major environmental threat, and the urban environment will be unsustainable for living.

WTP for improved SSWCMS in MCC

Statistics for WTP

We employed the payment card approach of CVM to calculate the WTP for SSWCMS in MCC. We have asked the respondents whether they are willing to pay for an improved and sustainable waste collection and management system. Analysis shows that 14.58% of respondents did not agree to pay. About 50% of them (WTP = 0) believe that this is the responsibility of the government. Another 30.36% said that their income is not sufficient enough to pay for such improvements. We have found that 85.42% of people agreed to pay and they believe that the poor waste collection and management system is one of the major problems in MCC, and it is also a source of other

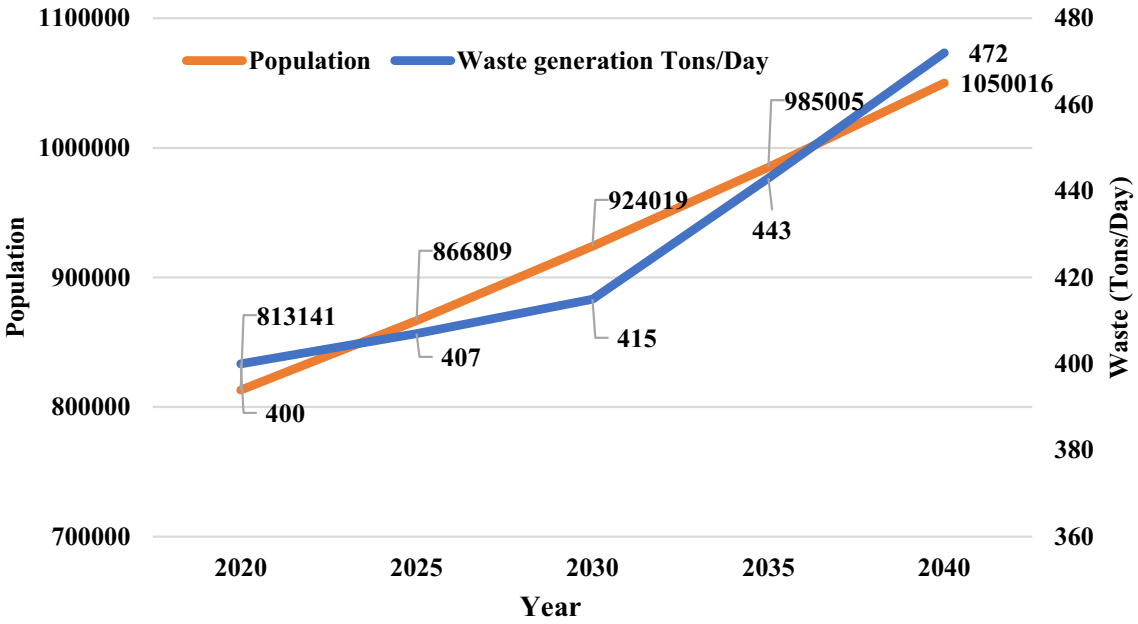

Fig. 4 Projected daily waste generation for MCC up to 2040

problems such as disease, dengue, odor, and waterlogging, especially during the rainy season. The majority of people want to pay because they are suffering from pollution-related ailments, whereas some may be unwilling to pay due to a lack of environmental awareness or concern.

The result shows that the mean value of WTP is 283.38 Tk/month (USD 3.37) and the maximum WTP is 500 Tk/month (Table 9). Descriptive statistics in Table 9 show that the median value of WTP is 250 Tk which is less than the mean WTP. One possible explanation is that with logit estimation, the estimated values of the latent variables for zero observations are more prominent than zero, which is consistent with [35, 55].

There are a total of 82,687 households in MCC. Based on this, the total WTP of the residents of MCC would be $(283.38 \times 82{,}687) = 23.432$ million Tk/ month (USD 0.28 million). Afroz et al. [7] calculated the aggregate WTP of 7.7 million Tk for only improved solid waste collection system in Dhaka City for the household number in 2009. Dhaka is the capital, and the SWCMS in Dhaka City is better than in other cities in Bangladesh. The increase in the population, the consciousness of people, and income level can be the reasons for this difference. Moreover, we have calculated the WTP for improved waste collection and management (recycling) systems.

Table 9 Descriptive statistics of WTP (sample size 328)

	Descriptive statistics
Mean	283.38
Median	250
Std. deviation	131.75
Minimum	0 Tk
Maximum	500 Tk
Skewness	2.238
Kurtosis	5.896

Drivers of WTP for SSWCMS

We have asked the respondents how much they are willing to pay every month for an improved and sustainable waste collection and management system. Table 10 represents the variations in responses to WTP under different sociodemographic groups. Findings show that 12.80% of the people are agreed to

Table 10 Attitudes of respondents of different sociodemographic profiles toward WTP

Criteria	Category	WTP					
		No	≤100	101–200	201–300	301–400	401–500
Age group	≤25	18%	14%	36%	21%	7%	4%
	25–40	9%	8%	14%	19%	32%	17%
	40–55	11%	13%	21%	13%	18%	24%
	Above 55	27%	9%	12%	26%	16%	10%
Education	No education	70%	19%	11%	0%	0%	0%
	Primary	35%	28%	26%	11%	0%	0%
	Secondary	17%	17%	33%	27%	3%	2%
	College	10%	7%	19%	37%	17%	10%
	Diploma	9%	9%	31%	23%	20%	9%
	Undergraduate	1%	4%	10%	13%	32%	40%
	Postgraduate	0%	4%	10%	14%	47%	24%
Income	≤15,000	59%	32%	8%	0%	0%	0%
	15,000–30,000	34%	20%	28%	14%	2%	2%
	30,000–45,000	17%	12%	36%	12%	11%	12%
	45,000–60,000	6%	8%	17%	29%	28%	12%
	Above 60,000	1%	3%	12%	23%	32%	29%
Household size	3	9%	9%	12%	15%	29%	25%
	4–5	8%	4%	24%	31%	21%	13%
	6–7	14%	14%	20%	12%	22%	18%
	More than 7	50%	31%	12%	2%	2%	2%
Employed family member	1	17%	17%	35%	17%	10%	6%
	2	15%	10%	14%	20%	22%	19%
	3	16%	4%	3%	28%	32%	17%
	4	4%	4%	4%	7%	33%	48%
	5	0%	0%	0%	10%	50%	40%

pay less than 100 Tk, 22.26% are willing to pay 101–200 Tk, 24.09% are willing to pay 301–400 Tk, and the rest 18.60% are willing to pay 401–500 Tk/month for sustainable waste collection and management system in MCC.

A regression analysis has been performed to assess the impact of different sociodemographic characteristics of respondents, such as age, education, income, family/household size, satisfaction level, employed family member, distance from the bin, and daily waste generation on the household's WTP for SSWCMS in MCC (Table 11). The sociodemographic characteristics and the responses of the respondents are considered as independent variables, while WTP is the dependent variable. The pseudo R^2 value of 39.2% indicates the excellent fit of the model [56], with a statistically significant value of 30.75 at the 1% level. Hence, this model's goodness of fit reveals a prediction accuracy of around 90%.

Table 11 Output of the logit model (WTP is the dependent variable)

Variables	Coefficient	Std. Error	Significance
Constant	2.165	1.451	0.099
Age	– 0.117	0.110	0.431
Education	0.346	0.139	0.001
Income	0.431	1.883	0.001
Household size	– 0.089	0.151	0.002
Satisfaction level	– 0.128	0.172	0.003
Employed member	0.227	0.111	0.000
Distance from bin	0.264	0.067	0.000
Waste generation	0.385	0.105	0.003
Pseudo R^2	0.392		
LR chi^2	30.75		

This study found the negative correlation of age ($b = -0.117$, $p < 0.431$, $R^2 = 0.2221$), household size ($b = -0.089$, $p < 0.002$, $R^2 = 0.64812$) and satisfaction level ($b = -0.128$, $p < 0.003$, $R^2 = 0.62136$) that the households with large member and more satisfied are less likely to pay for improved SSWCMS (Table 11, Fig. 5). The inverse correlation between WTP and satisfaction level indicates that people who are satisfied with the existing condition are not willing to pay for its improvement. According to them, why would they pay extra money when they are happy with the existing condition? And they believe that this is the government's responsibility. Lack of motivation and awareness is responsible for such behavior. The positive correlation of education ($b = 0.346$, $p < 0.001$, $R^2 = 0.81752$), income ($b = 0.431$, $p < 0.001$, $R^2 = 0.91415$), employed member in the household ($b = 0.227$, $p < 0.003$, $R^2 = 0.71334$), distance from household to waste collection points ($b = 0.246$, $p < 0.000$, $R^2 = 0.32396$) and waste generation ($b = 0.385$, $p < 0.003$, $R^2 = 0.41142$) indicates that household with a high-income level and multiple earning members are more likely to pay for SSWCMS of MCC. People with

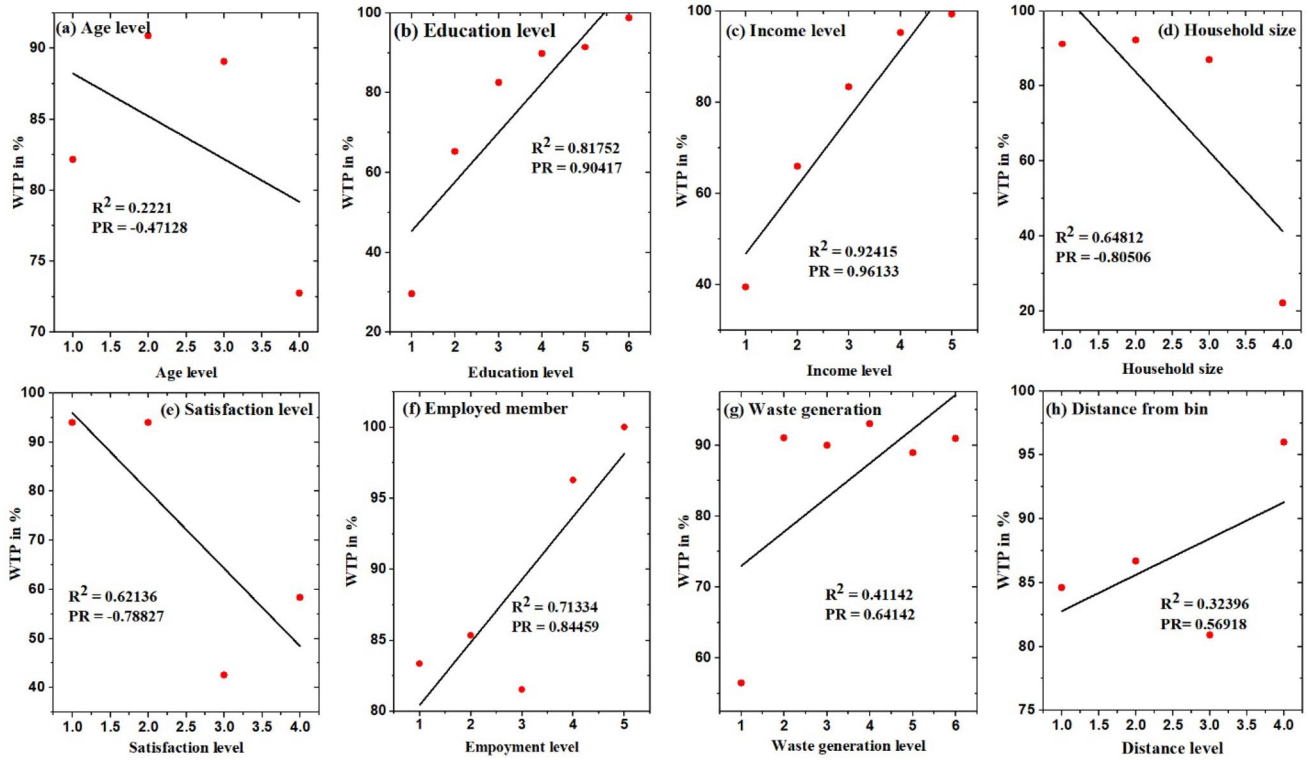

Fig. 5 Correlation analysis between respondents' WTP and influencing factors. (PR = Pearson's r)

lower incomes have to focus on their survival and spend less. On the other hand, the higher income groups do not need to think about survival, and they put more concern into public welfare, environmental concerns, utility services, and their WTP increases with the increase in income. These results are inconsistent with the prior studies in Bangladesh [7, 35] and also for other countries [57–62].

Policy implications and conclusion

Cities around the world have stepped up their efforts to ensure a sustainable urban environment. The government of Bangladesh is now more conscious of sustainable environmental management and has been trying to improve the solid waste collection and management systems of the cities across the country. But being a developing economy, it is difficult for the government to invest a higher amount of money in all the sectors. In this regard, it is important to establish a compensation mechanism for the SSWCMS to ensure a sustainable urban environment in the city. In this study, the existing SWCMS condition, and costs regarding household SWCMS of one of the major cities of Bangladesh has been investigated. Also employed the CVM to calculate the city residents' WTP for the sustainable solid waste collection and management system.

Findings show that most of the waste is organic and compostable. The composition of waste generation shows a good prospect for avoiding, minimizing, reusing, and sustainable disposal of wastes. But lack of manpower, money, instruments, and logistic support has made the entire waste collection and management system in Mymensingh City so acute that the future generation will be threatened with various destruct. A projection of waste generation shows that per-capita waste generation will increase to 0.45 kg/person/day by 2040. For waste management, MCC authorities use traditional land filling, but 95% of the landfill area has already been filled up. In this regard, most of the residents of MCC agreed to make a financial contribution to improve the existing conditions of SWCMS in a sustainable manner. The outcome of WTP analysis using CVM shows that 85.42% of the households agreed to pay 283.38 Tk/month for sustainable SWCMS. Various sociodemographic factors of the households had both positive and negative influences on their willingness to pay. However, overall study concludes that the participation of community members in activities related to environmental protection with the government is essential for sustainable urban management. If authorities rely solely on the government's unilateral power, they will face the risk of running out of funds, so they must properly motivate the majority of residents to contribute to a sustainable urban solid waste collection and management system. Thus, the following suggestions will be helpful to increase the WTP attitudes of the residents:

- **Raising awareness:** Findings summarizes that most of the people are not aware of the importance of SSWCMS. Raising awareness among the community people is a very effective tool, because it educates people about things that they are unfamiliar with and inspires them to participate in bringing change. Therefore, to enhance the people's awareness of the importance of SSWCMS, the government should propagate the significance of SSWCMS through radio, TV, social media, and the internet. In this way, we can improve the people's WTP and payout levels for the protection of the urban environment.
- **Education:** The findings of this study showed that the higher the respondents' education levels, the higher their WTP is. Consequently, we must expand education spending, particularly among primary and secondary school students. The government should organize environmental protection courses and raise environmental awareness. To establish a strong foundation for the future, we should approach youngsters during adolescence. We can invest in higher education and ongoing re-education in the sustainability of sensitive landscapes so that an increasing number of individuals will give compensation for environmental protection.
- **Family planning:** This study found the significant negative impact of family size on the WTP of the respondents. This is because large families have higher monthly expenses, which makes them reluctant to spend extra in other sectors. In this regard, mass education will be more effective.
- **Employment and income opportunities:** Fourth, the initiatives of increasing city economic levels and per-capita income are important. The empirical findings of this study reveal that as household income levels increase, the WTP rises as well. The government must increase residents' income as much as possible, continually motivate to increase income channels, and continuously improve residents' satisfaction levels so that more people join in the compensation mechanism for the development of urban SWCMS.

Aside from improving WTP practices, the recommendation will also promote waste generation reduction and reuse of generated waste. This study has some limitations that can be used to guide future research. Future research may calculate the WTP for different income groups, which will be more helpful to policymakers in making decisions. We have considered the WTP of only households' waste. Future studies can focus on both residential, commercial, and industrial waste sectors, as industrial and commercial waste sectors each contribute a large portion of waste. Finally, the use of multiple approaches in calculating WTP will be of more help. This study is an important scientific contribution in CVM studies with various sociodemographic factors in developing cities where the condition of

social service facilities is very poor. It would be interesting to apply the current research design to individual city problems in other countries to identify the differences in the major urban problems in developed, developing, and underdeveloped cities.

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Availability of data and material The datasets generated during and/or analyzed during the current study will be available from the corresponding author on reasonable request.

Code availability Will be available on reasonable request.

Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics approval This article does not contain any studies with human participants or animals performed by any of the authors.

Consent to participate Not applicable.

Consent to publish Not applicable.

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